Cost Benefit Analysis of an Automated Labeling System for Green Tokai Co., LTD.

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COST-BENEFIT ANALYSIS OF AN AUTOMATED LABELING SYSTEM FOR GREEN TOKAI CO., LTD.

An internship report submitted in partial fulfillment of the requirements for the degree of Master of Science

By

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ABSTRACT


This project was conducted in order to analyze the causes of domestic trouble tickets (DTRs) at Green Tokai Co., Ltd., as well as provide recommendations on how to reduce them. DTRs cost Green Tokai $518,000 annually.

At the onset of this project it became clear that one of the major contributors to DTRs was the labeling process that was in place. Green Tokai was shipping incorrectly labeled parts to customers. This problem became the primary focus of the project, and several recommendations were made in order to reduce the DTRs due to labeling issues.

Many of the labeling issues could be traced to the general categories of training and poor processes. The team investigated each of these areas and made recommendations to correct them. Most of these recommendations were procedural changes that could be implemented at little cost to the company. The recommendation for a line-side labeling system, however, was the exception.

A cost-benefit analysis was performed on a line-side labeling system called Error Proof. This system was to be installed by Freedom Technologies Inc. The cost-benefit analysis for this system revealed that it would have an initial implementation cost of $176,060, and it was expected to provide an annual DTR savings of $21,500. As an added benefit the system would also reduce scrap by $11,000 per year. The analysis showed that at the end of the 10 year useful life of the system it would have a cumulative net present value of $21,600.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>II. PROJECT INITIATION</td>
<td>5</td>
</tr>
<tr>
<td>III. PROCESS DETAILS</td>
<td>13</td>
</tr>
<tr>
<td>IV. COST-BENEFIT ANALYSIS</td>
<td>20</td>
</tr>
<tr>
<td>OVERVIEW</td>
<td>20</td>
</tr>
<tr>
<td>THEORETICAL MODEL</td>
<td>21</td>
</tr>
<tr>
<td>EMPIRICAL MODEL</td>
<td>25</td>
</tr>
<tr>
<td>RESULTS</td>
<td>29</td>
</tr>
<tr>
<td>V. RECOMMENDATIONS</td>
<td>31</td>
</tr>
<tr>
<td>VI. CONCLUSION</td>
<td>34</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>1. FIGURE 1: PROCESS FLOW CHART</td>
<td>36</td>
</tr>
<tr>
<td>2. TABLE 2: COST-BENEFIT ANALYSIS</td>
<td>37</td>
</tr>
<tr>
<td>3. TABLE 3: 1ST SENSITIVITY ANALYSIS</td>
<td>38</td>
</tr>
<tr>
<td>4. TABLE 4: 2ND SENSITIVITY ANALYSIS</td>
<td>39</td>
</tr>
<tr>
<td>5. TABLE 5: 3RD SENSITIVITY ANALYSIS</td>
<td>40</td>
</tr>
<tr>
<td>6. TABLE 6: 4TH SENSITIVITY ANALYSIS</td>
<td>41</td>
</tr>
<tr>
<td>7. TABLE 7: 5TH SENSITIVITY ANALYSIS</td>
<td>42</td>
</tr>
</tbody>
</table>
I. INTRODUCTION

This project was initiated to find ways to reduce the domestic trouble reports (DTRs) that Green Tokai Co., Ltd. incurs during the course of business. One of the potential elements to this reduction is a proposed line-side labeling system. This system would greatly reduce the errors that are caused by the mislabeling of parts, containers, and shipments by eliminating the human errors in the process. The desire to reduce these errors spawned from the complaints from customers about the large number of incorrect parts that they were receiving. These complaints lead to DTRs.

In order to fully understand this project it is important to first understand Green Tokai, their products, and their customers. Green Tokai is a manufacturing firm that was founded by Ernie Green, a retired professional football player, in 1981, as Ernie Green Industries. A Japanese firm, Tokai Kogyo, bought the company in 1985 and changed its name to Green Tokai Company Ltd. Ernie Green remains on the board of directors today.

Green Tokai is a manufacturing company that specializes in automotive trim manufacturing, plastic injections pieces, and rubber and plastic extrusion parts. In all, Green Tokai manufactures over 800 different parts. Examples of these parts would be; body-side moldings, trunk seals, sunroof seals, front window seals, and rocker panels. They currently produce these parts for several different customers including; Honda, Toyota, Nissan, and Isuzu. Seventy-two percent of their parts are produced for Honda. Since Honda accounts for so much of Green Tokai’s business they have considerable
influence on the decision-making process. Honda is the main reason that this project is being considered.

Green Tokai makes shipments to Honda plants across the country every single day. They produce thousands of parts per day for Honda. Recently Honda has become concerned with the accuracy of the shipments they are receiving. When they notice a problem with a shipment, whether there are incorrect parts or quantities or defective parts, they send those parts back to the Green Tokai plant. These returns from Honda are called Domestic Trouble Reports (DTRs). After GTC receives these DTRs from Honda the shipment is inspected and an investigation into the reason for the problem takes place. As Honda became more concerned with the number of bad shipments they received they increasingly pressured GTC to correct the problems. Therefore, a large reason that the project was considered by Green Tokai was to maintain a good relationship with their biggest client.

Another reason that this project is being considered is the cost of Domestic Trouble Reports to the company. In fiscal year 2002, Green Tokai had $518,000 worth of DTRs. This accounted for nearly half of GTC's operating loss for the fiscal year. The goal of this new project is to eliminate as many DTRs as possible, without exceeding budgetary constraints. The budget is extremely tight due to the amount of capital that the company has put in to new model development and production for the fiscal year, and it is expected that, if successful in the initial implementation, more money would be allocated to the project in the future. A team was formed and charged with the task of solving the DTR problem as cost-effectively as possible. The team consisted of representatives from the Shipping, Sales, Quality Assurance, Purchasing, and MIS
departments. The team researched reasons for the DTRs and possible solutions. That is when Freedom Technologies Corporation became involved.

Freedom Technologies Corp. is an Information Technology consulting firm that specializes in developing complex IT systems for manufacturing companies. These systems consist of anything from software packages to robotic systems that help reduce errors on the manufacturing lines. Freedom was brought in to view GTC’s production lines and to make recommendations. Freedom recommended a system that would reduce the DTRs by using hardware and software that would be installed on the production line. This system was going to use scanners, printers, monitors, scales, and a server with MS Visual Basic software installed.

Once the team received the estimate for the project we had to decide whether or not this option was cost-effective. In addition to deciding the cost-effectiveness of the project, a limited budget and external factors influenced our decision. The budget is extremely tight due to the amount of capital that the company has put into new model development and production for the fiscal year, and it is expected that, if successful in the initial implementation, more money would be allocated to the project in the future. The most notable external factor was the pressure being applied by Honda to reduce errors and improve the overall quality of our products.

The DTR analysis team’s responsibility was to reduce DTRs, and the cost-benefit analysis of Freedom Technologies’ Line-side labeling Error Proof system was just one component of that task. While the system was capable of reducing DTRs that were caused by errors in the labeling process, it alone could not eliminate all of the problems. The team also identified other methods for reducing domestic trouble reports and helping
the company run more cost-effectively. Therefore, this paper discusses all aspects of the project. The cost-benefit analysis is the main focus of the project, but the paper will also discuss background information about the manufacturing process as a whole. Much of this will be helpful in performing the cost-benefit analysis.

In the process details section of the paper, the manufacturing process and the proposed Error Proof system will be detailed and illustrated. The methodologies section of this paper will detail the process and reasoning used in conducting the cost-benefit analysis. This will include both theoretical and empirical discussions. The results section of the paper will include the results for not only the cost-benefit analysis, but also any other pertinent information regarding the reduction of DTRs.
II. PROJECT INITIATION

The first step in the project initiation was to determine the cause of the DTRs. We knew that Honda would return shipments for many various reasons, including: incorrect parts (i.e. incorrect colors or part numbers), incorrect labels on the parts, on the packaging, or both, as well as incorrect quantities of parts. We discovered that the errors were equally dispersed throughout these categories. Many of the shipments had multiple errors and in those cases, we noticed that many of the multiple problems were a result of mislabeling the parts and/or the packaging. With the identification of the mislabeling problem we decided to focus on that problem as a way to reduce DTRs in general.

The DTR labeling problem became the primary focus, and our first goal was to determine why these problems were appearing. There were several reasons that mislabeling was occurring: training, lack of label control, shipping of labeled parts, old labels on packaging, quality issues, and lack of process control. We compiled data from DTR labeling problems and then assigned one of the above root causes to each DTR. Below is an analysis of each problem.

*Training*

The first problem that was attributed as a cause of mislabeling was training. Employee training is an important part of any process, and substandard training can lead to the breakdown of any system no matter how well the process was designed. Training problems accounted for 17.9% of the labeling problems in fiscal year 2002. We discovered that employees receive some on-the-job training, but often times they were
trained by people that did the job improperly. Therefore, we have been training bad habits into our process. Another major deficiency in the training process was the operating procedures manual for each production line. Each line has a standard operating procedure training manual. This manual explains every step of the process in detail, and also outlines what to do in given situations. The manual also contains the inspection and labeling criteria for each part that is produced on that line. The problem with the SOP manual was that it was very cumbersome and as revisions were made they were not properly organized. Sometimes there were four or five revisions of a process that were in the manual, and the employee had to sort through all of them to find the correct current procedure. Another problem is that some of the manuals were just outdated.

To fix the training problem we designated a “trainer” for each line. It was decided that the team leader for each process would serve as the “trainer” for that area. That person would be responsible for training or retraining all employees that worked on that line. Also we made sure that the trainer knew the correct procedures for the job, and they were to be given regular updates and directions from the director of their production department. To solve the SOP manual’s problems we decided that the best course of action would be to completely rewrite all of the procedures and assign a librarian for each of the three divisions that were responsible for keeping the manuals up to date and organized. These initiatives should help to correct some of the labeling issues that occur.
Lack of Label Control

The lack of label control means that there were not sufficient checks to ensure that labels were being produced and applied properly. Many labels were printed with incorrect information, were the wrong size, or were put onto the wrong packages and parts. We found that in 2002, lack of control for the labels accounted for 21.4% of all labeling issues. This made this problem one of the most serious for the labeling process.

Freedom Technologies’ Line-Side Labeling Error Proof® system would be more than capable of fixing this problem. The Error Proof system would be able to produce the correct labels for each part by use of a monitor that is capable of determining the part and the color of the part as it comes off of the production line. It would then print the labels for the part and for the shipping container at the line. This would ensure that the labels used are the correct size and contain the proper information for the part. Freedom claims that the system is 100% accurate and will stop the line if there is a problem in recognizing the type of part or the color of the part.

Shipping Labeling

When the shipping label is applied to a package it is sometimes applied incorrectly or the label is wrong. This problem is similar to the above problem, lack of label control. The packages that are mislabeled can cause parts to be shipped to the wrong plant, and cause Green Tokai to incur the price of another DTR. The DTR analysis team determined that the only acceptable failure rate for shipping is 0%. We determined that if the parts are labeled correctly at the production line by Freedom’s Error Proof system, then there should be no reason that the incorrect labels are applied in shipping.
The Error Proof system consists of wireless handheld scanners that can read the package label and send that information to the server. The server contains shipping information and transmits that information to the label printer, which then prints the proper label for that package. The shipping label can then be scanned at anytime and the label will tell when and where the package is scheduled to be shipped. This process in conjunction with the Error Proof system that is placed at the production line should be able to completely eliminate the errors in the shipping label process, which currently account for 14.3% of the DTRs.

*Old Labels on Packaging*

This problem occurs when packages are re-used and the wrong label is scanned or a new label is not even put onto the package. The procedure to follow when re-using packaging is to clearly mark-out the old label with a red marker, and then apply the new label to the appropriate location. If this process is followed it should eliminate most of the errors of this type. This type of error only accounts for 7.1% of the labeling DTRs. The Error Proof system can also help eliminate errors that may still exist due to operators not performing their function correctly. The scanners that will be used in shipping can determine if the label that is scanned on a package has already been used, and if so, will give the operator an error signal. This tells the operator that something is wrong and allows them to correct the problem. The operator should mark-out the incorrect label and scan in the correct label. If no other label is found the operator must determine where the package came from by opening it and scanning the part labels. The software application of the system can tell when and where the part was run and can produce the proper label.
for that package. However, this should not need to be done because the system produces a label at the line and will not process additional pieces until the operator has signed off in the system that the label has been applied. These measures combined should eliminate this problem from occurring.

**Quality Issues**

There are many quality issues that cause DTRs. Many of these problems can be solved by solutions that were previously discussed in this project. Better training and control of the production process can eliminate many of these errors. One of the key sources of errors is bad material. We often do not inspect the material that comes into the plant. Inspection is a time consuming and ineffective way of reducing errors with material. Although GTC has taken the approach that our suppliers should improve the quality of their materials so that we do not have to check them, we do still require visual inspection of the raw materials at the production line. This helps to eliminate bad parts before they are made. This has been expressed to our suppliers, and we have seen an improvement in the quality of materials coming into the plant. Scrap parts due to bad material are down from 6% in June to 3.2% in August. Our goal is to have a scrap rate due to bad material of less than 1%.

Another quality issue stems from the lack of proper nonconformity recognition at the end of the production process. Parts are visually inspected as they come off of the line, and quality assurance examines samples to determine if a machine is functioning within its normal limits. Other times the part comes off of the line within specifications,
but is handled poorly after that time, which may cause damage to the parts as they are packed and as they are stored or shipped.

In order to ensure that the machines are working properly quality assurance has been assigned to develop a charting system that can be conducted at the workstation that allows the team leader to check to see if the distribution of parts starts to drift towards the limits of the acceptable error. If the Freedom system is implemented it will allow the operator to concentrate on the quality of parts instead of worrying about measuring or weighing them. The Error Proof system can measure parts as they pass under the camera, and record this measurement. The team leader can print charts that will show the distribution of parts throughout the acceptable range. If the team leader notices that the standard distribution of the parts is getting close to the limits he/she can shut the machine down while it is checked and calibrated if needed.

The Error Proof system can help reduce many of the quality issues by having a standard that is free of human error. The camera measures the pieces, checks their color, and weighs them at the end of the process. The problem is that this can help reduce DTRs, but does nothing to save the company money from scrap production. This issue will be addressed in the next section.

*Lack of Process Control*

When examining the entire production process from a labeling and error reduction standpoint we concluded that the factor causing most errors was a lack of process control. Process control needs to be established for the entire production process in order to reduce errors. Not including the problems areas already mentioned, we estimated that a lack of process control can be attributed to over 21% of the labeling errors. The process
needs to be controlled better at every stage. There are controls needed in the receiving and shipping departments as well as with the production lines and quality assurance. The Error Proof system that Freedom has designed for GTC can help eliminate some of these problems.

The first area that the system can help gain control of is receiving. Currently receiving does not use any scanners to scan incoming equipment. The new system would provide them with the same hand held scanners that shipping will use. To save money these scanners can also be purchased independently of the system from another vendor. The scanners will relay the material information to the server, which allows our purchasing department to have a better understanding of our on-hand quantities without having to go out and physically count inventories.

Another control that can be provided by Freedom’s system would be the ability to scan the material at the beginning of the line. This may help reduce the amount of scrap that is caused by using the incorrect material for a given job, although we currently do not have any figures of these possible cost savings.

The issues stated above are the key elements to reducing GTC’s domestic trouble reports. Many of these issues can be remedied by the successful implementation of the Error Proof line-side labeling system, but a few of the problems will need alternate solutions. The goal of this project is to reduce all DTRs and not just those that can be fixed with the Error Proof system. Therefore, in the recommendations section of this paper, there will be a discussion of all of the possible cost-saving measures that this team developed along with the recommended action to be taken concerning the Error Proof system.
The purpose of this section is to give a detailed description of the advantages and disadvantages of the proposed Error Proof system, the manufacturing process for which the Error Proof system is being considered, and also to give a detailed description of the system itself. The description of the process will include not only the actual assembling of the part but also what needs to happen to get the material ready to begin the production process. It will also include a description of what happens to the parts after production is finished. This will allow us to understand the entire process flow, so that any decisions being made about the process are completely informed. The detailing of the system will cover how it works and exactly how it will improve the overall production process, including shipping and receiving. A workflow of the process with the system in place will also be included in this discussion.

Advantages

The one major advantage to the Error Proof system is that it eliminates most errors. It accomplishes this by taking much of the human element out of the error proofing process as well as providing more controls to eliminate problems in all aspects of the production process. The system uses four different types of error proofing. These error proofing methods are: label error proofing; production error proofing; shipping error proofing; and quality error proofing.
**Label Error Proofing**

Label error proofing ensures that the correct label with the correct information on it is applied to the part and to the packaging. Currently, labels are kept at each line and many times the labels that are being used might be outdated and have incorrect information on them. Also, the label does not contain as much information as we would like on it. The labels that are used in the Error Proof system contain 2D bar codes as opposed to the linear bar codes on the current labels. Linear bar codes are the type of codes that are on most goods that are sold at a department or grocery store. They are only able to hold 20 characters and have the ability to hold much less data. 2D bar codes or 2D symbology contain information on two different dimensions (vertical and horizontal). They have the ability to hold five times as many characters and have the ability for data restoration. This allows for complex information to be stored in a label, and data restoration enables data to be recovered when a portion of the label becomes damaged. The label error proofing also includes: item/part labeling; container labeling; master labeling; customer compliance labeling; production/work-in-progress (WIP) tracking; and receiving & material tracking.

**Production Error Proofing**

Production error proofing ensures that the production process is done right. The system authenticates the production process to ensure the process is correct, the product structure to make certain that the product meets specification, containerization to ensure
the correct containers are loaded with the correct part, and attribute-feature authentication
to ensure that the product is the right color or is the correct side (right/left).

**Shipping Error Proofing**

Shipping error proofing is an important form of error proofing that ensures that
the correct parts and quantities are shipped to the correct customers. The Error Proof
system also verifies that the label complies with company and customer guidelines.

**Quality Error Proofing**

Quality error proofing includes component lot tracking in receiving and inventory
and monitors production usage. It allows for tracking of the production process through
the use of scanners and a reporting system. Quality error proofing also consists of data
management. Test and measurement data is captured along with material certifications
and the production date and time stamp.

Another advantage of the system is the ability for direct part marking. Direct part
marking is a method of marking a part with a label or some other system such as dot-peen
marking, ink-jet marking, or laser marking. Each of these marking systems has
advantages and disadvantages to it. The direct marking helps in the error proofing
process and also lot control, shipping/containerization, serialization, product
identification, production automation, and part path history traceability.
Disadvantages

The main disadvantage to the system is the time and money that must be invested into it. The initial costs of the system would be over $170,000 just to get the system up and running on one line. The price to set up the system on all of GTC's lines would be over 1 million dollars. In addition, there are annual costs that would have to be incurred. Another disadvantage of the system is that it requires intensive training to learn how to use it properly. The initial training for the system would be provided by Freedom Technologies, but any additional training would be the responsibility of Green Tokai. Fortunately, much of this training can be provided on the job without taking much time away from useful productive labor (revenue generating labor). The system could conceivably make the production of parts take longer, also. While this is not a definite, it is conceivable that the time spent logging into the system, producing labels, and applying direct part marking could take more time than the current process. The system would also need to be maintained by the software engineer. The software for the system is written in MS Visual Basic, and while major problems would be handled by Freedom, many of the routine updates and patches would have to be handled by the software engineer at GTC and currently there is only one on staff. This problem is not likely to be a large factor until the system is installed on several production lines.

Due to the up-front cost of the system and the budget constraints for the current fiscal year, Freedom's Error Proof system is only going to be considered for implementation for one production line for now. In order to determine which line would be selected we had to identify the lines that produced the highest DTR costs. We also had to take into account the feasibility of implementing the Error Proof system on that
line. Some lines, due to the nature of their input/output and flow are not proper candidates for this system. Along with the Freedom consultant we excluded all of the extrusion lines. Extrusion lines produce output that is measured by the length of material used. It is usually one continuous piece that is processed further on another line. Extrusion lines are also referred to as work-in-progress (WIP) lines because they produce material that is not a finished good. We selected a finish line, line 610-A, which produces body-side moldings for the Honda Accord and Odyssey. These are injection parts that are have snaps on them that allow the part to be snapped into place on the left/right side of the vehicle. Due to the nature of this part there is a high probability for error associated with it. On the Accord, for example, there are four different moldings. Each front door and each rear door has a different molding. These moldings all look very similar and can easily be confused by a human inspector. This line was identified as being the most problematic, but also as one that has a process that is well suited for the Error Proof system.

The current process for this part consists of an operator visually checking the material before loading it into the machine. The machine then processes the material and produces the part. The operator then applies the clips and tape to the backing of the part and again visually inspects it for non-conformities. The part is then placed into a container. This process continues until the container is fully packed, at which point the operator seals it and has it sent to inventory. Any scrap that the operator finds is put into a scrap bin and counted at the end of the shift.

In addition to implementing the system on the 610-A line, changes also have to be made to the shipping and receiving processes. The receiving process does not currently
use any scanners or label printers. In order to ensure complete quality control it will be necessary to change the practices in the receiving department. The new receiving process will have receiving scanning shipments that they receive, so that the system knows what is in inventory. This will also benefit the purchasing department because it will facilitate their inventory control and make it easier for them to know what to order and when. The system will then print a label on the material that will contain data about the part and when it was received. This process also allows the production line to scan the material into their process, which will be discussed in more detail later in this section.

Changes will also need to be made to the shipping process, but these changes will be less apparent because of the style of process that is already in place. Currently shipping uses scanners when they receive finished goods from the line and put them into their finished goods inventory. The new scanners will also allow them to relay information to the system about where the parts are stored on the floor, and they can scan them out of the system when they are shipped. The process records the date and time that the parts were loaded onto the truck. Also the scanner will get shipping schedules from the system to determine if the correct part and quantity are being shipped. This is possible because of the advanced technology built into the label, which will be discussed later.

The combination of the changes made to shipping and receiving procedures should help reduce the amount of errors that occur in these departments. The new process will eliminate many of the causal factors of ordering and shipping errors.

The Error Proof system, if approved, will be installed on line 610-A. The system will help eliminate many of the problems that this line has. The system components for
this process consist of scanners, a camera, 2 printers, a computer with monitor, and a scale. The scanner is used to capture data from the material when it arrives to the line. This will ensure that the correct type and color of material is being used in the system. It will also subtract the quantity from the raw materials inventory. The camera is placed at the end of the line and has the ability to visually check the finished part for color, length, and noticeable blemishes that would cause the part to be scrapped. An indicator light tells the operator if a piece needs to be scrapped. The printers are used to print part and container labels. These are the specialized labels that allow for advanced tracking of the part. The labels also help with the gathering of data for metrics. The computer and monitor work together as a data collection server and the brains of the system. The operator must use the computer to enter data into the system. All aspects of the process are tracked through the server. The scale is used to weigh the container once it is loaded with the parts. The scale is calibrated to adjust for the weight of the container and can determine if the wrong quantity of parts are in the container.

Process Flow

The production process flow for the 610-A production line would become much more complex if the Error Proof system is installed on the line. Steps for scanning the material into the system, adding labels to the parts and containers, and recording and storing data must be included into the flow. For a flowchart diagram for this process please refer to Figure 1 on page 36.
IV. COST-BENEFIT ANALYSIS

A. OVERVIEW

Some of the corrective measures that may be implemented as a result of this project can be enacted with little cost to the company. However, the main focus of this DTR reduction project is whether or not GTC should purchase and implement Freedom Technologies’ Error Proof line-side labeling system. There is a large expense associated with this system and the benefits may not be immediately realized. Therefore the best way to determine whether or not we should recommend this system for GTC would be by conducting a thorough cost-benefit analysis for the product. This section of the paper will deal with all of the aspects that must be considered when conducting a cost-benefit analysis. Both the theoretical and the empirical model will be discussed. The justification for all figures and estimates will be given. All of the pertinent data will be displayed in tables to include multiple sensitivity analyses. The recommendation section will discuss all relevant results and recommendations for the project.
B. THEORETICAL MODEL

The first decision made about Freedom’s Error Proof system was that GTC did not have the budget to implement the system on every production line in the plant. There are seventy production lines in the Brookville, OH plant and another thirty-three in Maysville, KY. The costs for implementing the system on each of those lines would be extreme. Also we determined that due to the nature of the extrusion production lines we would be unable to successfully implement a meaningful system on those lines. We decided to focus on our finish production lines, and as mentioned above, chose the 610-A line that produces body-side moldings. Due to budget constraints, implementing the system on additional lines would not be feasible at this time.

Methodology

Before moving to the costs and benefits of the Error Proof system one more decision was required: How would we value the project? When doing a cost-benefit analysis there are many different decision rules that can be used. For this project we have decided to use the net present value (NPV) approach. This is an approach that uses discounting to determine a project’s validity over its useful life. A discount rate is applied in order to determine if the initial opportunity cost of investment will payoff in the end. The discount rate that is used in this approach is crucial to the outcome. The rate can determine whether the project passes or fails the cost-benefit analysis. The discount rate chosen for this project and its justification will be discussed in the empirical model.
Costs

There are many potential costs to implementing a system of this size. The first and most obvious cost is that of the system itself. The system is made up of a significant amount of hardware and software that is costly and takes time to install. Freedom Technologies estimates that it will take approximately one month to install the system and get it running. Another month will be spent making sure that the entire system runs smoothly and the management fully understands how it functions. During this installation period the MIS department will have to work with Freedom’s consultants extensively in order to understand the system well enough to trouble shoot it. This potential cost takes time away from the department’s regular productive work. Also, GTC’s software engineer will have to work with the consultants to customize the software to our system. Since there is only one software engineer in the company all other software projects would be put on hold. There could be a potential cost associated with putting those projects on hold.

Another key cost to the system is the amount of time spent on training. Freedom will provide a one-week training course that is intended for management and team leaders. The first two days of the training would consist of a high-level overview with the remaining three days spent training the team leaders on the production lines. The team leaders will be responsible for providing training to the production workers that will use the system. All of the time spent on training is time that the team leaders and production workers are not producing parts. For line 610-A, time is very important and any loss puts monthly quotas in jeopardy. This is a potential cost that will only be incurred if overtime is required to meet monthly quotas, since production is stopped once
quotas for the line have been met. Once quotas have been met for the month, employees usually are required to clean their areas, attend production meetings, and when needed, sit in continued training sessions. The new system training would replace the time the employee spends on these activities, so there would be no additional cost to train them on the new system.

Other costs that will be incurred over the life of the system apply as well. There are annual costs for software licenses, and potential costs associated with replacement parts and repairs once the warranty expires (there is a 1 year warranty on the system hardware). There is also a potential cost that could be incurred if the system makes the production line run at an increased cycle time. At the end of the product’s useful life there will be disposal costs, and there is little or no anticipated salvage value for the hardware or software from this system.

**Benefits**

A major benefit of the system is the satisfaction of GTC’s major client. Honda is pushing for all of their vendors to have some sort of line-side labeling system in place on their processes that have been identified as deficient. Line 610-A is the most problematic process that we have. As with any business whose future success is dependent on a singular client, GTC goes above and beyond to insure that this client is extremely satisfied with the company’s performance.

Another benefit of the system is that we anticipate that DTRs can be reduced as well as scrap. DTRs cost the company a great deal of capital each year along with
displeasing the client. If the system can prove to save the company money it will be worth the investment.

The team has also agreed that there is a possibility that the system will increase efficiency and productivity on the production line and therefore save more money than anticipated. There is no concrete evidence of this, and therefore it is immeasurable, but many of the senior members of the team believe this to be a strong possibility.

In essence, this system holds the possibility to please GTC’s clients as well as making the company more efficient and therefore saving GTC money. The current Honda contract expires in 2007, and the better GTC’s performance is, the more leverage it has in the contract negotiations. This could mean greater revenue and increased business with Honda. The next section will deal with the empirical costs and benefits to the implementation of the system. This information will be the basis for the decision on whether or not to approve the system.
C. EMPIRICAL MODEL

In this section the measurable costs and benefits of the project will be examined. These are the figures that will be the basis for the cost-benefit analysis. This section leads into the results section that will tell us what the cost-benefit analysis reveals about the project. The first area that this section will cover in detail is the choice of the discount rate that is to be applied to the project.

Methodology

The discount rate is crucial to the outcome of the cost-benefit analysis. The discount rate is the rate at which dollar amounts are discounted in future periods. It is normally used when projects continue for a long period of time. There are many different methods that can be used to determine a social discount rate, and all of them have pros and cons to them. GTC has guidelines for the discount rate that is to be used when evaluating capital intensive projects. According to the firm’s documentation, a discount rate of 7.0% is to be used for all projects that are to be implemented with available capital. Due to the importance of the discount rate, several sensitivity analyses will be run in order to test the project’s sensitivity to the rate. The company’s guidelines require a sensitivity analysis be done at 5% and 9%.

Freedom’s system has a limited useful life that must also be estimated in order to conduct a cost-benefit analysis. Due to the nature of the system it is likely to become obsolete before it has to be scrapped for mechanical reasons. Technology is advancing very quickly and systems that seemed state-of-the-art just a few years ago are now considered dinosaurs. The programming language that the system uses, MS Visual
Basic, is already considered an old language. The estimated useful lifespan for this system is 10 years. The decision to use this timeframe was based on the knowledge and expertise of the MIS department. As mentioned in the theoretical discussion above, we do not believe that the system component will have much salvage value even though they may still be functional when the system is scrapped. The reason for this is, once again, the rapid advancement of technology.

**Costs**

Most of the costs for this project are easily gathered and documented. One cost that we were not able to immediately calculate is the cost incurred if the system makes the production line run slower. We have no verification that this will happen, but the team was in agreement that it is a possibility. The cost of implementing the system, including training and the first year's software licenses is $176,060. This cost is made up of $6,060 for the software licenses, $148,000 for the hardware, and $22,000 for the consulting services. In addition to the initial implementation cost there is also a cost of $6,060 each additional year to cover the cost of renewing the software licenses.

\[
\$148,000 + \$22,000 + \$6,060 = \$176,060
\]

Adding additional costs for training and support were considered, but we felt that there would be no significant cost increase in these areas. The cost of the initial training of operators is included in the base price. New employees would have to be trained on the system, but they would have to be trained on how to operate the line regardless of implementing the new system or not. Therefore, we felt that a training cost was not necessary. The main support cost that was considered was the salary for the software
engineer that would support the Visual Basic application for the system. We decided not to include this cost, because it was determined that the existing software engineer had sufficient time and abilities to perform this function with no additional cost to the company. The cost for replacement parts and repairs, for the system, were not included in the estimate due to the nature of the hardware. The hardware for this system could easily last through the system's productive life, and if any problems do occur, the cost associated with those problems could vary greatly.

**Benefits**

The benefits of this project are not quite as easy to measure because they are all based on the estimates of our team. We are fairly confident that these estimates are as accurate as possible due the wealth of knowledge and experience that exists on the team. The system will allow the company to reduce the DTRs that are caused on the 610-A production line. These savings should be approximately $21,500 pr/year. This figure was agreed upon after consulting with the line’s engineers. The average cost in DTRs for line 610-A, per year, has been $23,890. While Freedom Technologies claims that their system can eliminate all errors, senior management was not as confident. Along with our engineers we concluded that at least 90% of the DTRs for that line would be eliminated. This is a conservative estimate, but one that all parties involved agreed is a safe estimate. This estimate allows the analysis to account for any bugs or human errors that the system can’t predict.

In addition to the DTR savings it is estimated that we can save an additional $11,000 pr/year from reduced scrap. This is the result of scanning the material into the
system to verify that it is the correct material and color. The scrap rate due to bad raw material at this line is 3.7%. The scrap rate for bad material for the entire plant is only 3.2%. The line’s engineers have estimated that the Error Proof system should catch almost all of the defects in the material, which would produce the scrap savings. The total benefits that we expect to receive each year are $32,500 ($21,500 + $11,000). This is the amount we will save each of the 10 years that the system is in use. The 1st year is the exception to this. If we decide to purchase the system it could be completely implemented by the end of October. This would be more than half way through the fiscal year and would only allow for a savings of $13,541 in the fiscal year 2003.

A potential benefit that was not included in the analysis was that of improved line productivity. As was mentioned in the costs section, the line could be slowed by this system, but it is also possible that the line could run more efficiently once the system is in place. Since we excluded the potential costs associated with a less efficient line, we felt that the potential benefits of improved efficiency should also be excluded.

In addition to all of the above mentioned benefits, there also exists the benefit of customer satisfaction. GTC’s business relationship with Honda should greatly improve as a result of this project. Honda’s efficiency is hampered by the DTRs, and if Honda were to become overly irritated by the volume of DTRs, they may choose to not renew our contract when the current one expires in 2007. This is very unlikely to happen because of the lack of alternate suppliers, but Honda may use poor performance as a bargaining chip when negotiating pricing in the new contract. By reducing DTRs, and therefore improving Honda’s efficiency, GTC would be gaining an edge in the contract renewal process.
D. RESULTS

This section details the results from the cost-benefit analysis. The analysis was performed taking into account all of the factors that were mentioned in this report so far. The figures were entered into a spreadsheet and the cumulative net present value of the project was determined. Table 2 shows the details of the analysis. The cumulative net present value for the project is $21,600. This assumes that the system has a useful life of 10 years. As Table 2 shows, the annual NPV is positive in every single year after the first year, and the cumulative NPV becomes positive in the 9\textsuperscript{th} year of the project. Based on the results displayed in Table 2 the project should be accepted due to the positive NPV of $21,600.

In order to verify the results of this analysis, several sensitivity analyses were run to observe the effects from altering the discount rate. These results can be found in Table 3 through Table 6. In Table 3 the discount rate is changed to 4.0%. This causes the cumulative NPV to go from $21,600 to $49,900, which makes the project even more attractive. With a discount rate of 4.0%, the cumulative NPV becomes positive in the beginning of 2011 as opposed to the middle of 2012. A 2\textsuperscript{nd} sensitivity analysis can be found in Table 4. Table 4 shows the results of the project using a discount rate of 5.0%. In this case the cumulative NPV for the project would be $39,600 in 2013. This analysis puts the break-even point for the NPV somewhere near the middle of 2011. Table 5 uses the discount rate of 9.0%. At this rate the NPV becomes positive in the final year of the products useful life. The NPV at this time would be $6,572. Table 6 contains a sensitivity analysis using the maximum discount rate that may be applied without the NPV dropping below zero. The maximum discount rate that will result in a positive NPV...
for this project is 9.99%. The NPV at the end of the 10th year, using this rate, would be $12. Obviously, with this discount rate any unforeseen expenses or unrealized savings would make the NPV negative.

Overall, we believe that while the discount rate is a very important factor in this analysis, there is sufficient room for variation of that rate. The rate can be increased by 3% without resulting in a negative NPV for the project. This allowable tolerance makes the project less of a risk-factor.

One final sensitivity analysis was conducted in order to fully understand the allowable variation in the project. We did an analysis to discover the lowest annual savings that this project could have and still produce a positive NPV. Using the discount rate of 7.0%, this project will need to provide an annual savings of at least $29,500 in order to still have a positive NPV. Table 7 shows the results of this analysis. It should be noted that any unforeseen expenses, a change in the cost of capital, or any unforeseen benefits could make the break-even savings value change.

The cost-benefit analysis gives us a guideline to base our decision on, but it is by no means the only factor for this decision process. The analysis will be used in conjunction with the other factors mentioned in this paper, and will serve as an important tool in this project. The next section contains the recommendations of the team for this project. The recommendations will include any measures that we believe should be taken to reduce DTRs. One of these recommendations will be whether or not to implement Freedom Technologies’ Error Proof system.
V. RECOMMENDATIONS

This team was charged with finding ways to reduce the number of DTRs that Green Tokai incurs each year. This paper has discussed many issues that could lead to this goal. These recommendations have been based on the research that has been conducted by the team as well as the team's extensive knowledge of GTC's business. The main recommendation for this project stemmed from the cost-benefit analysis that was performed on Freedom Technologies' line-side labeling system. Other issues that have been addressed within the recommendations include training, process control, and quality issues.

The first recommendation that will be discussed is the most important. Should the Error Proof line-side labeling system be approved? The cost-benefit analysis clearly shows that in most situations the system will repay GTC's investment. The system's useful life of 10 years, and in most of the analyses conducted, the NPV will become positive before the 10th year. Based on the initial analysis the NPV will be $21,668. The team is recommending that the line-side labeling system be implemented on line 610-A. Furthermore, if the system does indeed meet or exceed the estimated returns, the team recommends that the company implement the system on several other lines within the next few years. If the company decided to implement the system on additional lines, the marginal cost for each additional line would be less than the cost for the first line. In addition to saving money for the company, this system will also improve the relationship between GTC and the company's biggest client, Honda. Honda has been strongly urging
GTC to implement a system such as this, and this system may help during contract negotiations in 2007.

To address the training concerns we recommend that the company completely redevelop and monitor a new training process. As mentioned previously, the company currently has a training system that is less than sufficient. Employees are often times being trained by unqualified personnel or by employees that were trained incorrectly themselves. This leads to an inbreeding of bad habits. Our recommendation is to start from scratch in the training process. One person per division needs to be assigned as the trainer, and that person will be responsible for updating the training manual and ensuring that new and existing personnel are trained properly to perform their assigned function.

The divisions currently have enough personnel to allow an existing staff member to take on the added responsibility of training coordinator. These measures will produce a more tightly structured training program, which will help reduce the DTRs that are caused by a lack of proper training.

Process control is another area that needs to be improved on the production lines. The existing standard operating procedures (SOP) are poorly organized, out of date, and make little sense. One way that the process control can be restored on the production lines is to rewrite the SOP. The SOP needs to be clearly defined and written, and a process needs to be in place in order to ensure that it is properly updated. The team librarian of each production line should be responsible for making sure that this happens. The problem that needs to be avoided occurs when new information is thrown into the back of the SOP. What instead needs to happen is updated information needs to be put in its proper location, and the outdated information removed. Hopefully this can help
produce a clear understanding of the correct procedures that are to be followed in all aspects of the production process.

In order to solve the quality problems several things need to happen. First of all, the above recommendations need to be taken. These recommendations will go along way towards improving the quality of our products. This will only accomplish so much. One of the major obstacles to improving not just quality, but any process, is that the employees need to care. If employees do not care about the quality of their work, any measures taken to improve quality may fall short of their goal. Management must come up with a way to get employees to care about the quality of their work, which will not be an easy task at Green Tokai. One way that this can be done is to change the incentive system for production workers. Currently workers are rewarded, with paid time off, for attendance and parts produced. A new guideline should stipulate that incentives are based on attendance and good pieces produced or by keeping scrap below a certain level.

These recommendations should serve as a productive set of guidelines towards improving the performance of the company. They are not the only actions that can be taken, but they are effective solutions to some of GTC’s most troublesome problems. The recommendations that the team has made are all feasible and, with the exception of the Error Proof system, they are all fairly inexpensive to implement.
VI. CONCLUSION

The domestic trouble report reduction team was established to help solve one of Green Tokai’s most troublesome production problems. DTRs cost the company $518,000 every year, and the goal of this project was to reduce that amount by pooling our knowledge and resources to produce effective resolutions. The team focused on the main causes of DTRs, which were lack of an effective training procedure, lack of label control, shipping label errors, old labels on packages, quality issues, and an overall lack of process control.

The training issue was addressed by recommending that the training process become more structured and controlled. By having training coordinators in charge of making sure that training is completed properly and that training manuals are current and accurate, the number of DTRs caused by improper training should be reduced.

Freedom’s Error Proof line-side labeling should solve virtually all of the problems associated with the labeling process. The cost-benefit analysis of this system shows that it will reduce DTRs by $32,500 annually. The team chose to recommend the system based on a positive NPV in most foreseeable situations. The system should also help with our relationship with Honda, which will be important when negotiating a new contract in 2007.

To help alleviate the problems caused by a lack of control in the production process the team decided that the SOP needed to be rewritten and all employees, especially team leaders, need to be aware of the correct operating procedures. They should have access to the procedures if they have any questions.
The team feels that they have done a thorough analysis of the DTR problem and we feel confident that many of the issues can be resolved through the implementation of these projects. The projects, when combined, should be able to help the company operate more efficiently. The increased production capacity will allow Green Tokai to meet future demands from customers as well as allowing the company to increase its business.
Figure 1: Production Process Flowchart for line 610-A

Material is received at workstation

Material is scanned and inspected by operator

Is material good?

Yes

Material is loaded into the machine

The part is made by the machine

The part passes under camera which inspects the part

Does the part pass inspection?

Yes

Results are Recorded

No

Material is scrapped

Part is scrapped

Operator logs out of system at end of shift

Label is produced and applied to part

Data is saved by server

Item is scanned and placed into container

Manufacturing Process repeated until system notifies operator that the container is full

Container Label is produced and applied

Information is stored by server

Container is scanned and sent to finished goods inventory
TABLE 2: Cost-Benefit Analysis for Error Proof – 7.0% Discount Rate

<table>
<thead>
<tr>
<th>YEAR</th>
<th>BENEFITS</th>
<th>COSTS</th>
<th>NET BENEFITS</th>
<th>DISCOUNT FACTOR</th>
<th>NET PRESENT VALUE</th>
<th>CUMULATIVE NET PRESENT VALUE</th>
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<td>0.47509</td>
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Cumulative Net Present Value $21,668
### TABLE 3: Sensitivity Analysis – 4.0% Discount Rate

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<th>YEAR</th>
<th>BENEFITS</th>
<th>COSTS</th>
<th>NET BENEFITS</th>
<th>DISCOUNT FACTOR</th>
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**Cumulative Net Present Value** $49,936
TABLE 4: Sensitivity Analysis – Discount Rate 5.0%

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<th>BENEFITS</th>
<th>COSTS</th>
<th>NET BENEFITS</th>
<th>DISCOUNT FACTOR</th>
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Cumulative Net Present Value

$39,661
TABLE 5: Sensitivity Analysis – Discount Rate 9.0%

Cost-Benefit Sensitivity Analysis

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<tr>
<th>YEAR</th>
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<th>COSTS</th>
<th>NET BENEFITS</th>
<th>DISCOUNT FACTOR</th>
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</thead>
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<td>$176,060</td>
<td>-$162,519</td>
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<td>-$149,100</td>
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<td>$32,500</td>
<td>$6,060</td>
<td>$26,440</td>
<td>0.84168</td>
<td>$22,254</td>
<td>-$126,846</td>
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<td>$26,440</td>
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<td>$32,500</td>
<td>$6,060</td>
<td>$26,440</td>
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<td>$26,440</td>
<td>0.64993</td>
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<td>-$70,515</td>
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<td>$6,060</td>
<td>$26,440</td>
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<td>$6,572</td>
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Cumulative Net Present Value $6,572
TABLE 6: Sensitivity Analysis: Discount Rate – 9.99%

Cost-Benefit Sensitivity Analysis

<table>
<thead>
<tr>
<th>YEAR</th>
<th>BENEFITS</th>
<th>COSTS</th>
<th>NET BENEFITS</th>
<th>DISCOUNT FACTOR</th>
<th>NET PRESENT VALUE</th>
<th>CUMULATIVE NET PRESENT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>$13,541</td>
<td>$176,060</td>
<td>-$162,519</td>
<td>0.90917</td>
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<td>-$147,758</td>
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<td>$6,060</td>
<td>$26,440</td>
<td>0.82660</td>
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<td>$6,060</td>
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<tr>
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<td>$6,060</td>
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<td>0.62120</td>
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<td>-$71,543</td>
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<td>$6,060</td>
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Cumulative Net Present Value $12
TABLE 7: Sensitivity Analysis: Annual DTR reduction of $29,500

<table>
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<tr>
<th>Year</th>
<th>Benefits</th>
<th>Costs</th>
<th>Annual DTR Reduction</th>
<th>Discount Factor</th>
<th>Net Present Value</th>
<th>Cumulative Net Present Value</th>
</tr>
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</tr>
<tr>
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<td>$6,060</td>
<td>$23,440</td>
<td>0.62275</td>
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Cumulative Net Present Value $760