ABSTRACT

SUTTON, KRISTEN RUTH. Systematic Approach for Error Proofing Transaction Processes. (Under the direction of Dr. J.A. Joines, Dr. C.T. Culbreth, and Dr. T.G. Clapp.)

The purpose of this research was to develop a model to reduce errors in transactional processes within companies. The model created utilized three error proofing concepts: the FMEA, TRIZ Solution Directions, and the Error Proofing Healthcare (EPH) model. The research involved analyzing 250 FMEA's that were previously conducted in a large transactional corporation and obtaining feedback from associates. The model that was created consisted of three phases. Phase one identifies the potential failures that could occur within a process while phase two uses TRIZ solution directions to create multiple innovative solutions and phase three uses a method called Solution Priority Number (SPN) to rank and evaluate the solutions generated. The SPN consists of the return on investment (ROI) and the ease of implementation of each solution. Excel worksheets were created to support the Error Proofing Transaction (EPT) model. A case study was performed within a large transactional corporation. A team completed the existing FMEA and then completed the new EPT model. When comparing the existing FMEA and the EPT model it was found that the EPT model reduced the team meeting time by 50% and produced more failure modes, more effects, more causes, more high risk failure modes, as well as a more enhanced set of solutions.

Systematic Approach for Error Proofing
Transaction Processes

by
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DEDICATION

First I would like to thank God for all of the gifts and opportunities that he has given me. He has supported me and helped me through my 19 years of school. Without God I would not have completed all that I have done including my thesis. Next, I would like to thank my family especially my parents Keith and Christiane for all of their continued support and motivation throughout school. They have always believed in me and supported me in completing my thesis. Lastly, I would like to thank my fiancé, Matt, for supporting me through this process and always making me smile even when I was overwhelmed with writing. Without everyone's support I would not have been able to complete my thesis.

BIOGRAPHY

Kristen Sutton was the Valedictorian of her graduating class in May of 2003 from South Rowan High School. She started attending North Carolina State University in August of 2003. She graduated Cum Laude with a Bachelors of Science in Textile Engineering and a Minor in Industrial Engineering from North Carolina State University in May of 2007. When Kristen completed her Bachelors of Science in Textile Engineering she started pursuing a Co-Masters of Science in Textile Engineering and Industrial Engineering in August of 2008. Upon completion of her Co-Masters of Science in Textile Engineering and Industrial Engineering Kristen will go to work at a corporation where she will utilize her skills in Six Sigma and Quality Improvement.

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Chapter I- Introduction

The Merriam-Webster definition of a transaction is: "an exchange or transfer of goods, services, or funds." A transactional corporation is a company that provides goods, services, or funds to a customer, but the focus in transactional settings is the customer. An example of a transactional type setting is a bank which provides funds for their customers. Another example of a transactional service is a restaurant which provides service and a product or food to their customers.

Transactional process differ from manufacturing. In manufacturing there is a product that is being produced from start to finish. There is equipment and machinery that can be altered to improve a process. Most of the products that are being produced are known prior to their creation. In a transactional setting the company has to respond quickly to the request of their customer. In transactional settings there are few machines that can be altered to improve a process and most of the improvements that are made are focused on eliminating human errors.

Everyday there are billions of transactions that occur where there is a finite probability that an error could occur each time. For example, in banks if an error in one transaction occurs it could be catastrophic and there are many different effects this error can cause. Some of these effects could be customer dissatisfaction, loss of a customer, and/or the loss of potential monetary gain. Since the customer is the top priority of any transactional setting it is very important to insure that errors do not occur; so that there is no impact to the customers which could result in a monetary loss. Therefore it is imperative that banks utilize different error proofing tools. This thesis will analyze Error Proofing methods and their application in other types of industries in order to develop a systematic approach for Error Proofing Transaction Processes.

Chapter II- Existing Quality Methods

Companies use a variety of quality methods (i.e. Six Sigma, Total Quality Management, Lean, etc.) to help improve processes within their organization. Several transactional service companies now utilize Lean and Six Sigma methodologies where they previously used Total Quality Management (TQM).

2.1 Quality Methods in Transactions Prior to Lean and Six Sigma

There are many different types of errors that occur in transactional services. For example, in a bank manual data entry can lead to many errors. Therefore, controls are put in to place to keep these errors from occurring. However, it would be devastating if these errors occurred and the repercussions would be great. To help eliminate errors, many banks have started to use Six Sigma in order to improve their quality and to keep these errors from occurring.

Before the use of Six Sigma and Lean, banks used a variety of quality improvement methods based on Total Quality Management (TQM), now referred to as Quality Management. Banks used TQM because it is focused on customer satisfaction which should result in long term success. Banks utilized Deming's 14 points in order to increase quality and productivity. Banks also utilized the Shewhart Cycle of Plan, Do, Check, and Act to assist with problem solving. Plan your objectives and how you are going to reach them, do what you have planned to do, check to see if doing your plan gets the desired results, and act on what was learned to improve. This methodology allowed banks to learn from what they were doing and improve the current process. (Evans, 2005)

Each bank used different tools from TQM, Deming's 14 Points, and Shewhart's method. There was not a specific set of tools or a roadmap to follow for quality improvement in banks until Six Sigma and Lean were applied. Also, banks often used their own variation of Six Sigma and the benefits have been tremendous. For example, from 2001-2004 Bank of America has saved about 2 billion dollars and has increased their customer satisfaction by 25% from the utilization of Six Sigma (Gupta, 2005). The Six Sigma methodology has allowed banks to utilize a structured roadmap to improve their process.

There has been a big difference in using Six Sigma in banks instead of just TQM. When TQM was used, a team would look at one problem in order to reduce cycle time and defects. When a specific isolated problem is the only item that is analyzed the potential savings are small and the work may not be validated (Michalski, 2003).

Six Sigma and Lean have a much broader scope since they analyze the entire process, where TQM only focused on pieces of the process. In using TQM each problem was attacked by a team of quality assurance personnel while in Six Sigma each employee in a corporation becomes a process improver (Michalski, 2003). As with many companies who adopted the Six Sigma and Lean methodology transactional companies have been able to realize large savings.

2.2 LEAN

Companies have started using Lean tools in order to restructure their manufacturing methods. Lean focuses on removing wasteful activities such as: waiting, transportation, material hand-offs, inventory, and over production. Lean allows companies to operate as a whole instead of many separate units. When companies start to adopt a Lean way of thinking, which eliminates waste by reducing cycle time and increases productivity and quality, an incredible return on investment (ROI) can be realized. An example of a company that had a great ROI was General Motor's largest plastics supplier, Blackhawk Automotive Plastics. Before becoming GM's largest supplier, Blackhawk adopted the idea of lean manufacturing. Blackhawk's Lean processes led to 100% on time delivery, increased productivity by 15%, and decreased inventory levels by 25% for twelve months (Forger, 2003).

Lean has two key components: feedback of information and process speed. Lean is very focused on reducing waste not only on the manufacturing floor, but also in other parts of the company. Lean focuses on cleaning up the workspace in order to change the time it takes to complete a task. Many organizations have adopted Lean's 5S theory in order to clean and organize each employee's desk.

2.2.1 History

Henry Ford was the first business man to understand that process speed affected cost that where processes are slow, there is waste. Inventory in the system can slow down a process. Ford's process was very successful for many years and was very revolutionary and his initial concept of low cost is one of the key concepts of Lean. However, Lean differs from Ford's process in that his mass production lines where balanced for only one product and ultimately failed in environments where there are small lot sizes. Lean focuses on producing a variety of different products while at the same time keeping the costs low. Toyota developed the lean concepts and was the first corporation to combine low cost with high quality. Lean is a generalization of the production system developed at Toyota which is also known as Just-In-Time (JIT). With the combination of Henry Ford and Toyota's production systems a new an innovative process improvement methodology was created. In 1990, Jones, Womack, and Roos started the Lean terminology in their book *The Machine That Changed the World: The Story of Lean Productions*. And the Lean production revolution was started. In this book they discussed how an automotive industry transformed its operations from craft production, to mass production, and finally to Lean production. (Womack et al., 1990; Womack, Jones, & Roos, 1990)

2.2.2 Key Tools for Transactions

Lean is an improvement methodology that not only utilizes tools and techniques, but requires all levels of a company to implement a Lean way of thinking (Womack & Jones, 2003). In the book that was written by Womack, Jones, and Roos they discuss five principles to Lean Thinking which are: specify value, indentify value stream, make value flow, let customers pull, and pursue perfection (Womack & Jones, 2003). There are many other lean methodologies that are being used such as Lean office, Lean product development, Lean design, Lean accounting, and Lean warehousing (Trebilcock, 2004). Many different lean techniques that are utilized by banks and other transactional service industries have utilized many different lean techniques in order to reduce errors from occurring. Below are some of the lean concepts that are used by transactional services. (Conner, 2001)

- Seven Wastes (Reduction)
  - Defects, Overproduction, Transportation, Waiting, Inventory, Motion, and Processing (too much).
  - One of the most common forms of waste in transactions is waiting.
- End-2-End Maps
  - Map of the entire value chain of events from start to finish of the target or selected good or service.
  - E-2-E maps are used in transactions for a visual representation of the process and to determine who is completing each task.
- Spaghetti Charts
  - Creates a picture of the physical traveling that the products/information experience within a process.
  - Used in transactions to create a picture of how information flows through a process.
- Visual Displays and Controls
  - Create common visual language in the workplace.

- 5S
  - Used to organize any environment by applying the 5 S's, which are sort, storage, shine, standardize, and sustain.
  - Sort- get rid of what is not needed
  - Storage- arrange and identify for ease of use
  - Shine- clean daily; clean up what's left
  - Standardize- eliminate cause; standard methods
  - Sustain- set discipline, plan, schedule
  - 5S is used in transactions to assure associate's workspaces are organized to increase efficiency.
- Load Chart
  - Visual display of each person's workload in a process.
  - Used in transactions to help to eliminate waste in each step.
- 5 Why's
  - Asking why a failure occurred multiple times, usually five, to determine the root cause of a problem.
  - i.e.: Why did your car not start? Because the battery is dead

    Why is the battery dead? Because the light was left on

    Why was the light left on? Because it was left on accidently

    etc.
  - Used in transactions to determine the root cause of a problem.
- Value Added Activity

  - An activity that changes the size, shape, fit, form, or function of material or information (for the first time) to meet the customer requirements.
- Non-Value Added Activity
  - All other activities that take time or resources or that does not satisfy the customer requirements.
- Time Value Map
  - Visual display of all of the steps in a process.
  - Used in transactions to help eliminate non-value added steps in a process.
- Product Process Flow
  - Used to determine the flow of a product through a process.
  - Used in transactions to determine how products flow through different processes.
- Work in Process
  - Causes: Instability (of operations), unbalanced capacity, monuments, demand variation, supply variation, and push.
- Poka Yoke
  - Mistake proofing

2.2.3 Key LEAN Error Proofing Tools for Transactions

Lean is a concept that has become very popular in transactional industries to help improve the functionality of the systems. There are a few tools that are applied for error proofing in transactional services. Three of the main Lean tools that are used for error proofing in transactional services are E-2-E Map, Poka-Yoke, and Seven Types of Deadly Waste.

2.2.3.1-E-2-E Map

In order to truly understand a system, a map of the entire process needs to be created to identify what potential errors could occur. In creating an end-to-end map, the entire chain of events that occur in a process from start-to-end can be seen, as seen in Figure 2.1. Each step of the process in the E-2-E map can be analyzed to identify potential errors. Failures first need to be identified before deciding on how to keep the error/failure from occurring. It is essential to create an accurate end-to-end map, or process map in Six Sigma, to determine each step that is performed in a process in order to correctly identify potential failures.

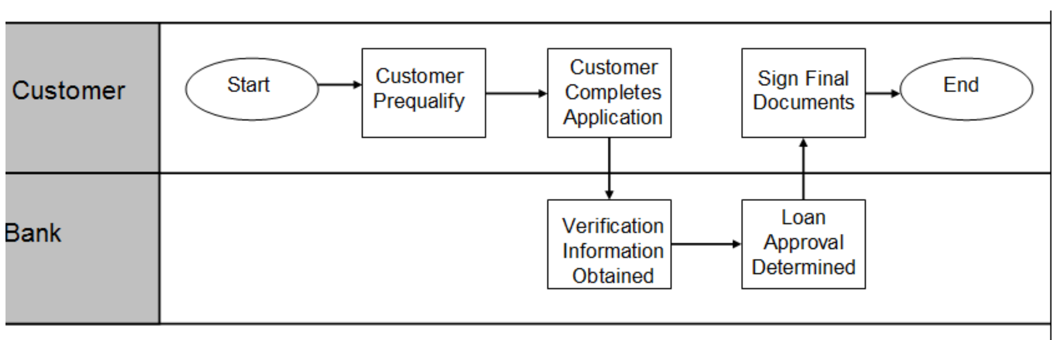


Figure 2.1- End to End Map for Receiving a Loan

2.2.3.2-Poka-yoke

Error proofing has had many different names over the years: mistake proofing, foolproofing, poka-yoke, but generally can be described as trying to eliminate errors before they can occur (Seastrunk, 2005). Error proofing has always been used in a manufacturing process where the operations are changed to fit the human. Nakajo and Kume have studied many different error proofing solutions and categorized them into five principles: elimination, replacement, facilitation, detection, and mitigation (Seastrunk, 2005). These principles were then broken down in to sub-principles so that they could be used to error proof many different processes (Seastrunk, 2005). Nakajo noticed that many manufacturing plants were making the exact same errors over and over and showed that proven solutions could be used to keep these errors from occurring. Also, if the same errors are occurring in different parts of a process, then one solution or type of solution can be used to keep these errors from happening as well. (Seastrunk, 2005)

2.2.3.3-Seven Types of Deadly Waste

Waste in Lean is viewed as an activity that creates no value while it utilizes resources and time; this is referred to as Muda (Wagoner, 2007). There are many different types of waste that are present within banks and other similar industries. In order to satisfy customers in a transactional industry you need to reduce all types of waste. There are seven types of waste that were defined by Shigeo Shingo from the Toyota Production System: overproduction, waiting, transportation, processing, stock (inventory), motion, and making defective parts (Wagoner, 2007). Another waste that has arisen is employee underutilization (Wagoner, 2007). Some of these seven types of waste do not apply directly to a transactional industry. For example, these transactional types of waste that could be reduced would be processing, motion, employee underutilization, and most importantly waiting. Waiting is directly tied to customer satisfaction and therefore reducing waiting increases satisfaction, which lead to overall success.

The seven types of deadly waste can be utilized when choosing a solution for a problem (error) that is occurring. In reducing the different types of waste that are present, the company will be more efficient which lead to increased customer satisfaction. Errors in a process are a form of waste. So, by reducing the errors that occur, waste will also be reduced. Identification and cause of the waste needs to occur before one can reduce/eliminate waste.

Error proofing is a critical component of lean because by reducing the amount of errors that can occur in a company ultimately reduces the waste in the system, the amount of rework, and the value add. When transactional companies utilize Lean techniques for error proofing they often see improved ROI (Return on Investment) because their workplace will be operating more efficiently.

2.3 Six Sigma

Six Sigma has many different definitions and has been described as "an improved quality assurance program, an updated measurement/improvement process, a new methodology, a philosophy, a strategy, a quality initiative, a new work ethic, or a top-to-bottom approach of how the organization performs to meet customer expectations" (Michalski, 2003). In a statistical sense, Six Sigma processing allows no more than 3.4

defective parts per million. Six Sigma supplies each employee with a toolbox of tools that when used correctly will cause great rewards for the individual and the company.

Many companies have implemented Six Sigma methodology. For example, some of these companies are: Caterpillar, 3M, Bank of America, Motorola, and General Electric which are only a small subset of the companies that have seen great rewards from the utilization of Six Sigma. In one year approximately 60% of Caterpillar's profitability came from Six Sigma improvements (Gupta, 2005). Caterpillar's first year gains after using Six Sigma exceeded their first year deployment costs. 3M "committed to Six Sigma as a way of doing business (Gupta, 2005)." They have accredited hundreds of millions of dollars saved by utilizing Six Sigma. 3M's CEO said the following regarding Six Sigma, "We're betting our performance on Six Sigma. That is saying that, if Six Sigma doesn't succeed, the company doesn't succeed" (Gupta, 2005). Bank of America has utilized Six Sigma for process improvements in many different projects in order to increase their customer satisfaction. From 2001-2004, Bank of America has saved approximately two billion dollars and has increased their customer satisfaction by 25% from the implementation of Six Sigma (Gupta, 2005). When Motorola utilized Six Sigma on their manufacturing floor between the years of 1987-1994, their manufacturing costs were reduced by 1.5 million dollars (Gupta, 2005). In the summer of 2004, Motorola claimed savings of 15 million from Six Sigma. In 1997, GE delivered about 300 million dollars to it's operating income while increasing that number to 750 million in 1998. GE has also witnessed a 62% reduction in their turnaround time (Gupta, 2005).

Many other companies had huge success from implementing Six Sigma throughout their entire corporation. (Gupta, 2005)

2.3.1 History

Motorola created the Six Sigma Process in 1987. They developed a four phase methodology that had to be completed in order to improve a process and were termed MAIC, which stood for Measure, Analyze, Improve, and Control. This first phase was Measure because the projects had already been defined and the correct people had been assigned to the projects. In later years the Define phase would be added to be completed before entering the Measure phase because correctly defining the project was noted as a key aspect to improve a process. (Eckes, 2005)

Bill Smith is given credit for the birth of Six Sigma, but Mikel Harry is given credit for packaging Six Sigma as a "vibrant quality-improvement methodology (Eckes, 2005)." Bill Smith created many of the original formulas and the statistics that are behind Six Sigma, but Mikel created many of the details around Six Sigma (Eckes, 2005). He published the book *The Strategic Vision for Acceleration Six Sigma.* Bill Smith and Mikel Harry together created the foundation for one of the greatest quality initiatives. (Eckes, 2005)

Motorola may have been the birthplace of Six Sigma, but they did not view Six Sigma as an ultimate management philosophy. However, General Electric (GE) was one company that viewed Six Sigma as the ultimate management (Eckes, 2005). Motorola did not utilize Six Sigma in all areas of their company since it was only used on the manufacturing floor to reduce defects. GE applied Six Sigma in all parts of their company along including their manufacturing floor, product design, transactions, processes, etc. GE focused on using statistical and non-statistical tools in order to lead to higher quality products in less time than their competition. GE helped to make Six Sigma into what it is today by taking the methodology that Motorola created and expanding it to all aspects of a company. (Eckes, 2005)

2.3.2 Key Tools for Transactions

In transactional processes, a human is a key part of a process. A human is not a machine that can perform the same task identically each time and is prone to making errors, since there are certain factors that cause variation. Six Sigma utilizes many tools and methodologies to help reduce the probability of human error. Since a majority of the work in transactional services is performed by humans it is vital to reduce the probability of human error. Transactional services use many of the Six Sigma tools. Each transactional service may use some of the tools in different ways as well as in different portions of the DMAIC cycle. The following list is some of the tools most commonly used by banks. (Michalski, 2003)

- Define Phase
    - Project Charter
        - Used to identify the team members, the project goal, the timeline, the problem statement, the business case, and the project scope.
    - Project Risk Matrix

        - Used to determine the risks that are present in this project and ranks each of these risks.
    - Stakeholder Analysis
        - Determines who is important to this project, how much they support the project, and how much they need to support the project. This is done to assure that support is provided when needed.
    - Primary Metric and Secondary Metrics
- Measure Phase
    - Cause and Effect Diagram
        - Determines how the measurement system, people, process/procedures, equipment/machines, environment, and materials affect the problem.
    - Cause and Effect Matrix
        - The customer requirements (CTQ's) are correlated to the risk factors.
    - Brainstorming
        - Used to generate ideas about the process and what could be improved or changed.
    - Failure Mode Effects Analysis
        - Identifies each failure that occurs in a process and ranks the severity, occurrence, and the chances of detecting this failure

before it occurs. This tool allows a person to determine which failures are high priorities.

  - Sample Size Determination
    - Helps to determine the appropriate sample size.
  - Data Collection Plan

- Analyze Phase
  - Hypothesis Testing
    - Used to test to see if the means of two different data sets are equal or not equal.
- Improve/Control Phases
  - Pugh Matrix
  - Control Plan
    - Used to insure that a process stays in control.
- The following tools are used in different phases of the DMAIC depending on the transaction company.
  - Control Charts
    - Used to determine if a process is in statistical control.
  - DOE
    - Used to determine what the best design would be.
  - Pareto Charts
    - Shows a graphical summary of the defect category occurrences.
    - 20% of the sources cause 80% of the problem.

- Histograms
    - Used to see the spread of the data and to determine what type of distribution would fit the data (i.e. a Normal distribution).
- Process Maps
    - Maps out each step of a process.
- MSA
    - Used to determine if a measurement system is working correctly. The reproducibility of the workers as well as the the repeatability of the measurement system is being tested.
- Correlation
    - Shows the linear relationship between variables
- Regression
    - Shows the relationship between an independent X variable and a response (Y).
- Analysis of Variance (ANOVA)
    - Used to show whether or not the variation between the average of the levels is greater than what could be expected form the variation that should occur at that level.

2.3.3 Key Six Sigma Error Proofing Tools for Transactions

Six Sigma is an improvement methodology that is used widely in transactional services. The three main tools used for error proofing in transactional services are:

Brainstorming, Cause & Effect Diagram & Matrix, and Failure Modes and Effects Analysis (FMEA).

2.3.3.1-Brainstorming

Brainstorming is a tool that is widely used by many different corporations in order to identify problems, find solutions for problems, and identify opportunities for improvement. Brainstorming was created by Alex F. Osborne in 1941 while he was searching for creative ideas and in doing so had an unstructured group process of interactive "brain-storming" (Michalski, 2003). When there is a group of individuals in a room verbalizing their ideas there is more discussion regarding each individual's ideas, hopefully generating more ideas. Brainstorming is like the old saying "two heads are better than one." Brainstorming is used by many different transactional industries in a variety of ways. Brainstorming is used to identify problems that are occurring and to identify ways to solve these problems, which ultimately is error proofing the process.

Brainstorming is also used to identify opportunities for improvement. Brainstorming is typically used to: "unlock the creativity in teams, generate a large list of ideas for problem solving or a list of problem areas for decision making or planning, develop creative alternative solutions, identify improvement opportunities" (Michalski, 2003). When a team brainstorms they are encouraged to discuss any idea that they have even if that idea seems crazy; which allows a team to think outside of the box and hopefully to identify all of the problems that could occur.

2.3.3.2-Cause & Effect Diagram & Matrix

In a Six Sigma Project one of the first things that is done is to collect a voice of the customer (VOC) and create a list of CTQ's (Critical to Quality Characteristics). There are many different methods to collect the voice of the customer. One of the most common ways is to survey the customer regarding the product that is being created or improved. The CTQ's are things that are identified as being critical to the quality of the project. CTQ's will be measured throughout the project to ensure that the project is succeeding. For example if there was a Six Sigma project being conducted on improving the printing process of airline tickets then a CTQ for that project would be printed airline ticket errors (Gitlow & Levine, 2005). There are two tools that are used for identifying the possible causes of variations of the CTQ's in a project and the causes of these variations: the Cause and Effect Diagram and the Cause and Effect Matrix. A Cause and Effect Diagram is used when there is only one CTQ for a project while a Cause and Effect Matrix is used when there are multiple CTQ's for a project (Gitlow & Levine, 2005).

A Cause and Effect Diagram is used to help a team identify all of the possible sources of variation and the causes of the variation for a single CTQ. The data for a cause and effect diagram can come from two different sources: a brainstorming session or a flowchart (Gitlow & Levine, 2005). A team will use a fishbone diagram (see figure 2.2) to document the causes and effects. The CTQ will be placed at the front of the diagram, in the area that says problem. There are many different categories that are used for the different bones of the diagram. The most common categories are: people, methods, materials, equipment, measurement, and environment. Going back to the example mentioned earlier; the categories for that CTQ of "printed airline ticket errors" would be: method (printing), material (ticket stock), personnel, and machine (Gitlow & Levine, 2005). These categories will vary depending on the project and CTQ being analyzed. Teams will then think about the CTQ and determine what are the potential causes of the errors that could occur within each category. For the example used earlier of "printed airline ticket errors" some of the causes of errors that could occur under the category Method (Printing) are: quality of the printing and the speed of the printing (Gitlow & Levine, 2005). A Cause and Effect Diagram is a tool used in the determination of what failures could occur in a process along with the potential causes. Once the causes of a failure are identified then it is much easier to keep these failures from occurring. (Gitlow & Levine, 2005)

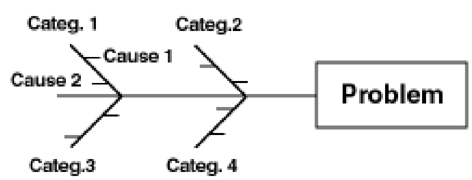


Figure 2.2- Cause and Effect Diagram (*Cause-and-effect diagram.*1998)

A Cause and Effect Matrix is used for multiple CTQ's to organize the possible sources of variation and the causes of the variation simultaneously. There are two sources in which the data for a Cause and Effect Matrix can be discovered: 1) a brainstorming session 2) a flowchart. In a Cause and Effect Matrix the CTQ's are listed on the left in a column while the weights of the CTQ's are listed directly to the right of each CTQ. The weights of each CTQ are determined in the define phase of the project by using the voice of the customer. The weights of each CTQ are defined between 0 and 1 with the sum of all the weights equal to one. The most probable causes of each of the CTQ's are listed horizontally (see Table 2.2). The relationship between each cause (X) and each CTQ are then determined by the team using the scale below in Table 2.1.

Table 2.1- C&E Matrix Relationship between X's and CTQ's
(Gitlow & Levine, 2005)

Score	Definition
9	Strong Relationship (Positive or Negative)
3	Moderate Relationship (Positive or Negative)
1	Weak Relationship (Positive or Negative)
0	No Relationship (Blank Cell)

After each of the X's are given relationship scores then the weighted averages are calculated for each X using the weight associated with each CTQ and the relationship score that was given between a certain CTQ and a certain factor. The X's with the highest weighted averages are viewed as the important X's for all of the CTQ's. It is also important to look at any blank cells, where the relationship was zero, to determine if that X can be eliminated. If an X does not have a relationship with some of the CTQ's then it is important to see if that X can be eliminated to reduce the complexity of the model. The Cause and Effect Matrix is a good tool to determine the important X's for all of the CTQ's in a project. If the causes of failures can be determined then it is easier to keep these errors from occurring in a process. (Gitlow & Levine, 2005)

Table 2.2- Cause and Effect Matrix (Gitlow & Levine, 2005)

			Xs			
		Weights	**X1**	**X2**	....	**Xm**
CTQ	CTQ1	W1	9	3		
	CTQ2	W2		1		
	CTQ11	W11				
Weighted averages						

2.3.3.3-Failure Mode and Effects Analysis (FMEA)

In many industries, companies would wait for a failure to occur and then they would take the necessary actions to keep that failure from occurring again. Other corporations would try to anticipate a failure, but there was not a tool for this purpose. Until the FMEA tool was developed, there was no structured way for corporations to determine failures before they occur. A FMEA can be described as a tool that intends to: identify a potential failure and the effects of that failure, recognize actions that can be taken to eliminate that failure, and document all of this information.

The automotive industry relies heavily on FMEA's to prevent defects from occurring in their parts and assemble products. Along with the design and process FMEA's that are required by the automotive industry there are also many other types of FMEA's that are used within a variety of industries (Lange, Leggett, & Baker, 2001). A few of these different types of FMEA's are System FMEA's, Concept FMEA's, and Machine FMEA's (Seastrunk, 2005). Throughout history the FMEA has been a tool that has been utilized by many different corporations and organizations to reduce failures.

2.4 Tools and Models Used for Error Proofing

There were three main concepts that were used to develop the error proofing model for transactions. The three main error proofing concepts that were utilized were: FMEA, TRIZ Solution Directions, and the Error Proofing Healthcare (EPH) Model. Parts of each of these three error proofing concepts will be used to create the Error Proofing Transaction (EPT) model.

2.4.1 FMEA

The FMEA is a tool that is best completed by a group and not an individual. Each team member needs to be familiar with the process that is being analyzed. An example of an FMEA worksheet that can be referred to as the FMEA process is pictured below in Figure 2.3.

FMEA Worksheet

System:	FMEA Number:
Subsystem:	Page of
Project Leader:	Prepared By:
Core Team:	FMEA Date: Orig. Rev.

											Action Results				
Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	SEV	Potential Cause(s)/ Mechanism(s) of Failure	PROB	Current Design/ Process Controls	DET	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Action(s) Taken	w Sev	New Prob	New Det	New RPN
			0		0		0	0							0

Figure 2.3- FMEA Worksheet (Seastrunk, 2005)

The first step of the FMEA is to create a process map which is a drawing that depicts the flow of a process. Figure 2.4 is an example of what a process map would look like for the process of receiving a loan.

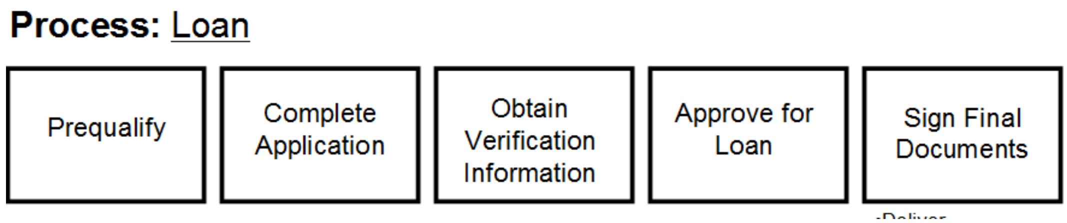


Figure 2.4- Simple Process Map

Each of the events that occurs, like "Prequalify", are called high level process steps. There are many different levels of depth that an organization can go into with a process map. Sub-process steps can be created for each high level process step. It is important to have the right amount of detail so that all of the potential failures in that process step can be identified.

After creating a process map, each of the process steps is listed in the "Item/Function" Column of the FMEA worksheet. Then, the first process step will be analyzed to identify the potential failures that could occur where each process step can have multiple failures. For example, a process step that was listed in Figure 2.2 was "Approve for Loan". For this process step, one of the potential failures could be that a "loan that should not be approved is approved". The potential failures for each process step will be listed in the "Potential Failure Mode(s)" column of the FMEA worksheet. Each potential failure mode will be listed beside the corresponding process step. After listing all of the failures that could occur for the first process step, the effects of each of the failure will be determined. There can also be multiple effects for each of the failures. For example, an effect of the failure of "loan that should not be approved is approved" could be "regulatory violations". These effects will be listed beside their corresponding failure mode in the column that is labeled "Potential Effect(s) of Failure." After listing the potential failures and effects for the first process step the severity of each failure is determined where the worst severity score is a ten. Table 2.3, defines each of the severity scores. The severity score will be placed beside the corresponding failure in the "SEV" column in the FMEA worksheet.

Table 2.3- Severity Table (Curtis, 2002)

Hazardous without warning	Very high severity ranking when a potential failure mode effects safe system operation without warning	10
Hazardous with warning	Very high severity ranking when a potential failure mode affects safe system operation without warning	9
Very High	System inoperable with destructive failure without compromising safety	8
High	System inoperable with equipment damage	7
Moderate	System inoperable with minor damage	6
Low	System inoperable without damage	5
Very Low	System operable with significant degradation of performance	4
Minor	System operable with some degradation of performance	3
Very Minor	System operable with minimal interference	2
None	No effect	1

After the severity score is determined for the failures of the first process step the next step is to brainstorm the potential causes for the failures. Using the failure of "loan that should not be approved is approved" a potential cause of this failure could be lack of associate knowledge. A cause will be listed for each failure mode in the "Potential Cause(s)/Mechanism(s) of Failure" column in the FMEA worksheet. After the causes are placed in the FMEA worksheet, the next step is for the team to score how likely it is for each failure to occur. In Table 2.4 the definitions for each score is given. The worst probability score is a probability score of 10. There is also a failure probability which shows a ratio of how many defective parts would constitute a certain score. The probability score will be placed beside the corresponding failure in the "PROB" column of the FMEA worksheet.

Table 2.4- Probability Table (Curtis, 2002)

Very High: Failure is almost inevitable	>1 in 2	10
	1 in 3	9
High: Repeated failures	1 in 8	8
	1 in 20	7
Moderate: Occasional failures	1 in 80	6
	1 in 400	5
	1 in 2,000	4
Low: Relatively few failures	1 in 15,000	3
	1 in 150,000	2
Remote: Failure is unlikely	<1 in 1,500,000	1

After the probability score is given for each failure for the first process step then the current process controls to keep the failure from occurring are listed. The current process controls are mechanisms that are in place to prevent a failure from occurring. In using the failure of "loan that should not be approved is approved" a current process control could be a second person reviews the loan. All of the current process controls are listed beside each of the corresponding failures in the "Current Design/Process Controls" column in the FMEA worksheet. After all of the current process controls are listed for the failures of the first process step then the detection score is determined. The detection score is a score that rates how likely it is that a certain failure will be detected before it occurs where the worst detection score is ten. All of the Definitions for each of the scores are given in Table 2.5. The detection score will be placed beside the corresponding failure in the "DET" column of the FMEA worksheet.

Table 2.5- Detection Table (Curtis, 2002)

Absolute Uncertainty	Design control cannot detect potential cause/mechanism and subsequent failure mode	10
Very Remote	very remote change the design control will detect potential cause/mechanism and subsequent failure mode	9
Remote: Failure is unlikely	Remote chance the design control will detect potential cause/mechanism and subsequent failure mode	8
Very Low	Very low chance the design control will detect potential cause/mechanism and subsequent failure mode	7
Low	Low chance the design control will detect potential cause/mechanism and subsequent failure mode	6
Moderate	Moderate chance the design control will detect potential cause/mechanism and subsequent failure mode	5
Moderately High	Moderately High change the design control will detect potential cause/mechanism and subsequent failure mode	4
High	High chance the design control will detect potential cause/mechanism and subsequent failure mode	3
Very High	Very high chance the design control will detect potential cause/mechanism and subsequent failure mode	2
Almost Certain	Design control will detect potential cause/mechanism and subsequent failure mode	1

After each failure is given a detection score, the team calculates the Risk Priority Number (RPN) by multiplying the Severity *Score x Probability Score x Detection Score.* So, the worst RPN number that a failure could have is: 10x10x10=1,000. The RPN is calculated for each of the failures and is listed beside the corresponding scores in the "RPN" column in the FMEA worksheet. The team will then determine the potential failure modes, effects, severity score, causes, occurrence score, controls, and detection score for the remaining process step using the same procedure.

After the RPN is calculated for all of the potential failure modes for each process step, the high risk failure modes will be determined based on the RPN. Usually the company will have a set cut off value for the RPN. For example a company or team could determine that all RPN's greater than 150 are deemed high risk potential failures. After all of the high risk failures are determined then the recommended actions that need to be taken to mitigate this failure are listed. These actions are listed beside the corresponding failure in the "Recommended Action(s)" column in the FMEA worksheet. After all of the recommended actions are listed for the high risk failures then each of these actions will be assigned to a person to complete along with a completion date. The person that is assigned the high risk failure as well as the completion date are listed beside the corresponding action in the "Responsibility & Target Completion Date" column in the FMEA Worksheet. After this high risk failure is assigned to an individual then that particular FMEA session is complete. However, after all of the completion dates have passed the same team meets again to determine if the recommended actions are helping to control the high risk failures. The team will use the same FMEA as before.

Each of the high risk failures will be listed and actions that were taken to mitigate that particular failure. These actions will be listed beside the corresponding failure in the "Action(s) Taken" column in the FMEA Worksheet. After listing the actions taken the new probability and new detection scores will be determined while taking into account the actions that were taken. The same tables and definitions as before will be used to determine the correct score. The new scores will be placed beside the corresponding actions in the "New PROB" and "New DET" columns in the FMEA worksheet. After re-scoring each of these failures then a new RPN will be calculated. This RPN is calculated the same way as before, by multiplying the Severity by the Probability and then by the Detection. The new RPN's will be placed beside the corresponding scores in the "New RPN" column in the FMEA worksheet. In comparing the old RPN score and the new RPN score a team can determine whether or not the recommended actions did help to mitigate the high risk failures.

2.4.2 Theory of Inventive Problem Solving (TRIZ)

As part of the FMEA, solutions have to be generated for high risk failures. TRIZ is a problem solving methodology with many solution principles that were created by in depth research on different problems and the solutions that were generated for them. This research was done by Genrich Altshuller and several of his students in the 1940's. Altshuller was a patent clerk and he noticed that only a few types of solutions were being developed across all fields of work (Althshuller, 1984). Altshuller was also able to determine that the "engineering system is not a random event but is governed by certain parameters (Terninko, 1998)." After conducting this research Althshuller realized that creativity can be taught. The goal of all of this research that Altshuller and his students conducted was to help direct the mind outside of the normal realm of thinking (Fey, 1997). Altshuller's major solution generation techniques can be seen below in Table 2.6.

Table 2.6- TRIZ Methods (Terninko, 1998)

Levels of Innovation
Contradictions
40 Inventive Principles
39 Engineering Parameters
Four Separation Principles
Ideality
76 Standard Solutions
Patterns of Evolution
ARIZ (Algorithm of Inventive Problem Solving
Substance-Field Analysis

The 40 Inventive Principles that Altshuller created can help to generate proven solutions. The principles will help to direct the mind a known direction and allow for more solutions to be generated. The 40 Inventive Principles will help to generate innovative solutions.

2.4.3 Error Proofing Healthcare (EPH) Model

A new model was needed in healthcare because it is a complex and tightly knit system that is prone to errors. The current model used in healthcare, the FMEA, was not keeping errors from occurring. At North Carolina State University, an all-encompassing and systematic algorithm was developed to reduce errors in healthcare in a three-phase approach. The steps include identifying the errors, generating solutions from error proofing principles, and evaluating and selecting the best solution (Seastrunk, 2005). This approach utilizes the Healthcare Failure Mode Effects Analysis (HFMEA) in the first step but greatly expands upon it and leads to more effective and successful solutions in the end. In addition, this method was created to stimulate and guide a team's thinking when analyzing error-prone processes. There are three main phases of the EPH: HFMEA, solution generation, and solution prioritization (Seastrunk, 2005).

2.4.3.1-Phase 1: HFMEA

A traditional HFMEA is performed during the first phase. A detailed process map highlighting potential failure modes with the aid of predefined generalized sub-processes and failure modes is completed first. The list of generalized sub-processes and failure modes can be seen in Figures 1 and 2 in Appendix I respectively and have been developed from research in healthcare and are specific to the industry.

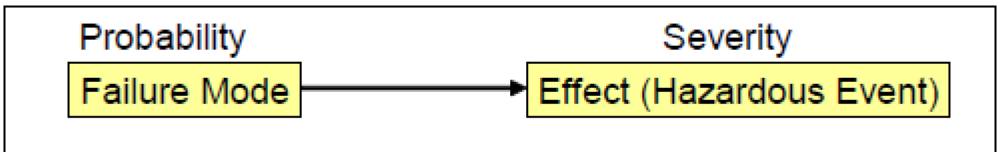
The identified failure modes are then evaluated on a scale from one to four on their occurrence and severity. Table 2.7 depicts an example of the patient outcome table for severity and in Table 2.8 the occurrence rating is shown. The hazard score is calculated by multiplying the probability and severity where high scores are considered risky. The hazard score is then examined using the Hazard Scoring Matrix for the HFMEA and is shown in Figure 2.5. (Seastrunk, 2005)

Table 2.7- HFMEA Severity Rating for Patient Outcomes (DeRosier et al., 2002)

Score	Description
1	***Minor*** **patient outcome: No injury, nor increased length of stay, nor increased level of care**
2	***Moderate*** **patient outcome: Increased length of stay or increased level of care for 1 to 2 patients**
3	***Major*** **patient outcome: Permanent lessening of bodily functioning, disfigurement, surgical intervention required, increased length of stay for 3 or more days, increase level of care for 3 or more patients**
4	***Catastrophic*** **patient outcome: death or major permanent loss of function, suicide, rape, hemolytic transfusion reaction, surgery/procedure on the wrong patient or wrong part of body, infant abduction or discharge to wrong family**

Table 2.8- HFMEA Occurrence Rating for Patient Outcomes (DeRosier et al., 2002)

Score	Description
1	***Remote*****: Unlikely to occur (may happen sometime in 5 to 30 years)**
2	***Uncommon*****: Possible to occur (may happen sometime in 2 to 5 years)**
3	***Occasional*****: Probably will occur (may happen several times in 1 to 2 years)**
4	***Frequent*****: Likely to occur immediately or within a short period (may happen several times in one year)**



Probability of Failure Mode	Severity of Effect			
	Catastrophic (4)	*Major* (3)	*Moderate* (2)	*Minor* (1)
Frequent (4)	16	12	8	4
Occasional (3)	12	9	6	3
Uncommon (2)	8	6	4	2
Remote (1)	4	3	2	1

Figure 2.5- Hazard Scoring Matrix (DeRosier et al., 2002)

Next a Decision Tree (i.e. an additional tool used when completing the hazard analysis) is employed. For the decision tree analysis, hazard scores that are greater than eight require three questions: “1) is the failure mode a single point weakness?; 2) is there an existing control measure?; 3) is this detectable?” (Seastrunk, 2005). The decision tree analysis is shown below in Figure 2.6. Each organization will have a different scale for determining which failure modes to apply decision tree analysis (Seastrunk, 2005). Some organizations will use all of the failures that have a severity of four while other will focus on failures that have a hazard score of eight or greater. What failures are included will be determined from the size and the scope of the project (Seastrunk, 2005). All of the failure modes with a Hazard Score greater than eight will be analyzed using the Decision Tree in Figure 2.6. The failure modes that made it to the box “PROCEED TO Phase Two” will go to the second phase of the EPH model, which is generate solutions (Seastrunk, 2005). See Figure 3 in Appendix I for the detailed worksheet completed during the first phase (Seastrunk, 2005).

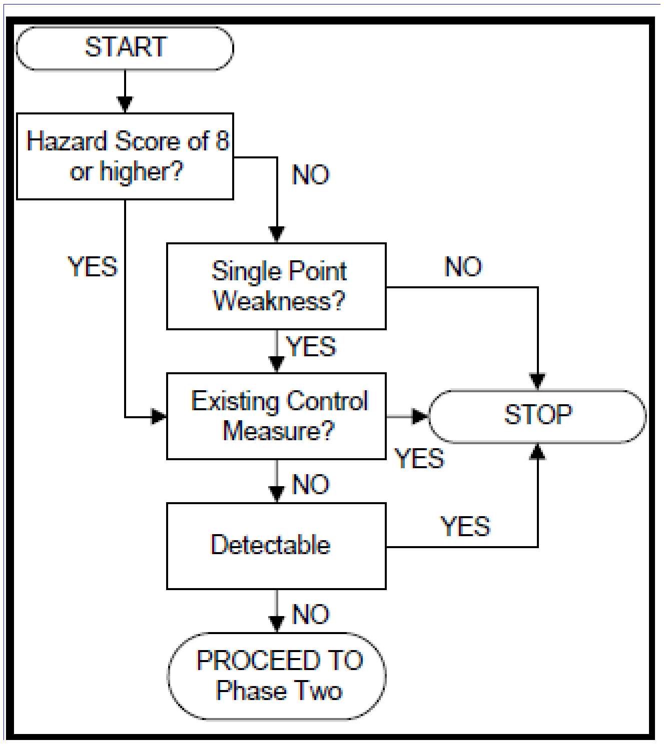
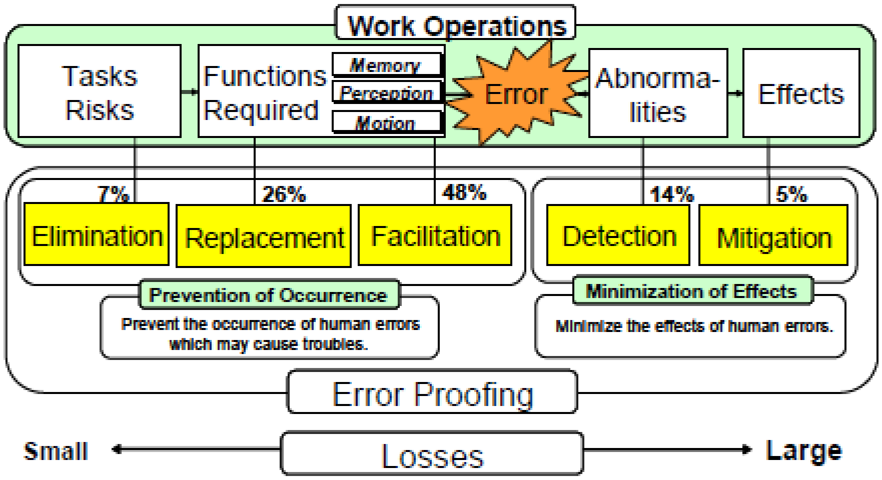


Figure 2.6- Decision Tree Analysis (DeRosier et al., 2002)

2.4.3.2-Phase 2: Solution Generation

The second phase after the identification of potential errors is to generate solutions from error proofing principles and proven solution directions. The five error proofing principles (Elimination, Replacement, Facilitation, Detection, and Mitigation) were identified by researchers after looking at more than 1000 solutions and categorizing them into these five major groups. Figure 2.7 overviews these five error proofing principles (Seastrunk, 2005). The first three principles are to be taken in order to keep a failure from occurring in the first phase while the last two principles are used after a failure has occurred.



Note: The percentage indicates the ratio of examples corresponding to each principle in healthcare.

Figure 2.7- Error Proofing Principles (Seastrunk, 2005)

In addition to the error proofing principles, Theory of Inventive Problem Solving (TRIZ) theory is utilized in this phase to help guide the team towards proven solution directions across industries and expand their thinking towards innovative solutions. The solution principles that were created by Altshuller have a direct correlation to the five error proofing principles mentioned above. The EPH model contains specific questions that relate to the TRIZ solution directions that were created for healthcare. These questions are to aid a team in generating solutions; as seen in Figure 2.8 (Seastrunk, 2005).

Principles	Question
Eliminate Tasks/Risks	Trimming - Can we eliminate the error-prone process or harmful objects?
	Self Elimination - Can the harmful action or object eliminate itself?
	Prior Action - Can we do something beforehand to eliminate the error-prone process or harmful objects?
Replace Error-Prone Human Operations	Automation (Automatic Inspection) - Can we automate the process to solve our problem?
	Prior Action - Can we do something beforehand to support human operations?
	Combining - Can we combine (bring together/closer) two or more things to automate or support human operations?
Facilitate Human Operations	Trimming - Can we trim similar or confusing things to facilitate human operations?
	Standardization - Can we standardize the process to facilitate human operations?
	Copying - Can we use redundancy to facilitate human operations?

Figure 2.8- Solution Generation Questions (Seastrunk, 2005)

2.4.3.3-Phase 3: Solution Prioritization

The third and final phase involves the evaluation and selection of the best error proofing solutions to effectively eliminate the failure mode. A new tool was to evaluate solutions by using the Solution Priority Number (SPN). The SPN takes into account things that are important to the healthcare industry when choosing a solution. These things are “how much will it cost, how difficult will it be to implement, and how effective will it be” (Seastrunk, 2005). The effectiveness, cost, and implementation are evaluated on a scale from one to three and multiplied together to form the solution priority number (SPN), where high scores represent a solution which is effective, cheap, and easy to implement. The scoring for each of these parameters can be seen in Tables 2.9, 2.10, and 2.11.

Table 2.9- Effectiveness Scoring (Seastrunk, 2005)

Score	Definition
3	**Very Effective**: *Probability* can be eliminated and reduced to 1, or *Control Measure* or *Detectability* can be changed to “Yes.”
2	**Effective**: *Probability* can be reduced; however, *Hazard score* is still more than 8, and *Control Measure* and *Detectability* remain to be “No.”
1	**Ineffective**: *Probability* can not be reduced, and *Control Measure* and *Detectability* remain to be “No.”

Table 2.10- Cost Scoring (Seastrunk, 2005)

Score	Definition
3	**Low**: Within daily operation budget. No specific budget is needed.
2	**Moderate**: Unit level budget is needed.
1	**High**: Hospital level budget is needed.

Table 2.11- Implementation Scoring (Seastrunk, 2005)

Score	Definition
3	**Easy**: No training is needed. No resistance is expected.
2	**Moderate**: Training course is needed. Some resistance is expected.
1	**Difficult**: Culture change is needed. Strong resistance is expected.

This allows for the best solutions to be chosen to implement. A perfect SPN would be a 27 (i.e. 3 on effectiveness score times 3 on cost score times 3 on implementation score). Solutions with high SPN scores are implemented first because of their higher chance for success. The solutions that are chosen for implementation will have an action plan created which will include the associate who is responsible for implementation and a target date for when the implementation should be completed. The EPH model encourages teams to think about all the solutions that were generated because some solutions may eliminate multiple failures, while other failures may require multiple solutions. This new way of evaluating solutions allows for teams to consistently select the best solution (Seastrunk, 2005).

Chapter III- Error Proofing Transaction Model (EPT)

The FMEA which is current tool used to prevent errors from occurring in transactions is not sufficient for identifying all potential errors and requires lots of time. The FMEA does not contain a sufficient way to generate and select the best solutions. A new tool is needed for transactions that will identify more potential errors, generate effective solutions, and contain a set way to choose the best solution. A new model for transactions was developed using the Error Proofing Healthcare Model (EPH) as the starting point to develop the Error Proofing Transactions (EPT) model.

A team of six individuals in a large banking organization worked on modifying the EPH model to fit transactional services. The team was comprised of vice presidents, managers, and associates. Each member of the team was very familiar with the FMEA, which was the current error proofing process being employed and became familiar with the EPH model.

The new EPT model for transactional services is comprised of three phases. The first phase will be similar to the FMEA that is currently used and will be called the "Transactional Failure Mode and Effects Analysis" (TFMEA), the second phase will be the "Solution Generation" phase that will utilize TRIZ methodology to generate many possible solutions, and the third phase is the "Solution Evaluation" phase that provides a framework for developing an action plan for implementing solutions.

3.1 Phase 1: Transactional Failure Mode and Effects Analysis (TFMEA)

The current state of developing FMEAs in transactional processes within companies was analyzed. Multiple FMEA sessions were observed and the many issues were noted. A simple survey seen in Table 3.1 was given to many different associates asking what issues were encountered with the current FMEA process. The team members obtained greater detail when administering the survey in person which maximized responses received. Many issues were identified with the current FMEA when used in transactional services. These issues along with the HFMEA model and 250 completed FMEAs in a large banking company were analyzed to assist in developing the new TFMEA. Changes inthe format of the FMEA were the generation of the generalized sub-process steps, the failure modes, the causes, as well as the removal of the detection score.

Table 3.1- Simple Survey Questions

Questions	Number of Indivudals Surveyed	Yes	No
Think about the process step identified, are all of the potential failure modes identified?	25	25	0
Think about the process step identified, are all of the potential effects identified?	25	25	0
Think about the process step identified, are all of the potential causes identified?	25	25	0
Are the sub process steps, failure modes, effects, and causes representative?	25	25	0

3.1.1 Format of the Existing FMEA

The format of FMEA will be utilized in the TFMEA for identifying failures, because the FMEA is widely used and associates are familiar with the FMEA process. The FMEA that was being utilized had previously been modified to fit this corporation by changing the following.

1) The rating scale for severity, occurrence, and detection

2) The terminology that was used.

The rating scale for the FMEA was changed to be on a scale of one to five for severity, occurrence, and detection. The scale was changed to minimize discrepancy on ratings between team members. Any risk priority number (RPN) that scored above a "cut-off" number of 27 was a failure mode for action. The FMEA terminology was modified to focus on the customer rather than the typical manufacturing floor. The explanations of what was to be input into each cell were tailored to transactional services. The ratings scales for severity, occurrence, and detection were created with emphasis on the customer and the impact to the customer. These ratings scales can be seen below in Table 3.2.

Table 3.2- Severity, Occurrence, and Detection

Severity Score	Severity Definition
5	Customer will be Lost
4	Very likely that the Customer will be dissatisfied and their business will be lost
3	Customer will be affected and their business could potentially be lost
2	Customer is not likely to notice or be affected
1	No effect

Occurrence Score	Occurrence Definition
5	Failure Almost Always Occurs
4	Failure Occurs Repeatedly
3	Failure Occurs Occasionally
2	Failure Occurs Only a Few Times
1	Failure is Unlikely to Occur

Detection Score	Detection Definition
5	Little to No Chance of Detection
4	Very Low Chance of Detection
3	Moderate Chance of Detection
2	High Chance of Detection
1	Almost Certain Detection

One of the issues noted while observing the traditional FMEA sessions was that each team would conduct the FMEA in a different manner. Some teams would list all of the potential failure modes first and then list all of the effects. Other teams would list the potential failure modes for one process step and then list the effects. In order to assure that each team was conducting the TFMEA in the same manner a more structured approach was created by generating a list of steps. These steps are listed below and are embedded in the electronic spreadsheet describing the TFMEA.

1) Start with the tab labeled "1.)TFMEA"
2) Input all of the process steps from the Process Map and start with the first process step.

3) Determine all of the failures that could occur for the current process step, use the generalized failure modes that can be found in the worksheet titled "Generalized Functions & Failure." Note: These failure modes are just to assist you in thinking of all of the potential failure modes.
4) Determine all of the effects of failures for the current process step, use the generalized effects that can be found in the worksheet titled "Generalized Functions & Failure." Note: These effects are just to assist you in thinking of all of the potential effects.
5) Determine the severity of the failures for the current process step occurring. Use the rating scale that is located in the embedded comment in that cell. Note: To see the comment place your mouse over the red triangle in the top right corner.
6) Determine all of the causes of each failure for the current process step by using the generalized causes that can be found in the worksheet titled "Generalized Functions & Failure." Note: These causes are just to assist you in thinking of all of the potential causes.
7) Determine the occurrence of the failures for the current process step occurring. Use the rating scale that is located in the embedded comment in that cell. Note: To see the comment place your mouse over the red triangle in the top right corner.
8) The RPN will be automatically be calculated.
9) Repeat Steps 3-8 for each sub-process.
10) All of the failures with an RPN greater than or equal to ten will be deemed high risk.

11) Copy all of these high risk failure modes and paste them into the worksheet title "2.) Solutions and Scoring"

12) For each of the high risk failures, the team needs to think about potential solutions. In order to help with brainstorming potential solutions please look at the worksheet labeled "TRIZ" and consider each of the solution directions listed and ask the team the questions that are listed for each solution direction.

13) After each of the solutions are listed you need to determine the cost of the failure occurring. To assist with the cost determination, use the section of that worksheet titled "Costs to Consider When Determining the Cost of an Failure Occurring." Which should help to account for all costs. Note: This cost is an annual cost.

14) Determine the percent of the time that the solution will keep the error from occurring. Use the rating scale that is located in the embedded comment in that cell. Note: To see the comment place your mouse over the red triangle in the top right corner.

15) Determine the cost of implementation. Again the section below titled "Costs to Consider When Determining the Cost of an Failure Occurring" can be used to account for all of the costs.

16) The return on investment (ROI) will automatically be populated.

17) The number of months to breakeven will automatically populate as well.

18) Determine the ROI score. Use the rating scale that is located in the embedded comment in that cell. Note: To see the comment place your mouse over the red triangle in the top right corner.

19) Determine the ease of implementation score. Again, the rating scale that is located in the embedded comment in that cell. Note: To see the comment place your mouse over the red triangle in the top right corner.

20) The SPN will automatically update where the best solutions are the solutions with the highest score.

21) The solutions that are chosen for implementation should have an individual assigned to oversee implementation and a target date of when the implementation should be completed.

3.1.2- Generalized Sub-Process, Failure Modes, Effects, and Causes

When conducting a TFMEA high level process steps must be identified where three to five steps is typical. After these high level process steps are generated then the sub-process steps, failure modes, effects, and causes can be determined. Two of the issues that were identified in the existing FMEAs were the following.

1) The amount of time required to generate sub-process steps, failure modes, effects, and causes.
2) The problem of overlooking or missing important failure modes.

To help alleviate the two previous issues the HFMEA approach was taken. In utilizing the HFMEA format, generalized sub-processes, failure modes, effects, and causes were generated. To create these generalized sub-processes, failure modes, effects, and causes for transactional services 250 FMEAs were extracted and analyzed. Also, feedback from many associates was utilized in creating the generalized sub-process, failure modes, effects, and causes. There were a total of ten high level sub-processes that were determined for transactional services as seen in Table 3.3.

Table 3.3- Generalized Sub-processes

Decision
Authentication
Review/Approve
Transcription
Report
Develop/Build/Maintain
Deliver Product/Service to Customer
Monitor/Oversee/QA
Communicate
Gather Requirements from Customers

Each of the original sub-process steps, in the 250 FMEA's, were replaced with the corresponding generalized sub-processes. These high level sub-process steps were reviewed with multiple associates to obtain their feedback. The associates felt that the list of generalized sub-process steps was representative and are now being used.

As was done with the sub-processes the failure modes from the 250 FMEA's were analyzed. All of the failure modes under each of the generalized process steps were reviewed and categorized into high level failure modes. A list of generalized failure modes was then created for each generalized sub-process step. The failure modes for each sub-process step are different. The generalized failure modes can be seen below in Table 3.5.

Each of the original failure modes were replaced with the corresponding generalized failure mode. Like the sub-processes, the generalized failure modes were verified by multiple associates to obtain their feedback. The associates felt that the list of generalized failure modes was representative. These generalized failure modes will assist in determining all of the potential failure modes that could occur within a sub-process step and decrease the amount of time required for this step.

Next, the effects from the 250 FMEA's were analyzed and categorized to create ten generalized effects, seen in Table 3.4. Unlike the failure modes, these effects could relate to any failure mode within any sub-process step.

Table 3.4- Generalized Effects

Loss of Sale
Loss of Existing Customer
Rework
Negative Customer Experience
Refulatory Violations
Reputation Damage
Incur Extra Expense
Can't Measure Success
Unable to Execute Business Strategy
Uncompensated Risk Exposure

These ten generalized effects were validated to be representative by multiple associates. These generalized effects will assist in determining all of the effects of each potential failure mode and decrease the amount of time required for this step.

All of the causes from the 250 FMEA's under each of the generalized failure modes were grouped together to create high level causes. A list of generalized causes was created for each potential failure mode. The generalized causes can be seen below in Table 3.5. Each of the original causes was replaced with the corresponding generalized cause and duplicates were removed.

The generalized sub-processes, failures modes, effects, and causes were assembled in a Excel worksheet that can be utilized when conducting the TFMEA to facilitate efficiency. The failure modes are grouped by generalized sub-process steps and the causes are grouped by generalized failure modes while the effects, since they relate to all failure modes, are listed separately in the worksheet. The worksheet was designed so that when a generalized sub-process step is selected only the generalized failure modes for that sub-process step will appear. When a generalized failure mode is selected only the causes for that failure mode will appear. A small part of the worksheet can be seen below in Table 3.5 and the generalized effects can be seen below in Table 3.6. The entire worksheet can be seen in Appendix I in Figure 4.

Table 3.5- Generalized Sub-process Steps, Failure Modes, and Causes

Please Choose a Similar Process Step or Function	Failure Modes	Causes
Decision	**Decision was Yes when it should have been No**	Inaccurate Data
Decision		Lack of Associate Knowledge
Decision	**Decision was No when it should have been Yes**	Inaccurate Data
Decision		Lack of Associate Knowledge
Decision	**Decision not made at all**	Non-Adherence to Policies and Procedures
Decision		Lack of Associate Knowledge
Decision		Resource Constraint
Decision		Roles and Responsibilities are not defined
Decision	**Decision made later than required**	Non-Adherence to Policies and Procedures
Decision		Lack of Associate Knowledge
Decision		Resource Constraint
Decision		Inadequate Information Provided

Table 3.5 (Continued)

Authentication	**Fail to authenticate**	Lack of Associate Knowledge
Authentication		Non-Adherence to Policies and Procedures
Authentication		Communication Gap
Authentication		Roles and Responsibilities are not clearly defined
Authentication		Insufficient Information
Authentication	**Authenticate someone who should not have access**	Lack of Associate Knowledge
Authentication		Non-Adherence to Policies and Procedures
Authentication	**Fail to authenticate someone who should have access**	Insufficient Policies and Procedures
Authentication	**Take too long to authenticate**	System Limitations
Authentication		Lack of Associate Knowledge
Authentication		Insufficient/Unavailable Data
Review/Approve	**Review not performed**	Lack of Associate Knowledge
Review/Approve		Non-Adherence to Policies and Procedures
Review/Approve		Resource Constraint
Review/Approve	**Approval beyond your authority to approve**	Inadequate Policies and Procedures
Review/Approve		Lack of Associate Knowledge
Review/Approve		Non-Adherence to Policies and Procedures
Review/Approve	**Approval when correct decision would have been rejection**	Lack of Associate Knowledge
Review/Approve		Mis-Interpret data
Review/Approve		Inaccurate Data provided
Review/Approve		Inadequate Policies and Procedures
Review/Approve	**Rejection when correct decision would have been approval**	Non-Adherence to Policies and Procedures
Review/Approve		Lack of Associate Knowledge
Review/Approve		Inaccurate/Insufficient Data provided
Review/Approve	**Takes too long to review**	Inadequate Polices and Procedures
Review/Approve		Resource/Workload Constraint
Review/Approve		System Limitations
Review/Approve		Non-Adherence to Policies and Procedures
Review/Approve	**Review not thoroughly executed**	Lack of Associate Knowledge
Review/Approve		Non-Adherence to Policies and Procedures
Review/Approve		Inadequate/Insufficient Data provided
Review/Approve	**Review completed and not documented appropriately**	Non-Adherence to Policies and Procedures
Review/Approve		Lack of Associate Knowledge
Review/Approve		System Limitations
Transcription	**Transcribed inaccurately**	Lack of Associate Knowledge
Transcription		Non-Adherence to Policies and Procedures
Transcription		Resource/Workload Constraints
Transcription		Data not entered
Transcription		Data Inaccurately Recorded
Transcription		Non-Data Recorded
Transcription	**Not transcribed in a timely manner**	Lack of Associate Knowledge
Transcription		Non-Adherence to Policies and Procedures
Transcription		System Limitations
Transcription		Inadequate/Undefined Timeline
Transcription		Resource/Workload Constraints
Report	**Reported data is not timely**	Lack of Associate Knowledge; Non-Adherence to Policies and Procedures; Inadequate/Undefined Timeline; Isurfficient/Unavaliable data; Lack of Service Level Agreement
Report		Non-Adherence to Policies and Procedures
Report		Inadequate/Undefined Timeline
Report		Insufficient/Unavailable Data
Report		Lack of Service Level Agreement
Report	**Reported data is not relevant to the operation in question**	Technology Limitations
Report		Lack of Associate Knowledge
Report	**Reported data is relevant to operation in question but not valid**	Technology Limitations
Report		Lack of Associate Knowledge
Report		Insufficient/Unavailable Data
Report	**Reported data is relevant and valid, but is not "enough" data to make decision**	Limited Population
Report		Technology Limitations
Report		Insufficient/Unavailable Data
Report	**Report is not produced**	Non-Adherence to Policies and Procedures
Report		Lack of Associate Knowledge
Report		System Limitations
Report		Non-Adherence to Policies and Procedures
Report		Lack of Service Level Agreement
Report		Insufficient/Unavailable Data

Table 3.5 (Continued)

Develop/Build/Maintain	**Built solution does not work**	Lack of Associate Knowledge
Develop/Build/Maintain		Technology Limitations
Develop/Build/Maintain		Financial Constraints
Develop/Build/Maintain		Inadequate Testing Conducted
Develop/Build/Maintain		Incorrectly Designed
Develop/Build/Maintain	**Built solution does not conform to requirements**	Inadequate Testing conducted
Develop/Build/Maintain		Incorrectly Designed
Develop/Build/Maintain		Technology Limitations
Develop/Build/Maintain		Lack of Associate Knowledge
Develop/Build/Maintain		Lack of Quality Assurance Process
Develop/Build/Maintain	**Built solution does not deliver required customer value**	Incorrectly Designed
Develop/Build/Maintain		Technology Limitations
Develop/Build/Maintain		Financial Constraints
Develop/Build/Maintain		Lack of Associate Knowledge
Develop/Build/Maintain		Lack of Voice of the Customer
Develop/Build/Maintain		Inadequate/Undefined Timeline
Develop/Build/Maintain	**Built solution not delivered in a timely fashion**	Non-Adherence to Policies and Procedures
Develop/Build/Maintain		Technology Limitations
Develop/Build/Maintain		Financial Constraints
Develop/Build/Maintain		Lack of Associate Knowledge
Develop/Build/Maintain		Inadequate/Undefined Timeline
Develop/Build/Maintain		Resource Constraint
Develop/Build/Maintain		Lack of Service Level Agreement
Deliver Product/Service to Customer	**Do not deliver at all**	Non-Adherence to Policies and Procedures
Deliver Product/Service to Customer		Lack of Associate Knowledge
Deliver Product/Service to Customer		Unavailable Product/Service
Deliver Product/Service to Customer	**Do not deliver in a timely fashion per disclosures**	Non-Adherence to Policies and Procedures
Deliver Product/Service to Customer		Lack of Associate Knowledge
Deliver Product/Service to Customer		System Limitations
Deliver Product/Service to Customer		Workload/Resource Constraints
Deliver Product/Service to Customer		Unavailable Product/Service
Deliver Product/Service to Customer		Inadequate/Undefined Timeline
Deliver Product/Service to Customer		Resource/Workload Constraints
Deliver Product/Service to Customer	**Do not deliver product/service customer was expecting**	Non-Adherence to Policies and Procedures
Deliver Product/Service to Customer		Lack of Quality Assurance Process
Deliver Product/Service to Customer	**Do not deliver in a timely fashion per customer expectations**	Lack of Associate Knowledge
Deliver Product/Service to Customer		Clear Expectations not set
Deliver Product/Service to Customer		Inadequate/Undefined Timeline
Deliver Product/Service to Customer		System Limitations
Deliver Product/Service to Customer		Unavailable Product/Service
Deliver Product/Service to Customer		Resource/Workload Constraints
Deliver Product/Service to Customer	**Do not deliver product/service as we promised it**	Non-Adherence to Policies and Procedures
Deliver Product/Service to Customer		System Limitations
Deliver Product/Service to Customer		Lack of Associate Knowledge
Monitor/Oversee/QA	**Monitor the wrong elements**	Lack of Associate Knowledge; Non-Adherence to Policies and Procedures;
Monitor/Oversee/QA		Non-Adherence to Policies and Procedures
Monitor/Oversee/QA	**Method for monitoring does not present an accurate reflection of performance**	Lack of Governance
Monitor/Oversee/QA		Lack of Associate Knowledge
Monitor/Oversee/QA		Inaccurate Sampling Performed
Monitor/Oversee/QA	**Monitor too infrequently to provide feedback**	Inaccurate/Unavailable Statistical Sample
Monitor/Oversee/QA		Lack of Associate knowledge
Monitor/Oversee/QA		System Limitations

Table 3.5 (Continued)

Communicate	**Communicate incorrect information**	Lack of Associate Knowledge
Communicate		Non-Adherence to Policies and Procedures
Communicate		Lack of Customer Knowledge
Communicate	**Communicate incomplete information**	Lack of Associate Knowledge
Communicate		Non-Adherence to Policies and Procedures
Communicate		Lack of Customer Knowledge
Communicate	**Communicate too much information**	Lack of Associate Knowledge; Non-Adherence to Policies and Procedures; Lack of Customer Knowledge
Communicate		Non-Adherence to Policies and Procedures
Communicate		Lack of Customer Knowledge
Communicate	**Take too long to deliver communication**	Non-Adherence to Policies and Procedures
Communicate		Lack of Service Level Agreements
Communicate		Resource Constraints
Communicate	**Communication is unclear**	Lack of Associate Knowledge
Communicate		Lack of Customer Knowledge
Communicate	**Take too long to produce communication**	System Limitations
Communicate		Lack of Associate Knowledge
Communicate		Lack of Standardized Processes
Communicate		Non-Adherence to Policies and Procedures
Communicate		Resource Constraints
Gather requirements from Customers	**Talking to the wrong customers**	Voice of the Customer was access accurately
Gather requirements from Customers		Lack of Associate Knowledge
Gather requirements from Customers		Lack of Customer Knowledge
Gather requirements from Customers	**Mis-interpret customer needs**	Inappropriate Sample Size
Gather requirements from Customers		Lack of Associate Knowledge
Gather requirements from Customers		Communication gap
Gather requirements from Customers	**Not talking to enough customers**	Lack of Associate Knowledge; Inappropriate Sample Size;
Gather requirements from Customers	**Takes too long to gather requirements**	Inadequate Policies and Procedures
Gather requirements from Customers		Lack of Service Level Agreements
Gather requirements from Customers		Lack of Associate Knowledge
Gather requirements from Customers	**Requirements not gathered**	Lack of Associate Knowledge
Gather requirements from Customers		Lack of Governance

Table 3.6- Generalized Effects for all Failure Modes

Standardized Effects for all Failure Modes
Loss of sale
Loss of existing customer
Rework
Negative customer experience
Regulatory violations
Reputation damage
Incur extra expense
Can't measure success (PFP)
Unable to execute business strategy
Uncompensated risk exposure.

3.1.3- Removal of Detection Score

The previous phase helped to facilitate the generation of all the failures modes, the effects, and the causes as well as reducing to complete the task. One of the issues that was noted in prior research conducted by an associate was that the controls used to determine the detection score were not working properly which resulted in the errors still occurring. The 250 FMEA's that had been previously conducted were analyzed to assess the situation. It was found that in some cases the detection score was rated a "1" because the control that was in place was not functioning properly. This would result in this failure not being deemed a failure for error proofing

Research utilizing the 250 previous FMEA's was conducted on the effect if the detection score was removed from the Risk Priority Number (RPN) calculation and if was based only severity and occurrence were used. In order to remove the reliance on the controls in place that may not be working appropriately the team decided to remove the detection score. The controls are still listed so that if any failure mode is deemed a high risk failure mode, then the control that is in place can be reviewed. It can then be determined if the control is keeping the failure from occurring or not.

Multiple RPN "cut-off" numbers were explored if only severity and occurrence were used. It was determined that any failure mode that scored an RPN greater than ten should be a failure mode for error proofing. Using an RPN "cut-off" number of ten and the 250 FMEA's all of the true high risk failure modes would have been identified. By removing the detection score, only the failure modes that required action were identified. Each control for these failure modes was tested to assure that it was working properly.

The amount of time spent on testing was reduced by ten hours per process, resulting in annual potential reduction of 120,000 hours. The reduction of 120,000 hours resulted in monetary saving for the corporation.

3.2 Phase 2: Solution Generation/TRIZ

Conventional solution generation is often limited to an informal form of brainstorming. The list of solutions is generally short and limited by the experience of the team and time available. In applying TRIZ solution directions the number and quality of solutions tend to increase. The Error Proofing Healthcare (EPH) model was utilized to create Phase 2: the Solution Generation section of the EPT model which is new to transactional services. Previously, solutions were generated by informal brainstorming due to the lack of a standardized approach to generate solutions for failure modes. For the EPH model, TRIZ solution directions were researched. Ten solution directions were chosen that related to solutions often generated in healthcare as seem in Table 3.7.

Table 3.7- Solution Directions for EPH

Trimming
Self Elimination
Standardization
Unique Shapes/Geometry
Copying
Prior Action
Flexible Films or Thin Membrances
Color
Combining
Counting
Automation

There was a set of healthcare-related question created for each of the solution directions. Since the approach was successful it was applied to transactional services. For the EPT model, the solutions that were generated in the 250 FMEA's were analyzed. Based on the analysis eleven solution directions were identified see Table 3.8. To further facilitate and assist people in using the eleven solution directions transactional examples were created for each of these solution. Questions were created for each solution direction to be utilized by the team leader during this phase. These questions can be seen below in Table 3.9.

Table 3.8- TRIZ Examples

TRIZ Solution Direction	Transactional Definitions/Example
Preliminary action	Placing pictures on debit cards
Feedback	Reviews of Associates Work
Self-Service	Allowing Customers to Deposit Money and Checks via the ATM
Copying	Training being performed via the internet instead of on-site training
Segmentation	A loan application being completed in steps instead of all at one time.
Local Quality	Having a manger at a bank perform numerous actions such as reviews of the associates at that bank
Merging	The computer completing a required task while the associate is also completing a required task
Automation	Online Banking
Standardization	Developing a List of Procedures that a teller needs to perform in order to complete a certain task
Universality	A bank manager can open accounts and also perform managerial operations
Repetition	An employee completing the same task over and over again in order to increase their proficiency at completing the task

Table 3.9- TRIZ Questions

TRIZ Solution Direction	Questions
Preliminary action	Is there any action that can be performed before this process in order to keep an error from occurring?
Feedback	Is there anyway to introduce some form of feedback into this process in order to eliminate errors?
Self-Service	Is there any part of this process where the service that is being performed can be completed by the "customer"?
Copying	Is there any part of this process that can be replaced an a less expensive copy?
Segmentation	Is there any part of the complex part of the process that can be divided into smaller simpler steps?
Local Quality	Is there any entity in the Local Environment that can perform a quality check?
Merging	Are there any parts of this process that can perform parallel operations?
Automation	Is there any part of this process that can be automated?
Standardization	Is there anyway to standardize this process in order to keep failure from occurring?
Universality	Is there one part of this process that can perform multiple functions that does not currently perform multiple functions?
Repetition	Can any part of this process be repeated multiple times in order to eliminate errors?

The solution directions were tailored for transactional services and helped in generating solutions. The use of solution directions may result in more solutions as well as ones that were not previously generated using conventional brainstorming. Also, these solution directions directed associates to think in "proven directions" resulting in superior solutions to consider for implementation.

3.3 Phase 3: Solution Evaluation

The EPH model was utilized in creating Phase 3: Solution Evaluation of the EPT model. The EPH Solution Evaluation Phase had three sections.

- Effectiveness of the solution
- The cost of the solution
- The implementation of the solution

The two main parts of the solution evaluation for the EPT are 1) The return on investment (ROI) and 2) The ease of implementation of the solution. Since the EPT model was created for transactional services, the cost aspect of each solution was a major decision criterion.

3.3.1- ROI

*C*ost is an important factor for any project especially in the transactional world. The ROI is a concise way to demonstrate the monetary value of a project as given by the simple ROI formula (Rachlin, 1997).

$$\text{ROI} = \frac{\text{Cost of the Failure Occurring} * \%\ \text{Elimination of Failure}}{\text{Cost of Implementation}}$$

Data for the ROI calculation have to be determined using historical data or research into the existing process. The finance department of some corporations will have the necessary historical cost information. The first piece of information is the failure cost which is often the cost associated from past failures. However, if this information can not be obtained from historical data then research into the process needs to be performed. There are two main types of costs that are considered when determining the failure cost: visible costs and hidden costs. Activity based cost is the main type of hidden cost. Adding up all of the visible costs and hidden costs that are related to a failure will give an appropriate estimate of the cost of that failure. A list of common transactional cost examples was created to assure that each cost was considered. These costs were combined from two sources: *NCSU Six Sigma Notes* (Godfrey, 2005) and *Price Waterhouse Guide to Activity Based Costing (*Mabberley, 1996). The list of costs for hidden and visible costs can be seen in Table 3.10.

Table 3.10- Visible and Hidden Costs

Costs to Consider	
Hidden Costs Think of all of the costs that are related to a failure occurring that are not easily seen	**Visible Costs**
Poor Word of Mouth	Waste
Excessive Training	Rework
Delays	Cost of a Lost customer
Downtime	Rejects
Overtime	Employee Time
Lost Sales	
Billing Errors	
Employee Turnover	
Customer Allowances	
Complaint Handling	
Software Incompatibilities	
Non-value Added Work	
Opportunity Cost	
Facility Cost	
Number of Transactions Performed	
Number of Staff Required	
Experience of Staff/Training	
Risk Associated	
Number of Customers Serviced	
Level of Detail Required	
Regulatory Costs	
Degree of Automation	
Fees and Commissions	

The second piece of information that has to be determined for the ROI is what percent of the failure occurring was eliminated which is a value that should be discussed by the project team and determined. The values can range from 0 to 1, with “0” meaning the solution will not eliminate the failure and “1” meaning the solution will completely eliminate the failure. The descriptions for these values are found in the comment box embedded in the excel worksheet cell seen in Figure 3.1.

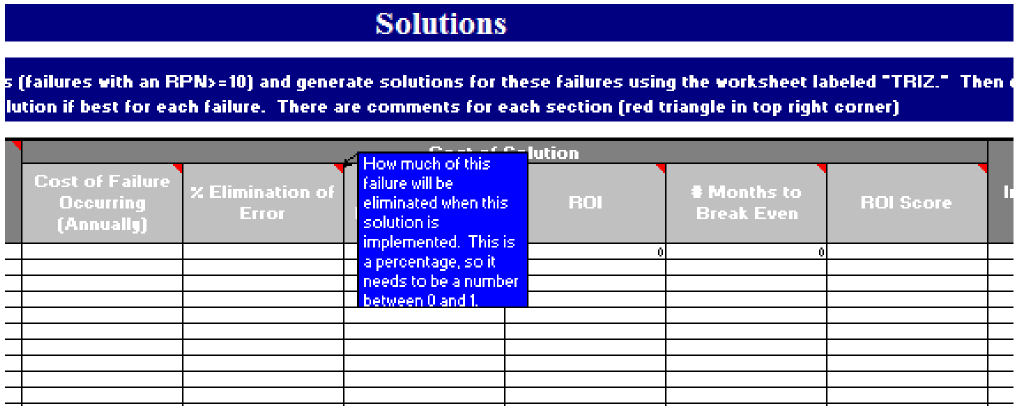


Figure 3.1- % Elimination of Failure Comment Box

The cost of implementation is the final piece of the ROI formula to be determined. Historical data of the cost of implementing similar solutions can be used. However, if this data is not available then all costs associated with implementing the solution should be explored and these costs include the direct and indirect costs with implementation.

Given the data, the ROI, and the number of months to breakeven will be automatically calculated. An established value for what was a good or acceptable ROI was not developed because it will vary depending on the process that is being analyzed. A team will determine the value of a good or acceptable ROI. A rating scale was developed so that each team can rate the ROI and the number of months to breakeven on a scale of one to three as seen in Table 3.11.

Table 3.11- ROI Scale

ROI Scoring	
1	**Low ROI/High # Months**: The return on investment is low and the number of months to break even is high.
2	**Moderate ROI/ Moderate # Months:** The return on investment is moderate and the number of months to break even is also moderate.
3	**High ROI/ Low # Months:** The return on investment is high and the number of months to break even is low

3.3.2- Ease of Implementation

Now that the ROI has been scored, the ease of implementation for each solution is determined. The ease of implementation score includes how hard the solution is to implement and also the level of resistance that is expected. The scale used for the EPH model can be seen in Table 3.12 which was altered to rate transactional solutions as seen in Table 3.13. The EPT scale for ease of implementation is focused on the implementation of the solution and resistance where as the EPH scale is focused on the training required and the resistance expected.

Table 3.12- EPH Ease of Implementation Scale

Score	Definition
3	**Easy**: No training is needed. No resistance is expected.
2	**Moderate**: Training course is needed. Some resistance is expected.
1	**Difficult**: Culture change is needed. Strong resistance is expected.

Table 3.13- EPT Ease of Implementation Scale

Ease of Implementation Scoring	
1	**Hard/High Resistance:** The solution is hard to implement and high resistance is expected
2	**Moderate/ Moderate Resistance:** The solutions is moderate to implement and moderate resistance is expected
3	**Easy/ Little or No Resistance:** The solution is easy to implement and little or no resistance is expected

3.3.3 Solution Priority Number (SPN)

Finally, the Solution Priority Number (SPN) will automatically update in the Excel worksheet when the ROI score and ease of implementation score are input. The SPN in the EPH model was composed of three components: effectiveness score, cost score, and implementation score. A perfect SPN for the EPH model is a 27 (i.e. a 3 for the cost score times a 3 for the effectiveness score times a 3 for the ease of implementation score). However, for the EPT model a perfect SPN score would be a 9 (i.e. a 3 for ROI score times a 3 for ease of implementation score) since the effectiveness score is part of the ROI that is calculated. The solutions with the highest SPN should be considered for implementation.

In some cases multiple solutions can be utilized to prevent one failure from occurring and in some cases one solution can keep multiple failures from occurring. If a solution keeps multiple failures from occurring, but the cost associated is high then this solution should be discussed with management. Also, any solution that fully eliminates a failure from occurring, but has a high cost should be discussed with management. Solutions with a low costs that are easy to implement should always be considered. These solutions coupled with high SPN solutions can greatly reduce the risk of failure occurrence.

3.3.4 Action Plan

Once solutions have been generated and prioritized a simple action plan is included in the EPT model. An associate will be assigned to lead the implementation of this solution along with an implementation due date. Complex solutions will require a detailed action plan that includes specific steps and actions to be performed by a team. This action plan can be created separately and tracked to assure that the solution is implemented correctly.

The EPT model is a new method that has been developed for transactional services. The tool combines parts of the existing FMEA that is currently being utilized for transaction services and portions of the EPH model plus new procedures that were created specifically for transaction services. This tool will help transactional corporations to efficiently identify their failures, develop multiple innovative solutions for these failures, and choose the best solutions for the corporation. Chapter IV will describe a step-by-step procedure of how to use the new EPT model.

Chapter IV- Error Proofing Transaction Method (EPT)

The Error Proofing Transaction (EPT) model is comprised of three phases that were developed in Chapter III. The first phase is the TFMEA, used to identify potential failure modes. The second phase is the Solution Generation, used to generate an exhaustive list of potential solutions to eliminate or reduce the risk of a failure occurring. The third and final phase is the solution evaluation which is used to evaluate solution ideas and prepares an action plan to manage the implementation of solutions. The next sections will step through the process of completing the EPT model.

4.1 Phase I-TFMEA

The TFMEA process contains four steps. The first step is to define the scope of the TFMEA and the process that is being improved while the second step assembles the team to evaluate the process. The third step graphically describes the process that is being reviewed and the fourth and final step is to generate potential failure modes, effects, causes, and to rate each potential failure mode. Each of these steps will be described in the next few sections.

4.1.1 Scope of the TFMEA

Defining the scope of the TFMEA is a vital step of the EPT model. The scope should be selected to cover the highest risk areas as well as the highest volume areas. The size of the scope should be controlled because if the scope is too large then the project will require too much time to complete an may not be implemented. The scope can be defined by upper management and then conveyed to the team before starting the EPT methodology since upper management can best define what results they expect. Additional tasks or goals being added to the scope must be controlled to keep the team focused and avoid scope creep.

4.1.2 Team Selection

Selection of the team members is critical to the success of the project. The team should have members that represent all process functional areas to be covered including people performing the process tasks, management, and process support representatives. The primary responsibility of the team leader that is selected is project management and communication with the organization. However, the team leader must have a thorough knowledge of the EPT methodology. The team must have an effective facilitator to organize as well as conduct meetings and document the project. The team leader can serve in this capacity or delegate the responsibility to another team member that has good facilitation skills.

4.1.3 Process Map

The first task of the team is to create a visual representation of the process by developing a process map. The process map consists of major high level process steps and the sub-processes for each of these high level steps. To gain a complete understanding of the process flow, the process should be observed by the team.

The high level process steps represent the high level flow of the process. If too many steps are being identified at this level then scope creep could have occurred or the process steps are not at a high enough level (Seastrunk, 2005). After completing the first draft the process steps should be examined to determine if any of the process steps are sub-process steps of other high level steps. The process mapping template used to list the high level process steps can be seen below in Figure 4.1.

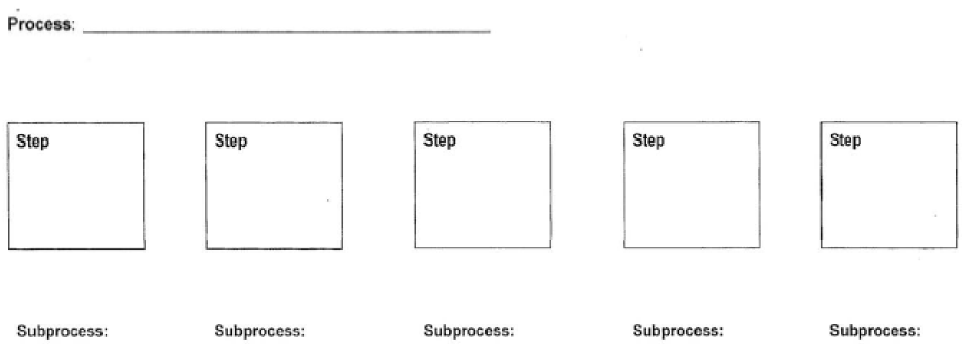


Figure 4.1- Process Mapping Template (Seastrunk, 2005)

Sub-process steps are then identified for each high level step to completely define the process step. It is imperative that all sub-process steps is being identified and not missed. To ensure that all sub-process steps are identified in a timely manner a list of generalized sub-process steps for transactions has been created and can be used. The ten generalized sub-process steps that have been identified are:

- Decision, Authentication,
- Review/Approve,
- Transcription,
- Report,
- Develop/Build/Maintain,
- Deliver Product/Service to Customer,

- Monitor/Oversee/QA,
- Communicate, and
- Gather Requirements from Customers.

More detail can be added to each of these generalized sub-processes to describe the specific activity. Using the generalized sub-processes will assure that a comprehensive list is generated. In figure 4.1, the sub-processes are listed below the high level process in the process mapping template.

4.1.4 Generating Failure Modes, Effects, and Causes

Generating the failures, effects, and causes for the TFMEA are very similar to the way that failures, effects, and causes are generated for the FMEA. This is a very important step. If all of the potential failures are not defined, then the process will still be prone to errors. There are comments for each column in the TFMEA worksheet which serve as reminders of what is supposed to be input into that column. The worksheet that is used for the TFMEA can be found in Figure 5 in Appendix I and the generalized functions, failures, effects, and causes table can be found in Figure 4 in Appendix I. Both of these documents will be utilized throughout section 4.1.

The first step of the TFMEA is to place the major high level steps that were identified during the creation of the process map in the column titled "Process Step/Function Requirements". After each step has been entered into the worksheet, a team brainstorming session should be conducted to list the potential failure modes for each sub-process step of this high level process. Each potential failure mode that could occur should be listed in the worksheet under the column labeled "Potential Failure Mode" directly beside the corresponding process step. In order to assure that each failure mode is identified, the table that contains the generalized transactional functions, failures, effects, and causes should be used. The team should select the closest generalized function to the current process step that is being analyzed. Once the function is selected, the potential failure modes will automatically appear. Then, these failures modes should be discussed to determine if any other failure modes need to be added or removed from the current process step.

After all failure modes have been identified, the potential effects of each failure should be determined. These effects should be listed under the column labeled "Potential Effect(s) of Failure" directly adjacent to the corresponding failure mode. There is also a list of generalized effects that can be found in the generalized functions, failures, and effects table. These generalized effects should be reviewed in order to determine if any of these effects relate to any of the potential failure modes.

Next, the severity of each failure mode has to be determined and is based on the effects of the failure mode occurring. Each failure mode should be rated on a scale of one to five of how severe the failure would be if it was to occur and should be listed in the "Severity" column of the TFMEA adjacent to the corresponding failure mode. The explanations for each score can be seen below in Table 4.1.

Table 4.1- Severity Scoring

Severity Scoring	
5	Loss of Customer
4	Very likely that the Customer will be dissatisfied and business will be lost
3	Customer will be affected and business could potentially be lost
2	Customer is not likely to notice or be affected
1	No effect

Once the severity of the failure mode has been scored based on the potential effects, the potential cause of each failure needs to be determined. Each cause should be listed under the column labeled "Potential Cause(s) of Failure" adjacent to the corresponding failure mode. A list of generalized causes has been provided to assist the team in identifying all potential causes. These causes should be reviewed to determine if any relate to the current failure mode.

Next, each failure mode should be rated on a scale of one to five based on the frequency of occurrence of this failure. The explanations for each score can be seen below in Table 4.2 and depending on the company quantitative occurrence estimates can be includeded to help the team determine the occurrence score. Each failure mode will be assigned an occurrence score and inserted in the "Occurrence" column in the TFMEA worksheet.

Table 4.2- Occurrence Scoring

Occurrence Scoring	
5	Failure Almost Always Occurs
4	Failure Occurs Repeatedly
3	Failure Occurs Occasionally
2	Failure Occurs Only a Few Times
1	Failure is Unlikely to Occur

All of the controls that are currently in place to keep a failure mode from occurring should be determined. The process map should be referenced to see if there were any controls that were noted during the creation of the process map to keep a failure from occurring. Each of these controls will be listed in the "Current Process Controls" column beside the corresponding failure.

The worksheet will automatically calculate the Risk Priority Number (RPN) for each failure mode by multiplying the severity score times the occurrence score. It is recommended that any failure mode with an RPN greater than or equal to ten should be deemed a failure mode for action.

For each of the remaining process steps, the same methodology needs to be applied. It is important to complete all of the required fields for one high level process step at a time in order to minimize confusion and to assure that each team member is only thinking about the current process step that is being analyzed.

4.2 Phase II- Solution Generation

Now that the TFMEA has been completed for each of the process steps, the next step in the EPT model will be to generated a comprehensive list of potential solutions. The solutions and scoring worksheet that will assist the teams in listing and scoring each solution can be found in Figure 6 in Appendix I while the Transaction Solution Direction (TSD) table which will assist the team in generating solutions can be found in Figure 7 in Appendix I. Both of these tables will be utilized in Section 4.2. There are comments for each column in the Solutions and Scoring table to specify what is to be input into each column.

All of the failure modes that were deemed a failure mode for action (i.e. failures with a RPN greater than or equal to ten) should be inserted into the Solutions and Scoring Table in the column titled "Failure Modes". Multiple solutions for each failure mode should then be generated. To help with the process of generating solutions and to assure that all potential solutions for each failure is identified the Transaction Solution Direction (TSD) table should be utilized. The column titled "TRIZ Solution Direction" lists eleven TRIZ solution directions identified to be applicable to transactional companies, such as banking, that assist in generating effective solutions. Banking related examples and definitions for each TRIX direction can be found in the "Transactional Definitions/Example" column to help in understanding each solution direction. At this point the team leader will ask the team each of the questions in the TSD table. The team will brainstorm each question to generate potential solutions for each failure mode. All of the solutions that are generated during this discussion will be captured in the "Solutions" column of the Solutions and Scoring Table beside the corresponding failure mode. Again, these solution directions assist in determining a comprehensive list of potential solutions for each failure mode.

4.3 Phase III- Solution Selection

Once all the potential solutions have been identified fro each process step, the final step of the EPT model will be solution selection. In this step each of the solutions will be ranked based on the Return on Investment (ROI) of the solution and the ease of implementation of the solution. The Solutions and Scoring table can be found in Figure 6 in Appendix I and will be utilized in section 4.3.There are comments for each column in the Solutions and Scoring worksheet to specify what is to be input into each column.

4.3.1 Return on Investment (ROI)

The Return on Investment (ROI) for each solution identified needs to be calculated. The ROI consists of the cost of the failure occurring, the % elimination of the error, and the cost of implementation. The first step in determining the ROI is to determine the historic cost of the failure. For each solution and failure mode combination, the cost of the failure occurring needs to be estimated and any data that can be found on the costs of this failure should be considered. The table in the worksheet titled "Costs to Consider" lists all of the direct and hidden costs that relate to the cost of a failure occurring. All of the costs that are related to a failure occurring should be added together to produce an annualized total cost of the failure occurring and inserted into the "Cost of the Failure Occurring" Column adjacent of the corresponding failure mode. See Figure 4.2 below to see the comment that is embedded into the worksheet to assist the user.

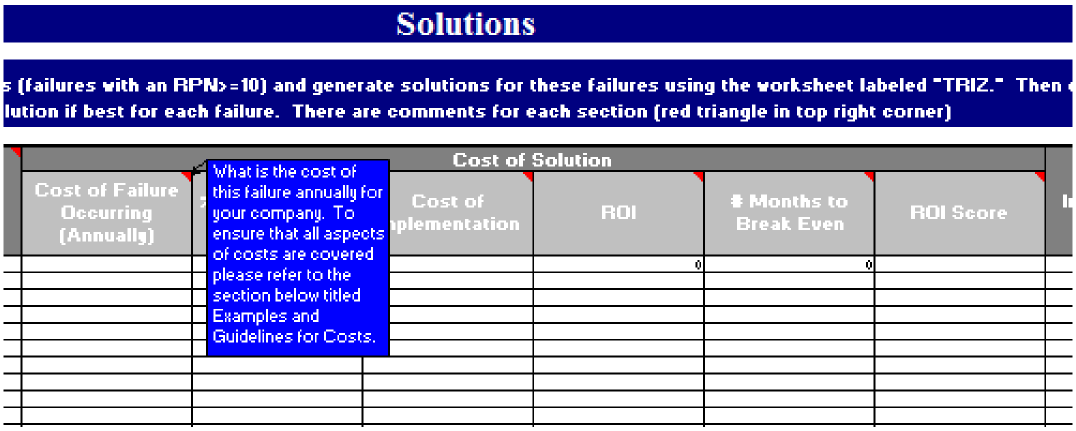


Figure 4.2- Cost of Failure Occurring Comment

The next step in determining the ROI for the current solution is to determine the percent elimination of the error. For each solution of a failure, how much of the failure will be eliminated if the solution is implemented has to be determined. Each solution should be given a percent elimination based on a continuous scale of zero to one. A score of one means that the failure will be fully eliminated while a score of zero means that the occurrence of the failure will not be reduced at all. This score should be placed in the column labeled "% Elimination of Error". See Figure 4.3 to see the comment that is embedded in the worksheet.

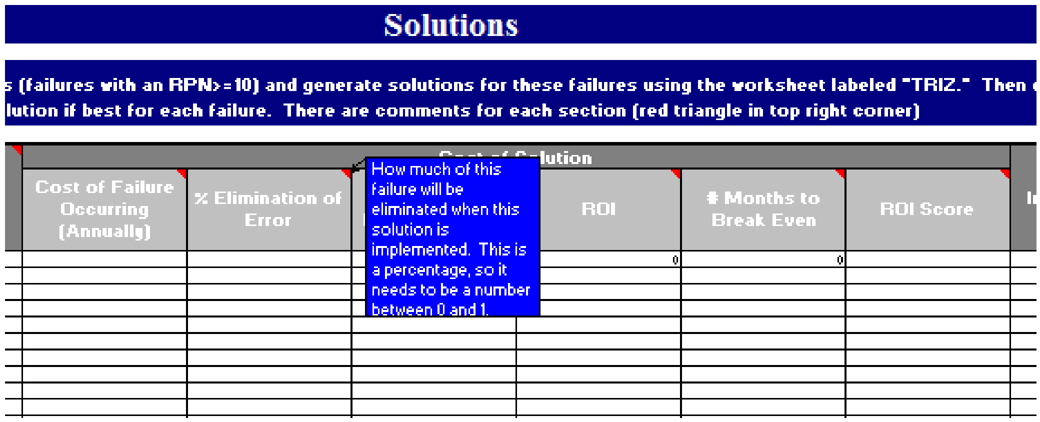


Figure 4.3- % Elimination of Error Comment

Once the cost of the failure occurring along with the percent error elimination has been estimated, the last step of determining the ROI is to determine the cost of solution implementation. The cost to implement each solution should be determined. The direct and hidden costs in the "Costs to Consider" table can be utilized to assist with determining the cost of implementation. The cost of implementation for each solution should be placed in the column labeled "Cost of Implementation". See Figure 4.4 to see the comment that is embedded in the worksheet.

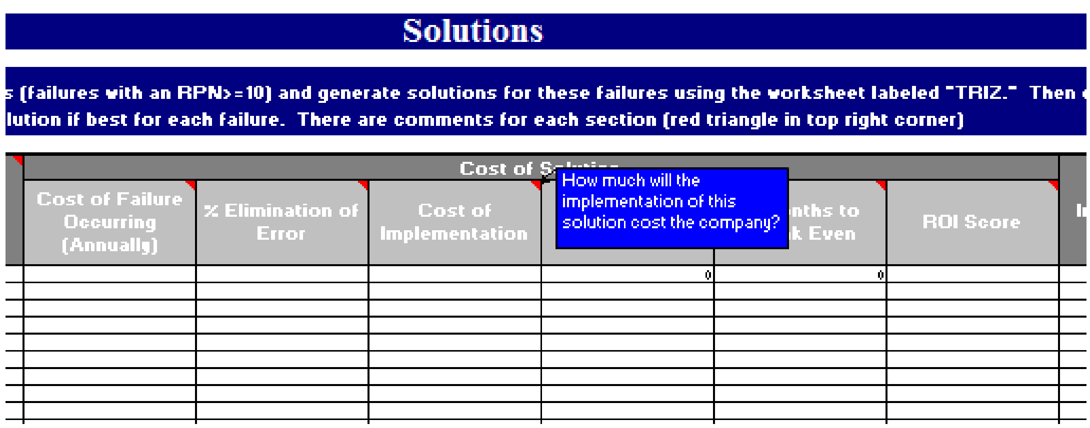


Figure 4.4- Cost of Implementation Comment

After the cost of the failure occurring, the percent error elimination, and the cost of implementation has been estimated the ROI and number of months to breakeven will automatically be calculated. The ROI is calculated by multiplying the cost of the failure occurring by the percent error elimination and then dividing this by the cost of implementation. The number of months to breakeven is calculated by dividing the cost of implementation by the cost of the failure occurring times the percent error elimination divided by twelve. After the ROI and the number of months to breakeven are calculated the overall ROI score will be determined. This score is based on the ROI and the number of months to breakeven. Table 4.3 will be used to assist in scoring and is present in the comment that is embedded in the ROI Score column.

Table 4.3- ROI Scoring

ROI Scoring	
1	**Low ROI/High # Months**: The return on investment is low and the number of months to breakeven is high.
2	**Moderate ROI/ Moderate # Months:** The return on investment is moderate and the number of months to breakeven is also moderate.
3	**High ROI/ Low # Months:** The return on investment is high and the number of months to breakeven is low

4.3.2 Ease of Implementation

The next step of the solution selection is rating each solution on how easy it is to implement. Not only should the difficulty of implementation be considered, but the level of resistance that will be experienced should be considered also. The table that can be used for scoring the ease of implementation can be seen below in Table 4.4 and is located in the comment that is embedded in the "Ease of Implementation" column in the worksheet.

Table 4.4- Ease of Implementation Scoring

Ease of Implementation Scoring	
1	**Hard/High Resistance:** The solution is hard to implement and lots of resistance is expected
2	**Moderate/ Moderate Resistance:** The solutions is moderate to implement and moderate resistance is expected
3	**Easy/ Little or No Resistance:** The solution is easy to implement and little or no resistance is expected

4.3.3 Solution Priority Number (SPN)

The Solution Priority Number (SPN) is calculated by multiplying the ROI score times the East of Implementation score. The best score for an SPN would have a value of nine. Any solution that receives a nine should be considered for implementation. Each of the solutions for each failure mode will be analyzed and the solution with the highest SPN should be chosen for implementation. Other solutions that were generated should be assessed and considered. There can be more that one solution that is implemented to keep a failure from occurring. To keep a failure from occurring sometimes multiple solutions have to be implemented. When determining which solution to implement, keep in mind that one solution could keep multiple failure modes from occurring. Each appropriate solution identified should be implemented to error proof the process.

4.3.4 Action Planning

The team should organize the solutions selected into either short term or long term categories or arranged by high priority and immediate action items. The solutions that need to be implemented immediately should be completed first. An individual from the team will be assigned to each solution and will be in charge of assuring this solution is implemented correctly as well as in a timely manner. A target date for each solution should be set as well as a review process to assure that everything is on target. The solutions, individuals in charge of the solution, and the target date for implementation should be shared with upper management and recorded.

Chapter V- Case Study

Chapter IV outlined the new Error Proofing Transaction (EPT) model methodology. To demonstrate the effectiveness of the EPT model, a case study was performed at a large banking corporation. The process to receive a loan was the focus of the case study. A team followed the EPT model by first creating a process map for the process of receiving a loan. Next, the failure modes, effects, causes, and solutions were generated along with solution selection using the EPT model and procedures. The case study will show how the EPT method compared to the traditional FMEA that is used in transactional services. The results from both methods were recorded and compared.

5.1 Assemble Team

Selecting the appropriate associates to include on a project team is one of the most important steps of any error proofing process. A team of five individuals was selected and consisted of managers, vice presidents, and associates that are familiar with the process being analyzed as well as the FMEA process. The team leader that was chosen had extensive knowledge of the EPT model, knowledge of the process that was being analyzed, and strong leadership skills. In this case, the team leader was also the facilitator and recorded the responses for the FMEA and the EPT model.

5.2 Map Process

Mapping the process assures that every team member has an understanding of the process being analyzed as well as no process or sub-process steps are missed. The team leader led the team through creating a process map for the loan process. The team first identified five high level process steps as seen in Table 5.1.

Table 5.1- High Level Process Steps

Prequalify
Complete Application
Obtain Verficiation Information
Approval for Loan
Signing Final Documents

Next, all of the sub-process steps were identified for each high level process step. The generalized sub-process steps were utilized to assure that all potential sub-process steps were identified. If a sub-process step is not identified, then potential failures will not be analyzed. The process map that was created can be seen in Figure 5.1 which illustrates the five high level steps along with all sub-process steps.

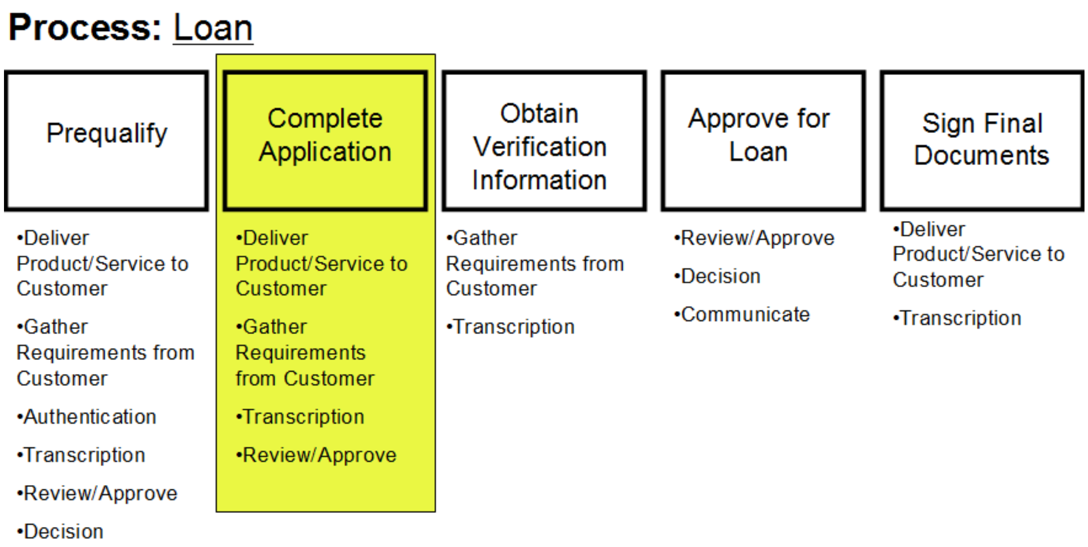


Figure 5.1- Process Map for Loan Process

The team leader then led the team through a discussion to identify the high level process step containing the most failures. The team chose the "complete application" step because it was believed to contain the most failures. The following sub-process steps for complete application were identified.

- Deliver product/service to customer
- Gather requirements from customer
- Transcription
- Review/approve

The EPT model next led the team to identify all the failure modes, effects, and causes for each of these sub-process steps.

5.3 FMEA & TFMEA

In order to compare the traditional FMEA used and the proposed EPT model both methods were used to create failure modes, effect, and causes. The results of the existing FMEA and TFMEA were recorded and analyzed. Any team discussion that took place regarding the existing FMEA and the TFMEA was noted.

5.3.1 Existing FMEA

The team leader started with the first sub-process step which was “deliver product/service to customer”. The team brainstormed potential failures that could occur during this sub-process step. The team decided the failure mode that could occur was an incorrect product could be given to the customer. The team next brainstormed potential effects of the failure occurring. Two effects were generated if the failure occurred: the customer is dissatisfied and potential loss of business. The team then discussed the severity of the failure occurring. The severity of the failure was given a score of three because of the effects listed. The team then brainstormed potential causes of the failure occurring. The team decided that the most likely potential cause would be lack of associate knowledge. In analyzing how often this failure would occur, the occurrence score was determined to be a two. In analyzing the controls that were in place to keep this failure from occurring, the team determined the detection score was a two. The RPN was automatically calculated and determined to be low. Therefore, the failure was not considered to be high risk. The effects, severity score, causes, occurrence score, detection score, and RPN that were generated can be seen below in Figure 5.2. These same steps were performed for the three other sub-process steps. The results of the FMEA were documented by the team leader as well as the time required. The FMEA that was completed can be seen in Appendix I in Figure 8.

Process Step/ Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Detection	RPN
Deliver Product/Service to Customer	Incorrect Product	Customer Dissatisfied Loss of Business	3	Lack of Associate Knowledge	2	2	12

Figure 5.2- FMEA for First Sub-Process Step

5.3.2 TFMEA

After completing the traditional FMEA, the team leader explained to the team the process of completing the TFMEA. The team used the generalized failure modes, effects, and causes worksheet and selected the generalized sub-process step of “deliver product/service to customer”. All of the potential failure modes for that sub-process step automatically appeared as shown in Table 5.2. The team discussed each failure mode generated and determined if it applied to the “complete application” step. The failure modes that were generated for the EPT model can be seen in Table 5.2. The team was surprised at the additional failure modes identified that were related to this sub-process step that were not generated during the brainstorming in the existing FMEA.

Table 5.2- Generalized Failure Modes

Please Choose a Similar Process Step or Function	Failure Modes
Deliver Product/Service to Customer	**Do not deliver at all**
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	**Do not deliver in a timely fashion per disclosures**
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	**Do not deliver product/service customer was expecting**
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	**Do not deliver in a timely fashion per customer expectations**
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	**Do not deliver product/service as we promised it**
Deliver Product/Service to Customer	
Deliver Product/Service to Customer	

Using the list of generalized effects, the team determined the effects for each of the failure modes identified. The effects that were created for the failure mode of “does not deliver at all” are displayed in Table 5.3. In analyzing the effects of the failure, the severity was then determined to be a two. Using the generalized failure modes and causes worksheet, the team selected an appropriate failure mode which automatically made the causes for that failure mode appear. The causes of the potential failure mode of “does not deliver at all” were: non-Adherence to policies and procedures which can be seen in Figure 5.3.

Table 5.3- Effects for "does not deliver at all"

Loss of Sale
Reputation Damage
Negative Customer Experience
Loss of Existing Customer

Please Choose a Similar Process Step or Function	Failure Modes
Deliver Product/Service to Customer	**Do not deliver at all**

Causes
Non-Adherence to Policies and Procedures

Figure 5.3- Generalized Causes

Once the occurrence of the failure mode was determined to be a two th RPN was automatically calculated to be a six. The team leader explained to the team that a high risk failure would be any failure that had an RPN of ten or above. The effects, severity, causes, occurrence, and RPN for the failure mode of “does not deliver at all” can be seen below in Figure 5.4. The same process was repeated for the other three sub-process steps. The results of the TFMEA were documented by the team leader as well as the time required. The TFMEA that was completed can be seen in Appendix I in Figure 9.

Process Step/ Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure
Deliver Product/Service to Customer	Do not deliver at all	Loss of Sale
		Reputation Damage
		Negative Customer Expereince
		Loss of Existing Customer

Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure
Loss of Sale	3	Non-Adherence to Policies and Procedures
Reputation Damage		Lack of Associate Knowledge
Negative Customer Expereince		Unavaliable Product/Service
Loss of Existing Customer		

Occurrence	Current Process Controls Inspection Prevention Detection	RPN
2		6

Figure 5.4- TFMEA for First Failure of First Sub-process Step

5.3.3 Comparison of the Existing FMEA and the TFMEA

The comparison results on the number of failure modes, effects, causes, and number of high risk failures determined for each method can be seen below in Table 5.4. In utilizing the TFMEA the team was able to produce twice the number of failure modes, four times the number of effects, six times the number of causes as well as and double the number of high risk failure modes. The amount of time that it took to complete the FMEA was documented to be 60 minutes while it took 35 minutes for the team to conduct the TFMEA. An almost 50% reduction in team effort combined with a more comprehensive failure mode analysis has significant benefits.

The team was surprised at the number of failure modes, effects, and causes that were found using the TFMEA method instead of the existing FMEA method. The team was pleased that the TFMEA required less time than the existing FMEA. There was less side discussion with the TFMEA because of the TFMEA's structured approach. The team was very comfortable with the TFMEA as well as the process. Since the case study, the TFMEA has been implemented in the organization. The amount of time required has been reduced by 50% in subsequent projects in utilizing the TFMEA. This has resulted in significant savings in personnel resources.

Table 5.4- Results of Existing FMEA and TFMEA

Existing FMEA				
Failure Modes	**Effects**	**Causes**	**High Risk Failures**	**Time**
7	11	8	1	60 minutes
TFMEA				
Failure Modes	**Effects**	**Causes**	**High Risk Failures**	**Time**
16	45	53	3	35 minutes

5.4 Solution Generation

In order to compare the existing FMEA currently used and the EPT model, both methods were used to generate solutions. The three high risk failures that were generated using the TFMEA were analyzed. To generate solutions for the FMEA, the team utilized brainstorming. To generate solutions for the EPT model the team utilized the TRIZ Solution Directions. The solutions that were generated and any discussion that took place regarding the EPT model were noted.

5.4.1 Brainstorming

As stated earlier, the traditional FMEA utilized a classical brainstorming session to generate solutions. Solutions for the high risk failure mode of "approval when correct decision would have been rejection" were generated. The team leader led the team through a typical brainstorming session on the potential solutions for the high risk failure. A lot of discussion around the potential solutions occurred. The team generated two solutions for the high risk failure mode: creating a standardized process and creating a checklist of steps that needed to be performed. It took the team 15 minutes to generate the two solutions. It was noted that for a normal project, one to two solutions are generated for each high risk failure mode.

5.4.2 TRIZ Solution Directions

The solution generation method that was developed for the EPT model utilizes TRIZ Solution Directions to guide the team in generating potential solutions. The team leader explained the eleven solution directions to the team by utilizing the "TRIZ Solution Directions" worksheet and the transactional examples that were provided. The same failure mode "approval when correct decision would have been rejection" was used. The team leader then asked the team each solution direction question to determine if there were any solutions for the high risk failure mode. There was a lot of discussion that occurred for each question and there were lots of solutions that were created for the failure mode. The team created seven solutions for this high risk failure mode and can be seen in Table 5.5. The total amount of time to generate the seven solutions was 15 minutes.

Table 5.5- Solutions Generated using TRIZ Solution Directions

Manager review application and decision
Computer pre-approval
Customer input all of required information
Having multiple individuals approve different prats of the loan
Automate the loan approval
Create a checklist of procedures to be performed
Create a standardized process

5.4.3 Comparison of Brainstorming and TRIZ Solution Direction

The team created three times as many solutions for the high risk failure mode utilizing the TRIZ solution directions compared to the traditional brainstorming session. The team was very surprised and excited about the additional solutions that were created using the Solution Directions. The team also commented that several solutions that were created were ones that would not have been listed previously. The team said that the examples helped them understand the Solution Directions and the questions led the team through a thorough discussion regarding the solutions. The team immediately accepted and saw the benefits of the TRIZ Solution Directions and the ability to "think outside of the box". The amount of time to generate the two solutions for the existing FMEA and the eight solutions using the TRIZ solution directions was the same. However, as the team understands the Solution Directions better, they will be able to produce solutions even faster.

5.5 Solution Evaluation & Selection

In order to compare the existing FMEA currently used and the EPT model, both methods were used to rank the solutions generated. The seven solutions that were created using the TRIZ Solution Directions were analyzed for both. To choose a solution for the FMEA, the team would discuss the potential solutions and reach a consensus on which solution was best. To choose a solution for the EPT model, each solution is scored based on its monetary effect to the company and the ease of implementation. Any discussion that occurred through the utilization of the EPT model was documented.

5.5.1 Selection by Discussion

The process for solution selection for the current FMEA is to choose a solution based on what the team agrees is the best solution. The team leader led the team through a discussion of each potential solution. The team discussed the advantages and disadvantages of each solution. After much discussion and debate the team decided that the best solution would be "standardizing the process for the approval of loans".

5.5.2 Selection based on ROI and Ease of Implementation

Recall, the EPT model ranks each solution based on the ROI and ease of solution implementation. The ROI contains three parts: the cost of the failure occurring, the percent elimination of the failure, and the cost of implementation. First, the team leader asked the team to determine what it would cost the company annually if a loan was approved when it should have been rejected. The team considered: how many times a year this occurred, the amount of the loan, and any fines that they could incur. After the cost was determined, the team leader showed the team the list of generalized costs from the worksheet. The team saw several costs that were not previously considered. Some of the costs that were not considered were: the cost of the loss of a current and potential customer, poor word of mouth (reputation), employee time, the facility costs, and the electricity for the facility. The team took into account the costs identified to produce the estimated cost of the failure occurring.

The percent of elimination was estimated for each solution. Activity-based costs as well as direct costs were used to estimate the cost of implementation. The ROI and number of months to breakeven were automatically calculated. An ROI score was determined by utilizing the ROI scale that was provided. The ease of implementation was determined by utilizing the ease of implementation scale that was provided in the comments. The SPN was automatically calculated with one solution having the maximum SPN: "customer input all of the required information". The team leader noted the fact that more than one solution could be implemented and they discussed the next highest ranking solutions as seen in Table 5.6. The Solution Selection worksheet can be seen in Appendix I in Figure 10.

Table 5.6- Next Highest Ranking Solutions

Solution	SPN
Customer pre-approval	6
Automate the loan approval	6
Create a checklist of procedures to be performed	6
Create a standardized process	6

5.5.3 Comparison of Existing Method and SPN Method

The team commented that choosing a solution based on the SPN took significant bias out of choosing solutions. During the wrap up, the team discussed the traditional method did not make the team think of the cost of the solution or how easy it would be to implement. A benefit of the new EPT model was that the ROI could be shown to upper management to support why certain solutions were chosen. The team noted the best solution selected according to the SPN was not the solution that they had initially chosen. The team agreed that the SPN was a standardized way for every team to choose the best solutions consistently.

5.5 Summary of Case Study

During the process, many improvements were identified from using the TFMEA as compared to the traditional FMEA. Table 5.7 shows the comparison results of the traditional FMEA versus the EPT model. This table can also be seen in Figure 11 in Appendix I. In utilizing the TFMEA and excel worksheet, more failure modes, effects, and causes were generated in a shorter amount of time. In utilizing the TRIZ solution directions the team was able to produce four times the number of solutions.

Table 5.7- Results of the Case Study

Existing FMEA				
FMEA				
Failure Modes	Effects	Causes	High Risk Failures	Time to complete Failure Modes, Effects, & Causes
7	11	8	1	60 Minutes
EPT Model				
TFMEA				
Failure Modes	Effects	Causes	High Risk Failures	Time to complete Failure Modes, Effects, & Causes
16	45	53	3	35 Minutes

Solutions were generated for the High Risk Failure Mode of: "Approval when correct decision would have been rejection"		
Existing FMEA		
Brainstorming		Solution Selection
Number of Solutions Generated	Time to Generate Solutions	Solution Selected
2	15 Minutes	standardizing the process for the approval of loans
EPT Model		
TRIZ Solution Directions		SPN Solution Selection
Number of Solutions Generated	Time to Generate Solutions	Solution Selected
8	15 Minutes	customer input all of the required information

In utilizing the SPN solution selection the team was able to see the value of each solution. The team noticed how multiple solutions could be utilized to keep a failure from occurring and how one solution could keep multiple failures from occurring. The ranking of solutions allowed the team to see the value of each solution. The ROI was a value that the team used to justify the solutions that were chosen. The three sections of the EPT model showed great improvements for error proofing a process over the traditional FMEA. The organization has now implemented the EPT model as the standard owing to the results of the case study.

Chapter VI- Conclusions and Future Work

6.1 Conclusions

A new model was created for error proofing transactional processes of corporations. The Error Proofing Transactions (EPT) model consisted of three main sections: Transaction Failure Mode and Effects Analysis (TFMEA), Solution Generation, and Solution Evaluation.

The TFMEA assists transactional corporations in identifying potential failures that could occur in a process. The traditional FMEA previously utilized in transactions was altered to create the TFMEA. The detection score was removed, the rating scale is one through five, and the definitions are focused on the customer. A list of generalized sub-processes, failure modes, effects, and causes was created, using data from a large transactional corporation, to produce more potential failures, effects, and causes. In a case study utilizing the TFMEA, double the failure modes, four times the effects, and six times the causes were generated when compared to the traditional FMEA. A TFMEA excel worksheet was created and can be seen in Figure 5 in Appendix 1. Another excel worksheet was created that contained all of the generalized sub-processes, potential failure modes, effects, and causes and can be seen in Figure 4 in Appendix 1.

There was not a way to efficiently generate solutions in the traditional FMEA. The EPT model used the theory of inventive problem solving (TRIZ) principles to generate more solutions. Data from a large transactional corporation was used to determine what TRIZ principles applied to transactions. Examples and questions were created for each of the solution directions to assist with generating solutions. In a case study utilizing the solution generation of the EPT model four times the solutions were created for a single high risk failure when compared to the traditional FMEA. An Excel worksheet was created that contained the TRIZ solution directions, examples, and questions and can be seen in Figure 7 in Appendix 1.

There was not a way to consistently choose the best solution to prevent failures from occurring. The EPT model has a way to rate each solution based on the return on investment and how easy the solution is to implement. The EPT model created a way for transactional corporations to consistently choose the best solution. An Excel worksheet was created to assist in evaluating the solutions. The worksheet contains the rating scales for the ROI score and the ease of implementation as well as the list of hidden and visible costs and can be seen in Figure 6 in Appendix 1.

Error proofing of a process in any company should identify all potential failures and all potential solutions. Error proofing a process should not require an excessive amount of time. The case study that was conducted was an ideal example of how the EPT model should be utilized in any transactional service company. Any company that utilizes the EPT model will have a new and effective way to error proof any process.

6.2 Future Work

The ROI section of the EPT model is a new and innovative part of the solution evaluation. Obtaining the cost of the failure occurring is difficult and could be improved. A database that contains the costs of failures occurring could be created. The information to input into the database could be obtained from the finance department of a transactional corporation. This database of costs would help a team when determining the cost of the failure occurring.

The model that was created is specific to transactional service companies. The model could be applied to other industries, including manufacturing industries. The solution generation and solution evaluation could be applied to other industries in order to create innovative solutions and choose the best solution for the company.

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APPENDIX I

Generalized Healthcare Subprocesses

	Generalized Subprocess	Examples of Subprocess
Prescribing	Visit/see	Visit patient on the floor; see patient prior to surgery.
	Assess/evaluate	Assesses patient; evaluate home medications.
	Review/screen	Review chart; review order; screen allergy/drug interaction.
	Consult/discuss	Consult pharmacist; discuss with Radiology MD.
	Choose	Choose procedure; choose system for entry; choose mode of delivery.
	Calculate/score	Calculate dose; assign score.
	Prescribe/transcribe/write	Prescribe medication order; transcribe medication order; write order.
	Enter	Enter order into computer; enter allergy information into computer
	Order/give	Order medications verbally; give directions.
	Feedback/repeat	Provide feedback to MD; repeat order
	Document/complete/sign	Document medications; complete note; sign form
Administration	Identify/clarify	Identify patient; Identify resources; identify needs; clarify IV status.
	Arrange/coordinate/establish	Arrange transporter; coordinate timing; establish time.
	Prepare	Prepare patient; prepare medications
	Set up/program	Set up device; program device.
	Obtain	Obtain medications; obtain flow sheet.
	Label/produce label	Label medications; produce labels for medications.
	Verify/check/confirm	Verify order; verify syringe; check medication; confirm room availability.
	Administer/apply	Administer medications; administer PCA; apply probe.
	Perform	Perform procedure.
Monitoring	Monitor/observe	Monitor patient; observe patient
	Respond/intervene	Respond to alarm; perform intervention.
	Adjust/manage	Adjust regimen; manage pain.
	Change/turn on/turn off	Change cartridge; turn on alarm; turn off alarm.
	Discharge/transition	Discharge patient; transition to oral medications.
Communication	Report	Provide report to floor
	Notify/page	Notify RN that exam/procedure completed; page MD.
	Communicate	Communicate expectations.
	Gather/get	Gather allergy information; get information from family.
	Answer/inform/update/support	Answer questions; inform patient; update family; support family.
Others	Pick up/return	Pick up slip; return chart.
	Place	Place form in chart; place allergy information on armband.
	Take/send/deliver	Take medications to bed; send order to pharmacy; deliver medication to unit.
	Receive	Receive order; receive medications.
	Transport	Transport patient.

Figure 1- Generalized Healthcare Sub-processes: For the Error Proofing Healthcare (EPH) model a list of generalized sub-processes were created and examples relating to healthcare were developed.

General Failure Modes – Questions for Listing Failure Modes

Question: ***What can go wrong?***	Examples of Failure Modes
Omission: What part of the subprocess is prone to be omitted?	• Omitting necessary steps in the preparation of a medication • Forgetting to switch on a humidifier in a respirator • Forgetting to return flow quantity after processing an additional medication
Excessive Repetition: What part of the subprocess is prone to be excessively repeated?	• Re-executing the finished work • Adding the same liquid twice into the mixture
Wrong Sequence: In what wrong sequence can the subprocess be executed?	• Filling an order without entering allergy information, patient weight, etc. • Proceeding care before producing the patient ID
Early/Late Execution: What execution can be early or late?	• Beginning work earlier/later than specified • Giving a medication in the wrong time
Incorrect Identification/Selection: What object of the subprocess, e.g., patient, medication, equipment, document etc, is prone to be selected or identified incorrectly?	• Giving a medication to the wrong patients • Choosing the wrong dose or the wrong syringe • Wrong-side surgery
Incorrect Counting/Calculating: What objects of the subprocess can be counted, measured or calculated incorrectly?	• Counting medications incorrectly • Miscalculating quantity of drugs and overdosing
Overlooking: What information, risk or failure/error is prone to be overlooked?	• Overlooking patient's allergies • Overlooking abnormal values displayed in a system • Not noticing information on drug-drug interactions or patient's other medicines
Misreading/Misunderstanding: What misunderstanding or misreading is prone to occur?	• Misreading medication orders • Misunderstanding status of the equipment • Misunderstanding bed availability
Incorrect Decision: What incorrect decision is prone to occur?	• Misjudgment of discharge criteria
Miscommunication: What miscommunication is prone to occur?	• Miscommunicating current status of patients in transition • Insufficiently notifying to other caregivers • Disagreement between the care team
Incorrect Transcription/Entering: What transcription/entering error is prone to occur?	• Making a mistake in transcription of doctor's instructions • Making a mistake in entering patient information into computer systems
Incorrect Route/Orientation/Positioning/Setting: What route/orientation/positioning/setting error is prone to occur?	• Operating controls on a defibrillator based on the understanding of different defibrillators • Connecting tubes/valves incorrectly
Unintentional Touching/Sticking/Splashing: What can be unintentionally touched, stuck or splashed?	• Unintentionally touching equipment switches • Being splashed with a toxic substance • Sticking needles in hands
Hazardous Movement: Where What movement can cause harm (slipping, falling etc)	• Slipping on the floor • Falling
Not Available: Who/what is prone not to be available?	• MD not available • Equipment/room/medication not available
Hardware Failure/ Incorrect Information: What hardware failure or incorrect information provision is prone to occur?	• Equipment failure or expired medication • Incorrect patient information system record
Unexpected Patient Reaction: What unexpected patient reaction is prone to occur?	• Unexpected patient reaction

NOTE: 1) Apply the above questions to each subprocess. 2) If the related latent risks are found, add the corresponding failure modes to the subprocess making their expressions specified for the subprocess

Figure 2- General Failure Modes-Questions: For the Error Proofing Healthcare (EPH) model questions to assist in generating failure modes were produced in order to increase the number of potential failure modes generated.

HFMEA Step ____ Subprocess ____ : ______________________________

HFMEA Step 4 - Hazard Analysis									
Failure Mode		Scoring			Decision Tree Analysis				Potential Cause
		Severity	Probability	Haz Score	Single Point Weakness?	Existing Control Measure ?	Detectability	Proceed?	

Figure 3- HFMEA worksheet: Used in the Error Proofing Healthcare (EPH) model this worksheet is used to assist in determining which potential failures modes are high risk.

Generalized
Process Steps, Failures, Effects, and Causes

Instructions: Please use the filter to choose a process step that is similar to yours and think about the failure modes and causes that are associated with that process step

Please Choose a Similar Process Step or Function	Failure Modes	Causes
Decision	**Decision was Yes when it should have been No**	Inaccurate Data
Decision		Lack of Associate Knowledge
Decision	**Decision was No when it should have been Yes**	Inaccurate Data
Decision		Lack of Associate Knowledge
Decision	**Decision not made at all**	Non-Adherence to Policies and Procedures
Decision		Lack of Associate Knowledge
Decision		Resource Constraint
Decision		Roles and Responsibilities are not defined
Decision	**Decision made later than required**	Non-Adherence to Policies and Procedures
Decision		Lack of Associate Knowledge
Decision		Resource Constraint
Decision		Inadequate Information Provided
Authentication	**Fail to authenticate**	Lack of Associate Knowledge
Authentication		Non-Adherence to Policies and Procedures
Authentication		Communication Gap
Authentication		Roles and Responsibilities are not clearly defined
Authentication		Insufficient Information
Authentication	**Authenticate someone who should not have access**	Lack of Associate Knowledge
Authentication		Non-Adherence to Policies and Procedures
Authentication	**Fail to authenticate someone who should have access**	Insufficient Policies and Procedures
Authentication	**Take too long to authenticate**	System Limitations
Authentication		Lack of Associate Knowledge
Authentication		Insufficient/Unavailable Data
Review/Approve	**Review not performed**	Lack of Associate Knowledge
Review/Approve		Non-Adherence to Policies and Procedures
Review/Approve		Resource Constraint
Review/Approve	**Approval beyond your authority to approve**	Inadequate Policies and Procedures
Review/Approve		Lack of Associate Knowledge
Review/Approve		Non-Adherence to Policies and Procedures
Review/Approve	**Approval when correct decision would have been rejection**	Lack of Associate Knowledge
Review/Approve		Mis-Interpret data
Review/Approve		Inaccurate Data provided
Review/Approve		Inadequate Policies and Procedures
Review/Approve	**Rejection when correct decision would have been approval**	Non-Adherence to Policies and Procedures
Review/Approve		Lack of Associate Knowledge
Review/Approve		Inaccurate/Insufficient Data provided
Review/Approve	**Takes too long to review**	Inadequate Polices and Procedures
Review/Approve		Resource/Workload Constraint
Review/Approve		System Limitations
Review/Approve		Non-Adherence to Policies and Procedures
Review/Approve	**Review not thoroughly executed**	Lack of Associate Knowledge
Review/Approve		Non-Adherence to Policies and Procedures
Review/Approve		Inadequate/Insufficient Data provided
Review/Approve	**Review completed and not documented appropriately**	Non-Adherence to Policies and Procedures
Review/Approve		Lack of Associate Knowledge
Review/Approve		System Limitations
Transcription	**Transcribed inaccurately**	Lack of Associate Knowledge
Transcription		Non-Adherence to Policies and Procedures
Transcription		Resource/Workload Constraints
Transcription		Data not entered
Transcription		Data Inaccurately Recorded
Transcription		Non-Data Recorded
Transcription	**Not transcribed in a timely manner**	Lack of Associate Knowledge
Transcription		Non-Adherence to Policies and Procedures
Transcription		System Limitations
Transcription		Inadequate/Undefined Timeline
Transcription		Resource/Workload Constraints

Figure 4- Standardized Process Steps, Failure Modes, and Causes

Report	**Reported data is not timely**	Lack of Associate Knowledge; Non-Adherence to Policies and Procedures; Inadequate/Undefined Timeline; Isurfficient/Unavaliable data; Lack of Service Level Agreement
Report		Non-Adherence to Policies and Procedures
Report		Inadequate/Undefined Timeline
Report		Insufficient/Unavailable Data
Report		Lack of Service Level Agreement
Report	**Reported data is not relevant to the operation in question**	Technology Limitations
Report		Lack of Associate Knowledge
Report	**Reported data is relevant to operation in question but not valid**	Technology Limitations
Report		Lack of Associate Knowledge
Report		Insufficient/Unavailable Data
Report	**Reported data is relevant and valid, but is not "enough" data to make decision**	Limited Population
Report		Technology Limitations
Report		Insufficient/Unavailable Data
Report	**Report is not produced**	Non-Adherence to Policies and Procedures
Report		Lack of Associate Knowledge
Report		System Limitations
Report		Non-Adherence to Policies and Procedures
Report		Lack of Service Level Agreement
Report		Insufficient/Unavailable Data
Develop/Build/Maintain	**Built solution does not work**	Lack of Associate Knowledge
Develop/Build/Maintain		Technology Limitations
Develop/Build/Maintain		Financial Constraints
Develop/Build/Maintain		Inadequate Testing Conducted
Develop/Build/Maintain		Incorrectly Designed
Develop/Build/Maintain	**Built solution does not conform to requirements**	Inadequate Testing conducted
Develop/Build/Maintain		Incorrectly Designed
Develop/Build/Maintain		Technology Limitations
Develop/Build/Maintain		Lack of Associate Knowledge
Develop/Build/Maintain		Lack of Quality Assurance Process
Develop/Build/Maintain	**Built solution does not deliver required customer value**	Incorrectly Designed
Develop/Build/Maintain		Technology Limitations
Develop/Build/Maintain		Financial Constraints
Develop/Build/Maintain		Lack of Associate Knowledge
Develop/Build/Maintain		Lack of Voice of the Customer
Develop/Build/Maintain		Inadequate/Undefined Timeline
Develop/Build/Maintain	**Built solution not delivered in a timely fashion**	Non-Adherence to Policies and Procedures
Develop/Build/Maintain		Technology Limitations
Develop/Build/Maintain		Financial Constraints
Develop/Build/Maintain		Lack of Associate Knowledge
Develop/Build/Maintain		Inadequate/Undefined Timeline
Develop/Build/Maintain		Resource Constraint
Develop/Build/Maintain		Lack of Service Level Agreement
Develop/Build/Maintain		
Deliver Product/Service to Customer	**Do not deliver at all**	Non-Adherence to Policies and Procedures
Deliver Product/Service to Customer		Lack of Associate Knowledge
Deliver Product/Service to Customer		Unavailable Product/Service
Deliver Product/Service to Customer	**Do not deliver in a timely fashion per disclosures**	Non-Adherence to Policies and Procedures
Deliver Product/Service to Customer		Lack of Associate Knowledge
Deliver Product/Service to Customer		System Limitations
Deliver Product/Service to Customer		Resource/Workload Constraints
Deliver Product/Service to Customer		Unavailable Product/Service
Deliver Product/Service to Customer		Inadequate/Undefined Timeline
Deliver Product/Service to Customer	**Do not deliver product/service customer was expecting**	Non-Adherence to Policies and Procedures
Deliver Product/Service to Customer		Lack of Quality Assurance Process
Deliver Product/Service to Customer	**Do not deliver in a timely fashion per customer expectations**	Lack of Associate Knowledge
Deliver Product/Service to Customer		Clear Expectations not set
Deliver Product/Service to Customer		Inadequate/Undefined Timeline
Deliver Product/Service to Customer		System Limitations
Deliver Product/Service to Customer		Unavailable Product/Service
Deliver Product/Service to Customer		Resource/Workload Constraints
Deliver Product/Service to Customer	**Do not deliver product/service as we promised it**	Non-Adherence to Policies and Procedures
Deliver Product/Service to Customer		System Limitations
Deliver Product/Service to Customer		Lack of Associate Knowledge

Figure 4 (Continued)

Monitor/Oversee/QA	**Monitor the wrong elements**	Lack of Associate Knowledge; Non-Adherence to Policies and Procedures;
Monitor/Oversee/QA		Non-Adherence to Policies and Procedures
Monitor/Oversee/QA	**Method for monitoring does not present an accurate reflection of performance**	Lack of Governance
Monitor/Oversee/QA		Lack of Associate Knowledge
Monitor/Oversee/QA		Inaccurate Sampling Performed
Monitor/Oversee/QA	**Monitor too infrequently to provide feedback**	Inaccurate/Unavailable Statistical Sample
Monitor/Oversee/QA		Lack of Associate knowledge
Monitor/Oversee/QA		System Limitations
Communicate	**Communicate incorrect information**	Lack of Associate Knowledge
Communicate		Non-Adherence to Policies and Procedures
Communicate		Lack of Customer Knowledge
Communicate	**Communicate incomplete information**	Lack of Associate Knowledge
Communicate		Non-Adherence to Policies and Procedures
Communicate		Lack of Customer Knowledge
Communicate	**Communicate too much information**	Lack of Associate Knowledge; Non-Adherence to Policies and Procedures; Lack of Customer Knowledge
Communicate		Non-Adherence to Policies and Procedures
Communicate		Lack of Customer Knowledge
Communicate	**Take too long to deliver communication**	Non-Adherence to Policies and Procedures
Communicate		Lack of Service Level Agreements
Communicate		Resource Constraints
Communicate	**Communication is unclear**	Lack of Associate Knowledge
Communicate		Lack of Customer Knowledge
Communicate	**Take too long to produce communication**	System Limitations
Communicate		Lack of Associate Knowledge
Communicate		Lack of Standardized Processes
Communicate		Non-Adherence to Policies and Procedures
Communicate		Resource Constraints
Gather requirements from Customers	**Talking to the wrong customers**	Voice of the Customer was access accurately
Gather requirements from Customers		Lack of Associate Knowledge
Gather requirements from Customers		Lack of Customer Knowledge
Gather requirements from Customers	**Mis-interpret customer needs**	Inappropriate Sample Size
Gather requirements from Customers		Lack of Associate Knowledge
Gather requirements from Customers		Communication gap
Gather requirements from Customers	**Not talking to enough customers**	Lack of Associate Knowledge; Inappropriate Sample Size;
Gather requirements from Customers	**Takes too long to gather requirements**	Inadequate Policies and Procedures
Gather requirements from Customers		Lack of Service Level Agreements
Gather requirements from Customers		Lack of Associate Knowledge
Gather requirements from Customers	**Requirements not gathered**	Lack of Associate Knowledge
Gather requirements from Customers		Lack of Governance

Figure 4 (Continued): For the Error Proofing Transactions (EPT) model generalized sub-processes, failure modes, and causes were generated to assist in determining high risk failure modes. These suprocesses, failure modes, and causes were generated using data from a large transactional corporation.

Transactional Failure Mode and Effects Analysis			
Process	Project Name	Team Leader	Date

Instructions: Comment boxes are imbedded in each column heading to provide direction on how to complete this form. There is an attached worksheet that lists standardized failure modes, effects, and causes. When your risky failures are determined please insert these failures into the Solutions and Scoring Worksheet.

Process Step/ Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Current Process Controls Inspection Prevention Detection	RPN

Severity Scoring		Occurrence Scoring	
5	Loss of Customer	5	Failure Almost Always Occurs
4	Very likely that the Customer will be dissatisfied and business will be lost	4	Failure Occurs Repeatedly
3	Customer will be affected and business could potentially be lost	3	Failure Occurs Occasionally
2	Customer is not likely to notice or be affected	2	Failure Occurs Only a Few Times
1	No effect	1	Failure is Unlikely to Occur

Figure 5- Standardized Effects: Used in the Error Proofing Transactions (EPT) model this worksheet is used to assist in determining which potential failures modes are high risk.

Solutions

Instructions: From your SFMEA please insert all of your Risky Failures (failures with an RPN>=10) and generate solutions for these failures using the worksheet labeled "TRIZ." Then complete all of the required sections to determine which solution if best for each failure. There are comments for each section (red triangle in top right corner)

Failure Modes	Solutions	Cost of Solution						Ease of Implementation Score	SPN	Action Plan	
		Cost of Failure Occurring (Annually)	% Elimination of Error	Cost of Implementation	ROI	# Months to Break Even	ROI Score			Who is Responsible	Target Date
					0	0			0		

Costs to Consider	
Hidden Costs Think of all of the costs that are related to a failure occurring that are not easily seen	**Visible Costs**
Poor Word of Mouth	Waste
Excessive Training	Rework
Delays	Cost of a Lost customer
Downtime	Rejects
Overtime	Employee Time
Lost Sales	
Billing Errors	
Employee Turnover	
Customer Allowances	
Complaint Handling	
Software Incompatibilities	
Non-value Added Work	
Opportunity Cost	
Facility Cost	
Number of Transactions Performed	
Number of Staff Required	
Experience of Staff/Training	
Risk Associated	
Number of Customers Serviced	
Level of Detail Required	
Regulatory Costs	
Degree of Automation	
Fees and Commissions	

ROI Scoring		Ease of Implementation Scoring	
1	**Low ROI/High # Months**: The return on investment is low and the number of months to break even is high.	1	**Hard/High Resistance:** The solution is hard to implement and high resistance is expected
2	**Moderate ROI/ Moderate # Months:** The return on investment is moderate and the number of months to break even is also moderate.	2	**Moderate/ Moderate Resistance:** The solutions is moderate to implement and moderate resistance is expected
3	**High ROI/ Low # Months:** The return on investment is high and the number of months to break even is low	3	**Easy/ Little or No Resistance:** The solution is easy to implement and little or no resistance is expected

Figure 6- Solutions and Scoring Table: Used in the Error Proofing Transactions (EPT) model this worksheets assists in determining the best solution by determining the ROI and how much of the failure each solution will eliminate.

Transaction Solution Direction (TSD) Table

Instructions: Look at the examples for each solution direction listed below and determine if this type of solution would keep your failure from occurring. Also ask yourself and the team each of the questions to determine if the solution direction could be used to mitigate your failure.

TRIZ Solution Direction	Transactional Definitions/Example	Questions
Preliminary action	Placing pictures on debit cards	Is there any action that can be performed before this process in order to keep an error from occurring?
Feedback	Reviews of Associates Work	Is there anyway to introduce some form of feedback into this process in order to eliminate errors?
Self-Service	Allowing Customers to Deposit Money and Checks via the ATM	Is there any part of this process where the service that is being performed can be completed by the "customer"?
Copying	Training being performed via the internet instead of on-site training	Is there any part of this process that can be replaced by a less expensive copy?
Segmentation	A loan application being completed in steps instead of all at one time.	Is there any part of the complex part of the process that can be divided into smaller simpler steps?
Local Quality	Having a manger at a bank perform numerous actions such as reviews of the associates at that bank	Is there any entity in the Local Environment that can perform a quality check?
Merging	The computer completing a required task while the associate is also completing a required task	Are there any parts of this process that can perform parallel operations?
Automation	Online Banking	Is there any part of this process that can be automated?
Standardization	Developing a List of Procedures that a teller needs to perform in order to complete a certain task	Is there anyway to standardize this process in order to keep failure from occurring?
Universality	A bank manager can open accounts and also perform managerial operations	Is there one part of this process that can perform multiple functions that does not currently perform multiple functions?
Repetition	An employee completing the same task over and over again in order to increase their proficiency at completing the task	Can any part of this process be repeated multiple times in order to eliminate errors?

Figure 7- TSD Table: Used in the Error Proofing Transactions (EPT) model to assist in developing solutions to prevent potential failures from occurring.

APPENDIX I

FMEA			
Process	**Project Name**	**Team Leader**	**Date**
Loan	N/A		

Instructions: Comment boxes are imbedded in each column heading to provide direction on how to complete this form. There is an attached worksheet that lists standardized failure modes, effects, and causes. When your risky failures are determined please insert these failures into the Solutions and Scoring Worksheet.

Process Step/ Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Detection	Current Process Controls	RPN
Deliver Product/Service to Customer	Incorrect Product	Customer Dissatisfied Loss of Business	3	Lack of Associate Knowledge	2	2		12
Gather Requirements from Customer	Customer Provides Incorrect Information	Incorrect Loan	3	Mistake of Customer	2	3		18
	Take too long to gather requirements	Customer Dissatisfied Loss of Business	4	Lack of Associate Experience Information hard to obtain	2	1		8
Transcription	Information is Entered Incorrectly	Incorrect Loan	3	Lack of Associate Experience	3	2		18
	Take too long to enter information	Customer Dissatisfied Loss of Business	4	Lack of Associate Experience	2	1		8
Review/Approve	Approve loan that should not be approved	Incorrect Loan	5	Guidelines not Identified	2	3		30
	Approval takes too long	Customer Dissatisfied Loss of Business	4	Guidelines not Identified	2	1		8

Figure 8- FMEA Completed in Case Study: An existing Failure Mode and Effects Analysis (FMEA) was conducted in a large transactional corporation analyzing the process of approving a loan.

APPENDIX I

Transactional Failure Mode and Effects Analysis

Process	Project Name	Team Leader	Date
Loan	N/A		

Instructions: Comment boxes are imbedded in each column heading to provide direction on how to complete this form. There is an attached worksheet that lists standardized failure modes, effects, and causes. When your risky failures are determined please

Process Step/ Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Current Process Controls Inspection Prevention Detection	RPN
Deliver Product/Service to Customer	Do not deliver at all	Loss of Sale	3	Non-Adherence to Policies and Procedures	2		6
		Reputation Damage		Lack of Associate Knowledge			
		Negative Customer Experience		Unavailable Product/Service			
		Loss of Existing Customer					
	Don not deliver in a timely fashion	Loss of Sale	2	Non-Adherence to Policies and Procedures	3		6
		Reputation Damage		Unavailable Product/Service			
		Negative Customer Experience		Inadequate/Undefined Timeline			
		Loss of Existing Customer		Lack of Associate Knowledge			
				System Limitations			
				Workload/Resource Constraints			
	Do not deliver product customer was expecting	Loss of Sale	3	Non-Adherence to Policies and Procedures	1		3
		Reputation Damage		Lack of Assurance Process			
		Negative Customer Experience					
		Loss of Existing Customer					
	Do not deliver in a timely fashion per customer expectation	Loss of Sale	3	Lack of Associate Knowledge	4		12
		Reputation Damage		Unavailable Product/Service			
		Negative Customer Experience		Workload/Resource Constraints			
		Loss of Existing Customer		Clear Expectations not set			
				Inadequate/Undefined Timeline			
				System Limitations			
	Do not deliver product as we promised it	Loss of Sale	3	Non-Adherence to Policies and Procedures	1		3
		Reputation Damage		System Limitations			
		Negative Customer Experience		Lack of Associate Knowledge			
		Loss of Existing Customer					
Gather Requirements from Customer	Takes too long to gather requirements	Loss of Sale	2	Inadequate/Undefined Timeline	3		6
		Negative Customer Experience		Lack of Service Level Agreements			
		Reputation Damage		Lack of Associate Knowledge			
		Loss of Existing Customer					
	Requirements not gathered	Rework	4	Lack of Associate Knowledge	2		8
		Negative Customer Experience		Lack of Governance			
		Uncompensated Risk Exposure					

Figure 9- TFMEA Completed in Case Study

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Transcription	Transcribed inaccurately	Rework	3	Lack of Associate Knowledge	2		6
		Negative Customer Experience		Data not entered			
		Uncompensated Risk Exposure		Data Inaccurately Recorded			
				Non-Data Recorded			
				Non-Adherence to Policies and Procedures			
				Resource/Workload Constraints			
	Not transcribed in a timely manner	Loss of Sale	2	Lack of Associate Knowledge	3		6
		Negative Customer Experience		Non-Adherence to Policies and Procedures			
		Loss of Existing Customer		System Limitations			
		Reputation Damage		Resource/Workload Constraints			
				Inadequate/Undefined Timeline			
Review/Approve	Review not performed	Loss of Sale	4	Lack of Associate Knowledge	1		4
		Negative Customer Experience		Non-Adherence to Policies and Procedures			
		Loss of Existing Customer		Resource/Workload Constraints			
		Reputation Damage					
	Approval beyond authority to approve	Uncompensated Risk Exposure	4	Inadequate/Undefined Timeline	2		8
		Regulatory Violations		Non-Adherence to Policies and Procedures			
				Lack of Associate Knowledge			
	Approval when correct decision would have been rejection	Uncompensated Risk Exposure	5	Lack of Associate Knowledge	2		10
		Regulatory Violations		Inaccurate Data Provided			
				Inadequate Policies and Procedures			
				Misinterpret Data			
	Rejection when correct decision would have been approval	Uncompensated Risk Exposure	5	Lack of Associate Knowledge	2		10
		Regulatory Violations		Inaccurate Data Provided			
		Loss of Existing Customer		Inadequate Policies and Procedures			
		Loss of Sale		Misinterpret Data			
	Take too long to review	Loss of Sale	2	Inadequate Policies and Procedures	3		6
		Negative Customer Experience		Resource/Workload Constraints			
		Loss of Existing Customer		System Limitations			
		Reputation Damage		Non-Adherence to Policies and Procedures			
	Review not thoroughly executed	Rework	3	Lack of Associate Knowledge	2		6
		Uncompensated Risk Exposure		Inadequate/Insufficient Date Provided			
		Uncompensated Risk Exposure		Non-Adherence to Policies and Procedures			
	Review completed and not documented	Uncompensated Risk Exposure	3	Non-Adherence to Policies and Procedures	3		9
		Rework		Lack of Associate Knowledge			
		Regulatory Violations		System Limitations			

Figure 9 (Continued): In a case study at a large transactional corporation the Transactional Failure Mode and Effects Analysis (TFMEA), which is part of the Error Proofing Transactions (EPT) model, was conducted in a large transactional corporation analyzing the process of approving a loan.

APPENDIX I

Solutions

Instructions: From your SFMEA please insert all of your Risky Failures (failures with an RPN>=10) and generate solutions for these failures using the worksheet labeled "TRIZ." Then complete all of the required sections to determine which solution if best for each failure. There are comments for each section (red triangle in top right corner)

Failure Modes	Solutions	Cost of Solution						Ease of Implementation Score	SPN	Action Plan	
		Cost of Failure Occurring (Annually)	% Elimination of Error	Cost of Implementation	ROI	# Months to Break Even	ROI Score			Who is Responsible	Target Date
Do not deliver in a timely fashion per customer expectation		0	0	0	0	0	0	0	0		
Rejection when correct decision would have been approval		0	0	0	0	0	0	0	0		
Approval when correct decision would have been rejection	Manger Review Application and Decision	$ 33,067,545.00	0.7	$ 1,196,000,000.00	$ 0.02	5	1	2	2		
	Computer Pre-Approval		0.9	$ 35,760.00	$ 832.24	1	2	3	6		
	Customer Input all Required Information		0.5	$ 1,320.00	$ 12,525.59	1	3	3	9		
	Have multiple individuals approve different parts of the loan		0.6	$ 174,720,000,000.00	$ 0.00	734	1	1	1		
	Automate the Loan Approval		0.99	$ 35,760.00	$ 915.46	1	2	3	6		
	Create a Checklist of Steps to be Performed		0.7	$ 5,320.00	$ 4,350.99	1	3	2	6		
	Create a Standardized Process		0.75	$ 5,320.00	$ 4,661.78	1	3	2	6		

Figure 10- Solutions and Scoring: Completed in Case Study: In a case study at a large transactional corporation the Error Proofing Transactions (EPT) model was utilized to generate potential solutions for the high risk failure mode of "approval when correct decision would have been rejection" for the process of approving a loan.

Existing FMEA				
FMEA				
Failure Modes	Effects	Causes	High Risk Failures	Time to complete Failure Modes, Effects, & Causes
7	11	8	1	60 Minutes
EPT Model				
TFMEA				
Failure Modes	Effects	Causes	High Risk Failures	Time to complete Failure Modes, Effects, & Causes
16	45	53	3	35 Minutes

Solutions were generated for the High Risk Failure Mode of: "Approval when correct decision would have been rejection"		
Existing FMEA		
Brainstorming		Solution Selection
Number of Solutions Generated	Time to Generate Solutions	Solution Selected
2	15 Minutes	standardizing the process for the approval of loans
EPT Model		
TRIZ Solution Directions		SPN Solution Selection
Number of Solutions Generated	Time to Generate Solutions	Solution Selected
8	15 Minutes	customer input all of the required information

Figure 11- Comparison of Existing FMEA and EPT Model: A case study at a large transactional corporation compared the existing Failure Mode and Effects Analysis to the new Error Proofing Transactions (EPT) model. The result for the comparison of the two models is shown.