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Optimizing an Organizational Program for Halton Company

Chandler Clark
Western Kentucky University, chandler.clark121@topper.wku.edu

OPTIMIZING AN ORGANIZATIONAL PROGRAM FOR HALTON COMPANY

A Capstone Experience/Thesis Project

Presented in Partial Fulfillment of the Requirements for

The Degree Bachelor of Science with

Honors College Graduate Distinction at Western Kentucky University

By

Chandler Clark

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Western Kentucky University

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CE/T Committee:	Approved By:
Professor Robert Choate, Advisor	
Professor Chris Byrne	______________________
Professor Matthew Nee	Advisor, Department of Engineering

ABSTRACT

A team of WKU Mechanical Engineering students is collaborating with Halton Company to create an organizational system for their plant. Each job performed at Halton is custom, leading to several different processes needing to be accounted for at once. The team is designing a program in Visual Studio that will be used to control the progression of the plant as well as store data to optimize future processes involved. Visual Studio will be implemented by summer of 2016 in order to give the team and company time to troubleshoot the program and insert optimizing options into the c ode of the program. In order to optimize the Visual Studio program, I will be implementing a barcode system. This will allow collection of analytical time studies that can be evaluated using real time analysis. It will also show issues throughout the plant, which can be evaluated using root cause analysis. Other methods, including verification and validation, Analytical Hierarchy System, Taguchi Methods, etc. will be considered to further evaluate the data in an attempt to implement both corrective and preventive actions throughout the plant. These methods, in combination, will result in total optimization of the plant, making it more efficient and capable of further expanding.

Keywords: Engineering, Halton Company, Root Cause Analysis, Visual Studio, Systems Engineering

Dedicated to my family, friends, professors, and all others who have helped me achieve my dream of becoming an engineer

ACKNOWLEDGEMENTS

This project would not have been possible without the help and support of the many individuals. I am thankful to Professor Robert Choate, my CE/T advisor, for his constant input and critiques of both the project as a whole and my individual portion of the Halton Company project. He has been a fantastic influence on the project. I am also very grateful to Professor Chris Byrne, my second reader, and Professor Matthew Nee, my third reader. I would especially like to thank my Senior Project Design team, including Caleb Carpenter, Jacob Latham, Ryan Howell, Jon Deel, and Nathan Lasley. Their commitment to the project throughout the entire year is what made my Capstone Thesis possible.

I would like to thank several organizations for aiding in completion of this project. The Western Kentucky University engineering department has encouraged the progress and enhanced the knowledge of the project. I am very grateful to Halton Company, especially Chris Gentry and Greg Lyons as the project would not exist without them reaching out to the department. Their input has formed the project to the program that best fits their needs at Halton Company. I would also like to thank the Honors College at Western Kentucky University for the opportunity to complete my Thesis.

Lastly, I would like to thank my parents for their support, my sister for her guidance, and my fellow engineering colleagues who are completing their own Thesis simultaneous to my own. These individuals include Will Johnson, Wesley Patterson, and Brad Cockrel, three individuals that I would not have completed this endeavor without.

VITA

December 30, 1993…………………………………....Born – Edgewood, Kentucky

2012………………………………………………Notre Dame Academy, Park Hills, Kentucky

Fields of Study

Major Field: Mechanical Engineering

Minor Field: Systems Engineering

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CHAPTER 1

HALTON COMPANY BACKGROUND

Halton Company is a global company that specializes in indoor climate and environmental products. It was founded in 1969 and currently employs over 1,400 members in over thirty countries. The Halton Company plant located in Scottsville, Kentucky designs and produces ventilation hoods for restaurant and industrial kitchens. Although jobs are similar, every order is considered custom. This is because specific requirements must be met for each restaurant. For example, two ordered hoods may be similar, but must fit in different parts of the kitchen. One may be in the open while the other must fit in a corner with a cut for a pipe. This allows Halton to create very similar hoods with slight differences, but these differences must be accounted for in order to provide for the customer.

The current organizational system in place at Halton Company is an oversized Excel sheet that contains all current and past plant information. The Excel sheet must be manually changed and manually interpreted. Over years, the sheet has become very complicated and cluttered in an attempt to keep all archived information. Most of the information at the plant is communicated between plant managers and lead engineers without using the Excel sheet. Although this solves problems temporarily, it does not make the process easier as much of the information is either lost or not accounted for.

This creates an environment of constantly catching up to meet deadlines instead of being able to plan ahead as jobs are received. Halton is looking for a system designed to organize and archive all plant information as well as to schedule current working and future job.

CHAPTER 2

PROJECT OVERVIEW

The engineering design team was enlisted to design a system that can better organize the total process at Halton Company. The effort to complete this task is sponsored by Halton Company, who provided the restraints and specifications for the task at hand. Other individuals involved in this project include our faculty advisor, Professor Robert Choate and WKU's engineering department. Our industrial contacts are Chris Gentry and Greg Lyons. Major goals of the system are to model the manufacturing process at Halton Company and to design a system that shall provide easy utilization and application in order to provide the opportunity to optimize the manufacturing process at Halton. The team asked to complete this task consists of Caleb Carpenter, Chandler Clark, Ryan Howell, Jon Deel, and Jacob Latham. The team designed the system through the fall of 2015 and shall complete the creation of the system by May of 2016.

CHAPTER 3

REQUIREMENTS

Requirements can be defined as the necessary components that are specified by the partner company in order to appropriately complete the task at hand. Halton Company had set requirements in the beginning phases of the project, but they have continued to develop them throughout the project in order to further detail the system being designed. The following requirements have been created and used as guidelines throughout the entire process of designing the program.

1. The system shall model the manufacturing process at Halton Company using the inputs of customer order, employee scheduling, and process time studies to return an estimated ship date as an output.
2. The design we provide to Halton Company shall provide easy utilization and application to the design and manufacturing processes of their ventilation hoods, allowing for them to minimize the risk of conflicting schedules.
3. The design we provide to Halton Company shall provide a feedback loop in which changes that must be made at each station notify those in charge, confirming that the entire building is constantly corresponding to one another.
4. The design we provide to Halton Company shall have the possibility of being created into an App in order to provide the use of tablets in the future.

These four requirements have been the basis for the project, and have been considered throughout the project in order to provide a successful outcome.

CHAPTER 4

SYSTEMS ENGINEERING IMPLEMENTATIONS

After going through a tour of the Scottsville plant with Chris Gentry and Greg Lyons, the design team gained a basic understanding of the process that a common ventilation hood would undergo. All hoods go through the essential processes, such as punching out the sheet metal and assembling the hood itself, but not all hoods require the same processes. As the complexity of the hood increases, so does the amount of steps required to produce it (in turn increasing the amount of time to manufacture it). In an effort to adequately cover all of the possible processes that a variety of hoods may require and represent it in a visual manner, a Function Flow Block Diagram (FFBD) was drafted. Several versions of this FFBD were drafted and modified based upon the feedback that was received from each design review with the company. This FFBD will prove to be very useful in developing the program, ensuring that the program adequately covers all possible setups.

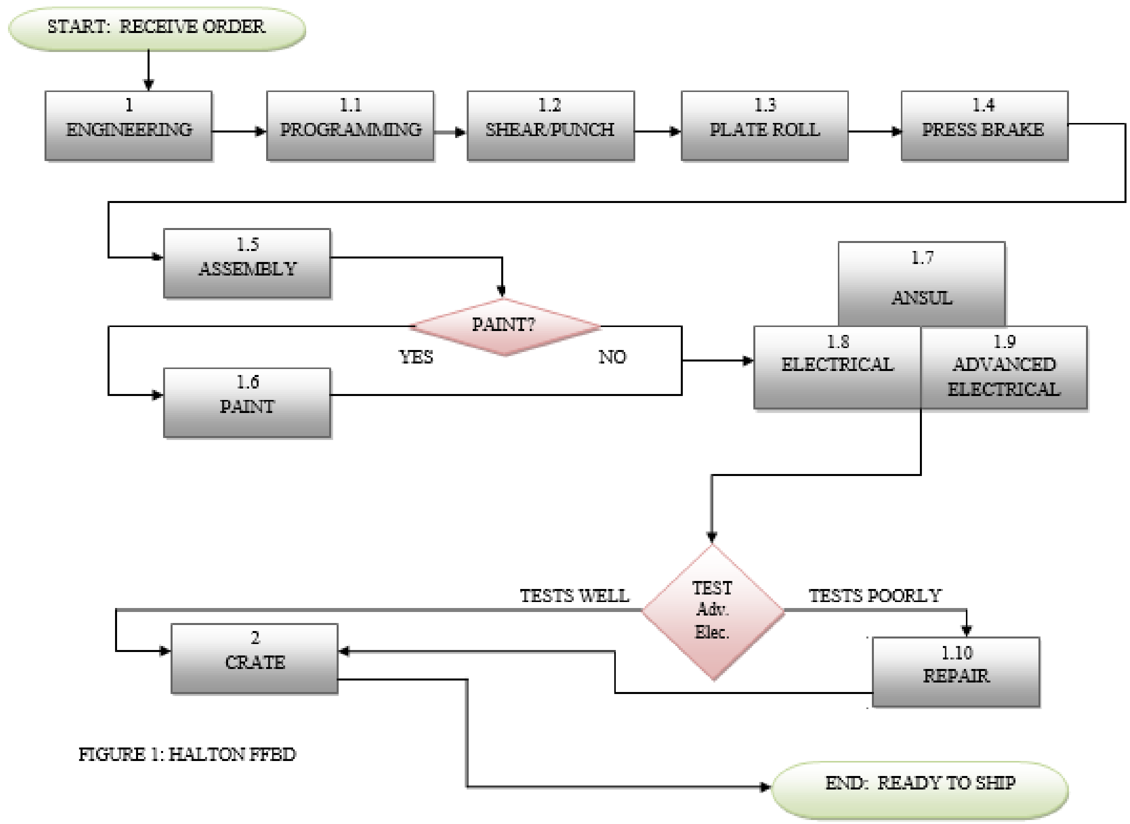

Figure 1: Functional Flow Block Diagram of Halton Company

In addition to the FFBD a manufacturing process chart was drafted, covering the same processes but assigning a time to each. Times assigned are purely fabricated and do not represent the actual amount of time required to complete each process. By applying more accurate information for each process in this chart to the final program, the user will receive a reasonable representation as to how long it would take to produce the requested hood. After receiving a production time, the program can then illustrate as to if it is feasible to produce the hood in the desired time span. This information shall be used in the Visual Studio program in order to appropriately estimate the time needed to complete each process as well as to use as a basis to determine if each employee is performing to their capabilities that are defined in the employee modification.

FUNCTION 1 Hood Model X Manufacturing Process												
Function		Minutes										
Number	Name	Average Duration (Minutes)	60	120	180	240	300	360	420	480	540	600
1	Engineering Design	60										
1.1	Program Build of Hoods	30										
1.2	Shear	15										
1.2	Punch	15										
1.3	Plate Roll	15										
1.4	Press Brake	15										
1.5	Weld and Assembly	30										
1.6	Paint	30										
1.7	Install Fire Supression	30										
1.8	Install Electronics	30										
1.9	Install Advanced Electric	30										
1.1	Repair If Needed	60										
2	Crate and Ship	60										
*NOTE: Chart is not accurate; need time studies to be complete												

Figure 2: Timeline Analysis

The information provided by the WKU Level Format provides a series of hood models and what manufacturing processes are necessary to manufacture any given model. It also provides information on how employee skill labor is organized, each employees is individually rated at each manufacturing process per hood model. This information can be fed into the N Squared matrix. The N Squared matrix links the inputs or outputs of various elements in the system together. The functions of the Halton manufacturing process are represented on the diagonal of the matrix. Elements in rows are output from the manufacturing step in that same row. Elements in columns are inputs for the manufacturing step in that same column. Elements about the main diagonal are being fed forward in the manufacturing process. Elements below the main diagonal are being fed backward into the manufacturing process. Feeding items backwards has the potential to create a loop. The N Squared matrix can also describe what resources are needed at each manufacturing step.

	Steps		Employee 1	Employee 2	Employee 3	Employee 4	Employee 5
KVE	Engineering	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Programming	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Shear/Punch	x	Level 0	Level 0	Level 4	Level 0	Level 0
	Rolling		Level 0	Level 0	Level 4	Level 4	Level 0
	Brake Press	x	Level 0	Level 0	Level 0	Level 5	Level 0
	Assembly	x	Level 4	Level 5	Level 0	Level 0	Level 0
	Paint		Level 0	Level 0	Level 0	Level 0	Level 0
	Electrical	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Ansul	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Advanced Electrical		Level 0	Level 0	Level 0	Level 0	Level 2
	Test / Inspect	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Crate	x	Level 0	Level 0	Level 0	Level 0	Level 0
KVR	Engineering	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Programming	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Shear/Punch	x	Level 0	Level 0	Level 4	Level 0	Level 0
	Rolling	x	Level 0	Level 0	Level 4	Level 4	Level 0
	Brake Press	x	Level 0	Level 0	Level 0	Level 5	Level 0
	Assembly	x	Level 4	Level 5	Level 0	Level 0	Level 0
	Paint	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Electrical	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Ansul	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Advanced Electrical		Level 0	Level 0	Level 0	Level 0	Level 2
	Test / Inspect	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Crate	x	Level 0	Level 0	Level 0	Level 0	Level 0
KVM	Engineering	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Programming	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Shear/Punch	x	Level 0	Level 0	Level 4	Level 0	Level 0
	Rolling		Level 0	Level 0	Level 4	Level 4	Level 0
	Brake Press	x	Level 0	Level 0	Level 0	Level 5	Level 0
	Assembly	x	Level 4	Level 5	Level 0	Level 0	Level 0
	Paint		Level 0	Level 0	Level 0	Level 0	Level 0
	Electrical	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Ansul	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Advanced Electrical		Level 0	Level 0	Level 0	Level 0	Level 2
	Test / Inspect	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Crate	x	Level 0	Level 0	Level 0	Level 0	Level 0

Figure 3: Halton Company Level Matrix

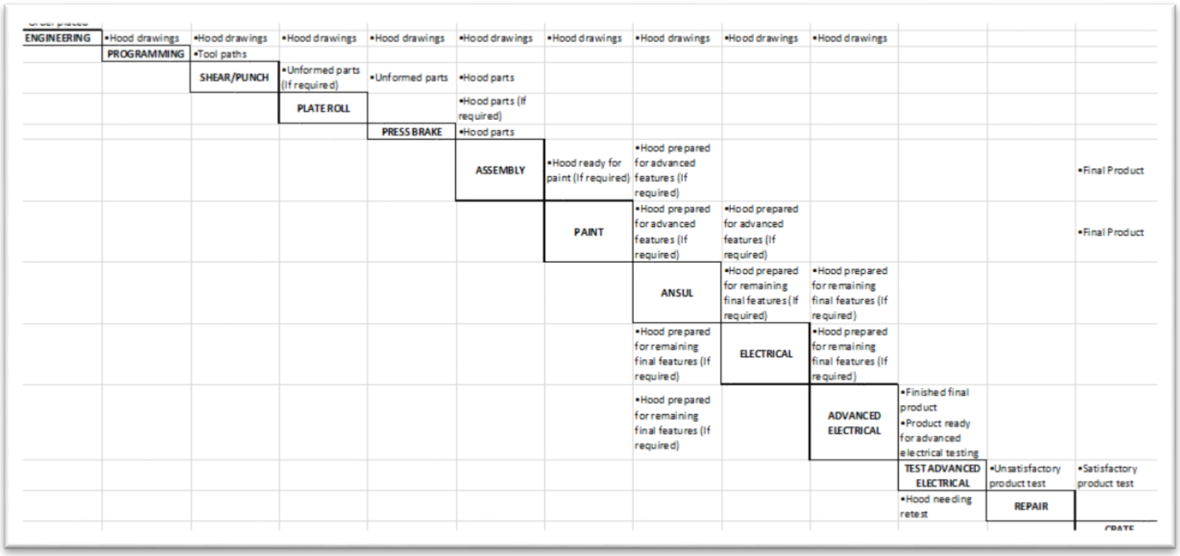

Figure 4: N2 Diagram

CHAPTER 5

PROGRAM CONSIDERATIONS AND DECISION

Two different programs were strongly considered when deciding on the platform of the project, Visual Studio and Microsoft Access. Both are very similar, although Visual Studio has more compatibility with iPads, phones, etc., while Microsoft Access is a much more cost efficient program. Further details of each program have been outlined for both the company and the engineering advisor.

The Visual Studio software is designed to make almost any program you can think of with any programming language you are comfortable with. The language options range from Visual Basic to C^+. The program can be built to run on a plethora of devices. It is said to be compatible with PC, Apple products (computers, tablets, phones), and Android devices as well. One thing to keep in mind is that the code written for the program needs to be set up on the right platform so that it can be formatted to work with all devices desired. Visual Studio is a Microsoft developmental tool. The resources for learning its ways are abundant. Every year that there is a new version of the software there is a new book that takes you step by step learning either how to use it, or for those who know what they are looking for what has changed from the previous version. When purchasing the software there are two options to think about. Like any software Microsoft produces; they would love for you to subscribe to their services. The Visual Studio

Professional with MSDN Licensure has an upfront cost of $1,199 plus tax. The renewal fee every year after that is priced at $799. There is a standalone option for Visual Studio Professional as well. It would be a onetime purchase price of $499. This standalone version would not have access to Microsoft support or online services but gives you full rights to the professional package. This would allow you to have the software, use it to develop what you need and then if you need a subscription you can always purchase that at a later date.

Microsoft Access is a database management system included with a subscription to Microsoft Office. It is created for the use of creating and manipulating tabulated data. It is made up of seven main components: Tables; Relationships; Queries; Forms; Reports; Macros; and Modules. Tables are the main storage component for data entered into the database. They look similar to a Microsoft Excel Spreadsheet when opened and therefore offers a familiar user interface experience. Relationships are bonds formed between data in Tables. They are used to help link data and create new information. Queries are powerful data manipulation tools. They allow for data to be displayed in a report. Query functions include sort, calculate, and filter. Forms are the interface through which users are able to enter data into the database. Reports are the results of the manipulation of data in the database. Unlike Forms, Reports cannot be edited only viewed. Macros are automated actions that Access can carry out for the database. Macros include run queries and change values of a field. Modules are the basis of the programming languages compatible with Access. Modules are the interface for storing and writing Visual Basic for Applications. Unlike Excel, Access allows the use of multiple simultaneous users. It also hides the inner workings of the project from the user. Applications are possible in version 13 and up. Access is included in Office Professional 2016 and is $399.00 per PC. This however also includes full version of Outlook, Publisher, Word, Excel, PowerPoint, and OneNote.   For Access 2016 alone it is $109.99.

The Analytical Hierarchy Process (AHP) is a decision making tool that allows you to choose between a number of products, systems, or ideas. It does this by first establishing criteria that must be met in order for a successful design to occur. These criteria are the weighed against the items or systems so that the best one for the set criteria of the project can be selected. The weighting values come in the form of Eigenvectors. The higher the number in the Eigenvector the more weight that choice has for the project. This process was used in this particular project so that we could choose the best platform for the program to be written with.

The full AHP for this project can be seen in the Appendix, while summarized results can be seen below. In this particular AHP we used four different criteria to decide between Visual Studio and Microsoft Access. The results of the AHP or decision matrix put the Visual Studio package as the winner with a .5575 Eigenvector value. At the end of the AHP you will see a cost to benefit ratio. This ratio once again has Visual Studio as the winner, however the margin is so close that it brings Access back into the picture. Looking at things from the standpoint of how well these software platforms help Halton Company progress and adapt in the future, we as a team have decided that Visual Studio is the better product for Halton to use in developing this scheduling program.

CRITERIA
C1= Accessible in many forms (program, app etc.)
C2= Interfaces with other programs well
C3= Intergrateble System
C4= General Maintenance Friendly

EIGENVECTORS						
	C1	C2	C3	C4		Comparison
VS	0.5714	0.5385	0.5333	0.5714	C1	0.2435
Access	0.4286	0.4615	0.4667	0.4286	C2	0.1826
	0	0	0	0	C3	0.2087
Total	1.0000	1.0000	1.0000	1.0000	C4	0.3652

RANKINGS	
VS	0.5575
Access	0.4425

VISUAL STUDIO IS THE WINNER OF THIS AHP CHART WITH AN EIGENVECTOR VALUE OF .5575. THIS PACKAGE GIVES YOU EVERYTHING YOU NEED TO CREATE THE SOFTWARE TO CONTROL YOUR SCHEDULE!

Cost to Benefit			
Access	399	0.4438	0.997105
Vis studio	500	0.5562	1.00231
	899	1.000	

This is the cost to benefit ratio. The two are so close when compared like this it is hard to tell which is better. Visual Studio Squeaks out another win here and if we think about continous improvement in the future we agree with the data and Visual Studio is the winner.

Figure 5: Analytical Hierarchy Process Summary

All of the above information has been used throughout the project to make necessary decisions in completing the project. They have been the baseline as to how to program will operate and function as well as to give the best way to explain all information in a way that all can understand the project at hand. After considering all information and decisions made to this point, the program has been designed and is in the process of being built by the engineering design team. Concept of Operations packets are also being developed concurrently with the program to instruct users on all capabilities.

CHAPTER 6

SOFTWARE STATUS

The initial page seen in the program is the Login page. The amount of information able to be seen or modified is dependent on the person's access. For example, a manager will have much more control over modifications than an employee on the floor. The 'Login' page requires a username and password to access any pages beyond this point. Once the Login is verified, the program continues to the Active Jobs page (Figure 2).

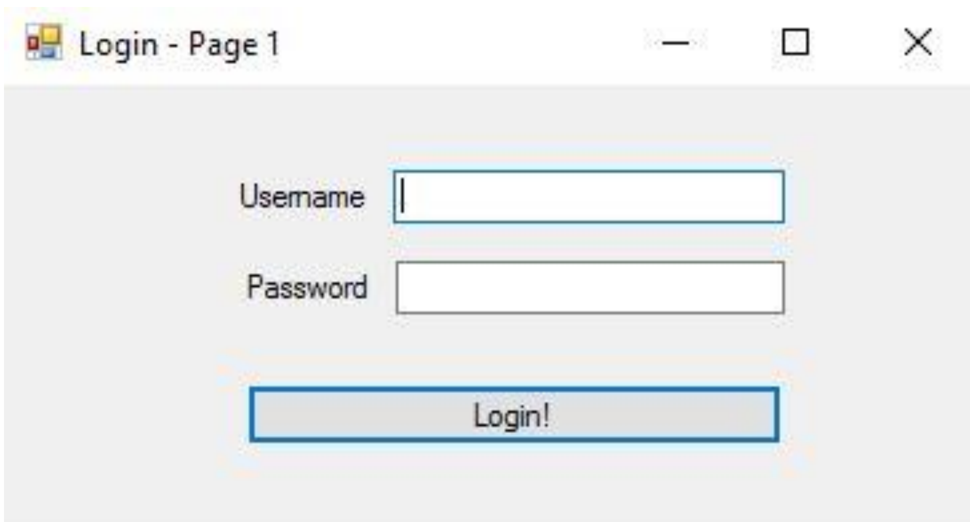

Figure 6: Software Login Page

The Active Jobs page will be seen after the Login page. This page is designed to show all necessary information for management at a quick glance. All active jobs are shown and can be organized by the reference order number, reference number, project manager, model, crate date, ship date, or current location. These topics can also be filtered in order to show only jobs associated with that item. The 'Clear' button will clear all filters being used on the Active Jobs page. Additionally, jobs can be deleted or archived from the Active Jobs form, job details can be viewed or modified, an active jobs list can be printed, and the archived jobs form can be pulled up all by pressing the 'Delete Job' button, 'Archive Job' button, 'View Job Details/Modify Job' button, 'Print Job List' button, and the Archived Jobs' button, respectively.

Several other pages are connected to this page through the buttons found on the panel. From the Active Jobs page, several actions can occur. Pressing the 'Add Job' button will direct you to the New Job form, as seen in Figure 8. Pressing 'Modify Employee' will direct you to the Employee Modification form, as seen in Figure 4. Pressing the 'Update' button will refresh the Active Jobs form to show any recently added jobs that are currently not visible, although the page shall automatically update when something is added or modified in the program. Pressing 'Log Out' will return the user to the Login page (Figure 1).

Figure 7: Software Active Jobs Page

The New Job Form is used to add a new job to the plant and can be used to see how a new job would affect the progress of the rest of the plant. In order to appropriately complete the page, the user must input the model, reference number, and quantity of the each product in the entire job. Employees are then selected for each process, or component, as well as the station it will be completed at. The project manager is specified, and crate and ship dates are set. Comments can be added at the bottom of the page, as they are encouraged to communicate throughout the plant.

Pressing the 'Modify Employee' button will take you to the Employee Modification page (Figure 9). The 'Upload' button will add the project details to the Active Jobs page and return the user to this page. The 'Back' button will return the user to the Active Jobs page and cancel all modifications made to the New Job Form page.

The ‘Log Out’ button cancels all changes made to the New Job Form page and returns the user to the Login page (Figure 1), where they will be required to login before making any other changes to the program.

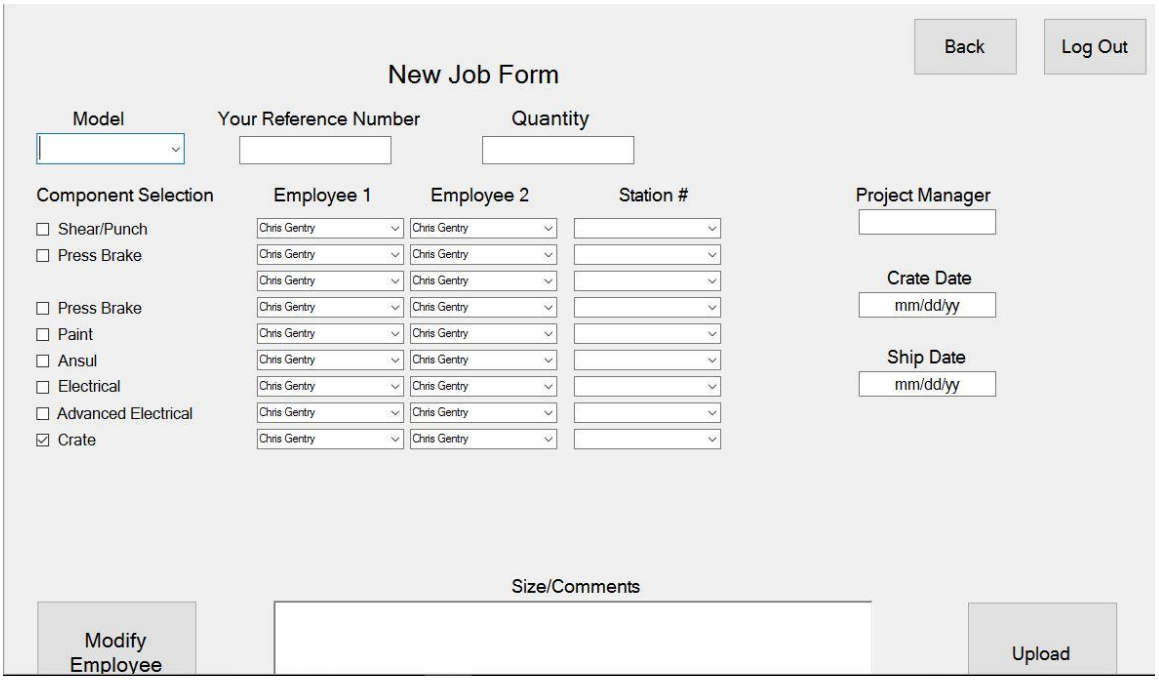

Figure 8: Software New Job Form Page

The Employee Modification page is used to modify details of an employee. Each employee has a different level of experience for each process of each job, so finding the best employee to complete each process is critical in creating an efficient and effective environment. The employee is identified using their three or four digit identification number, and all of the employees’ experience levels can be modified at this point. The employee’s full name, ID, start date of employment at the plant, and contact information are displayed when the employee is selected.

Pressing the ‘Find Employee’ button will search the database in order to locate the desired employee. Pressing the ‘Save’ button will save all changes made to the employee's information. Pressing the 'Delete Employee' button will remove the employee from the database. Pressing 'Add New Employee' will take the user to a similar page in order to input all new data for the employee. Pressing the 'Back To Active Jobs List' will return the user to the Active Jobs Page (Figure 2) and cancels all changes made since the last save. Pressing the 'Back To Modify Job/Job Details' button will direct the user to the Job Modification page (Figure 5).

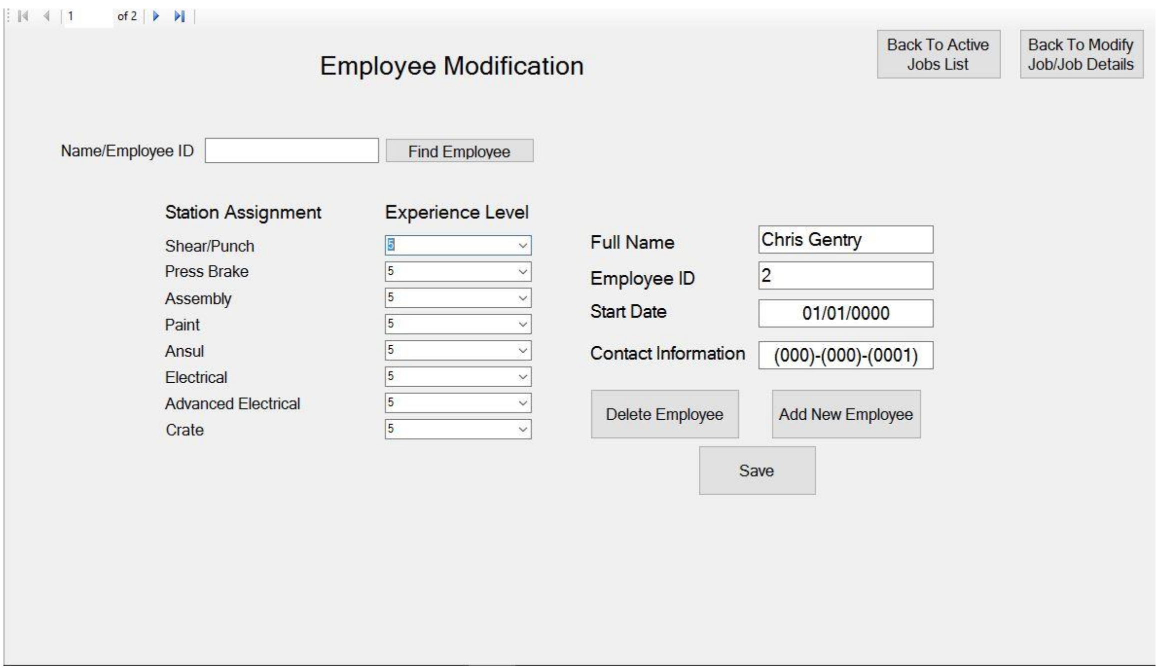

Figure 9: Software Employee Modification Page

The Job Modification page is used to adjust the details of a specific job. This page can be reached by either double-clicking on any of the active jobs in the Active Jobs page or by using the 'Modify Job' button found on the Active Jobs page. Any job can be found using the reference number and related order number. Any modifications can be made to the employees, project manager, crate date, or ship date at this time. The comments section can also be edited or updated to include more necessary information of the current process.

Pressing the ‘Cancel’ button will discard all changes made to the job details and return the user to the Active Jobs page (Figure 2). Pressing the ‘Save’ button will save all changes made to the job to the database and update the Active Jobs page. Pressing the ‘Back’ button will return the user to the Active Jobs page (Figure 2) or Employee Modification page (Figure 9), dependent on the last location of the user. Pressing the ‘Log Out’ button will cancel all changes made since the last save and direct the user to the Login page (Figure 1), where necessary credentials will be needed to regain access to the program.

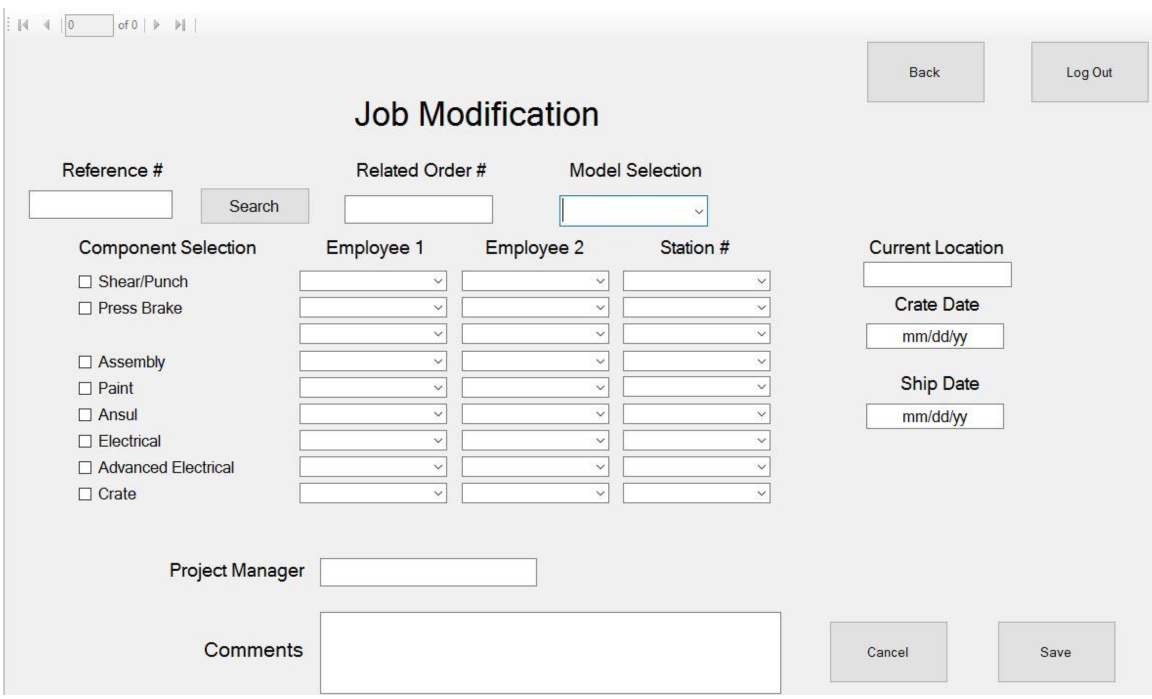

Figure 10: Software Job Modification Page

Each page created within the program has a complimenting Operation Instruction Sheet. This sheet is included for all who interact with the program but are not technically involved with the code for the program. This includes all employees and most of the managers as they will be interacting but not internally involved with the actual program. The Operation Instruction Sheet serves as a concept of operations document that includes details about each page as well as instructions to complete certain tasks. The Operation Instruction Sheet includes a step description that states what task is being completed, a step detail that states how and why the task is being completed, and images to aid in understanding. The Operation Instruction Sheets have specific symbols in place to bring special attention to these steps, whether it is a warning or reminder to complete that specific step. The Operation Instruction Sheets are ever changing and evolving as the program continues to become more sophisticated. Figure 11 is an example of a current Operation Instruction Sheet for Employee Modification. As stated in the sheet, the sheet was prepared on April 14th, 2016 by Caleb Carpenter. It states the five necessary steps to complete employee modification along with details as to why they are needed to be completed. The upside down triangular symbol seen by step 5 represents a critical process, meaning that this step must be taken in order to complete the process. The images on the right side of the sheet give visuals to show where each button or action can be found, making it simple for the user to complete the employee modification task effectively.

Bowling Green Assembly	Operation Instruction Sheet				
Op #: 4	Operation Description: Employee Modification	Date Prepared: 4/14/16	Prepared By: Caleb Carpenter		
Symbols:	▽ Critical Process	☐ Mandatory Sequence of STEPS		Est. Time	5 min.

Sym.	No	Step Description: (What)	Step Detail: (How, Why, Key Points)
	1	Click Modify Employee button	From active jobs page click the 'Modify Employee' button to open that page. See FIGURE 1.
	2	Fill in the Boxes and Dropdowns	Once the page is opened change necessary information.
	3	Click Add New Employee button	When necessary, click the 'Add New Employee' button to Add Employees. See FIGURE 2.
	4	Click Delete Employee button	When necessary, click the 'Delete Employee' button to Delete Employees. See FIGURE 2.
▽	5	Click Save button	Click the 'Save' button to save changes to any Employee Modifications. See FIGURE 2.

Images

FIGURE 1.

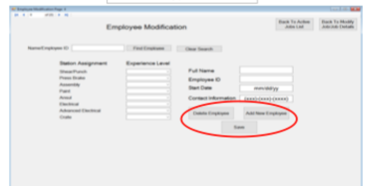

FIGURE 2.

Figure 11: Operation Instruction Sheet – Employee Modification

CHAPTER 7

VERIFICATION AND VALIDATION

Verification and validation are often used simultaneously to complete studies on improving processes within a company. The terms are seen together, but they are very different from one another and are both needed to complete studies effectively. They coincide with one another to build a system that meets all requirements and correctly functions as the customer envisions it.

Verification is the process of confirming that the system is compliant and functions correctly. To verify a system is to confirm that the system is built correctly. If the system cannot be verified, it means that the system does not function appropriately. Validation is the process of confirming that the design and system meet the intent of the customer. In other words, it is to confirm that the correct system is built to meet the customer's needs. If the system cannot be validated, the system works correctly but it does not fulfill the customer's needs correctly. (Module 17)

Figure 12 is a model demonstrating verification and validation during a project's maturity. The decomposition sequence defines how verification and validation affect the design of a system. The mission requirements are the initial point of the system. These are broad requirements that are meant to be followed in every project and include ethics, timelines, etc. The next step is to develop requirements specific to the customer's needs. These are important in creating a system that can be validated as the system must be built to fulfill the needs of the customer. The following step is to define the performance specifications of the system. These are even more specific design elements needed to verify that the system is designed to be built correctly. The requirements and performance specifications are used to fulfill the following step of designing components. This is the final step of design before creating the system, meaning all components must be checked to confirm that they will work correctly as well as fulfill all requirements given by the customer.

The integration sequence defines how verification and validation affect the testing and confirmation of the system. After the fabrication, assembly, or coding involved in creating the system is completed, each component must be verified to confirm that they function as they were designed to function. The following step is to integrate the components into an entire system, meaning that the components are no longer evaluated individually but as an entire system. After this step, the next is to verify the performance specifications. This step is used to compare and evaluate the defined performance specifications in the decomposition sequence to the current program's specifications and performance. The final step of the process is to validate the system. This step is the final step to confirm that the system has been built to fit the customer's needs.

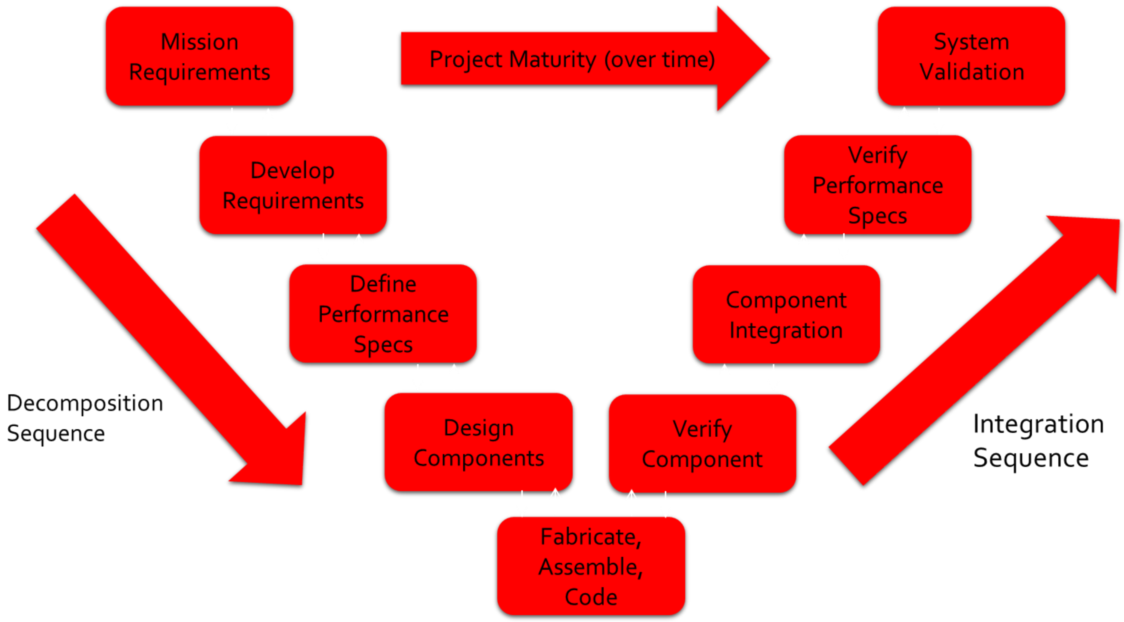

Figure 12: Verification and Validation Model

CHAPTER 8

ROOT CAUSE ANALYSIS

Root Cause Analysis is a primary tool used in quality engineering in order to identify the exact cause of the problem that has occurred or can occur in the possible future. The goal of the analyses being performed is to modify a system that shall create a more efficient and productive manufacturing environment. The root cause is determined to need either corrective or preventive actions in order to decrease the effect of the root cause or to eliminate the root cause altogether.

Root causes are defined by being specific underlying causes that can reasonably be identified. They must be control factors, and they must be able to have solutions or recommendations that can be applied in order to prevent recurrences of the problem. (Westcott) Underlying causes can be located using the Five Way's Analysis, which uses the question "Why?" at least five times in order to find the root of the complication. (Vidyasagar) The general number given for this rule is five, although more or less can be used until those analyzing the problem can no longer ask the question without concluding the same answer after each analysis. The goal is to decide that the problem is either a personnel, process, or policy problem. Concluding that one of these three or a combination of the three is the root cause of the problem aids in targeting a specific problem that can be solved.

Root Cause Analysis is performed in eight steps. The first step is to determine whether the problem has occurred or if there is sufficient reason to believe there is potential for a problem to occur. The second step is to detail the reasons why it is an issue or potential issue within the process being completed. The details should be as specific as possible and supported by data collection. The third step is to find the root cause, which can be done through the five why's process mentioned above or any other identification process the analyst chooses to use. The fourth step is to engage all who oversee the problem at hand. This initiative is taken in order to find available resources that can be used to resolve the issue at hand. Those that are involved in the complications in the process are much more likely to be involved in funding the fixation of the problem since the problem directly effects them. The fifth step of the process is to define a plan of action, including due dates, to share with all involved. The changes must be approved or agreed upon by all parties in order to ensure the best possible outcome for all involved in the changes being made. The sixth step is to actually implement the adjustments by making the necessary modifications that the action plan set out. The seventh step is to evaluate the results of the action plan. This step should be completed after a reasonable period of time for appropriate results and conclusions to be drawn. The final step of the process is to repeat the process by evaluating the effectiveness of the new implementations. Changes can again be made if necessary by following the Root Cause Analysis steps again, leading to further optimization of the program. (Westcott)

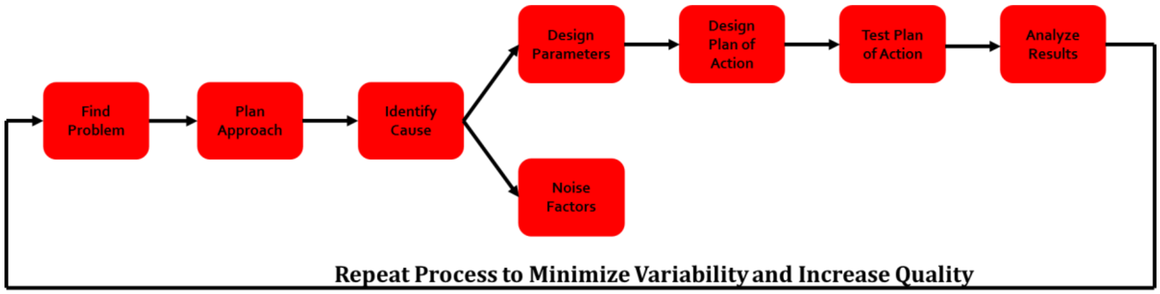

Figure 13: Root Cause Analysis Eight Step Process

Another technique used in Root Cause Analysis is to create Root Cause Analysis summary tables with causal factor charting. Causal factor charting analyzes black diagrams or functional flow block diagrams to find the deficiencies that could have been corrected before the problem occurred. The following shows the information needed to complete the Root Cause Analysis chart.

Figure 14: Root Cause Analysis Chart

Causal Description	Paths	Recommendation
-Factors effecting/effected -Background -Information in order for reader to address the addressed issue	-Shows all factors associated with defected factor	-Addresses corrections for each root cause involved in each path

This chart can be considered an advantage to simply following the steps listed above because of the organizational element. Often, the two are used simultaneously in order to ensure the most thorough analysis as well as having the information organized in an easily understood chart.

CHAPTER 9

TAGUCHI METHOD

The Taguchi Method is used in quality engineering in order to define a process that is as robust as possible. The most robust design would perform in a way that is insensitive to variations. The Taguchi Method functions in the design phase, as it is often believed that minimizing variation in this phase will minimize variation in the actual process, and therefore improve quality. Keeping the process as similar as possible as often as possible results in less variation in the corrections needing to be made and fewer factors that would be analyzed if an error were to occur. (Module 9)

The Taguchi Method looks to balance three main ideas: reducing variability, increasing quality, and reducing cost. By reducing the amount of factors involved in the process, all three of these ideas can be reached. Reducing variability in the system increases quality and reduces cost by allowing the company to purchase less to complete the same process. It is often questioned how increasing quality can reduce the cost since they are often an inverse relationship in industry, but by including the reduction of variability in the process both can be balanced in a way to give the best results at a low cost. Figure 8 demonstrates this balance and show how they interact with one another with the same importance.

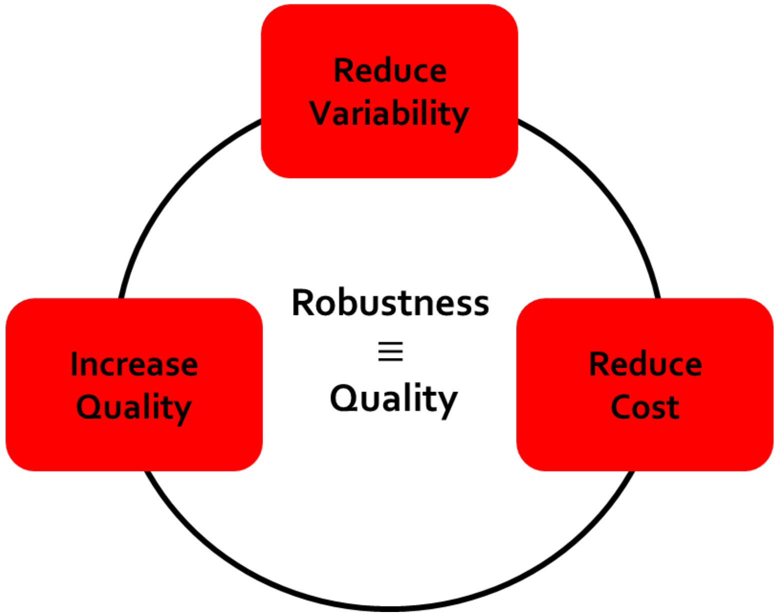

Figure 15: Taguchi Method Factors

The Taguchi Method can be completed in five steps. The first is to simply brainstorm the factors involved in the entire process or a focused section of the process. It is suggested to focus on one section of the process at a time to not overwhelm with the amount of factors involved in the entire process. Improving each individual section will also improve the entire system as a whole better than one would be able to when looking at the entire system at once. The second step in the process is to separate the design parameters and the noise factors. Noise factors cannot be controlled, while design parameters can be controlled. Noise factors would include orders received and employees taking vacation, as individuals who are organizing the process cannot control these. Design parameters include the design of how the process is completed and which employees are involved in the process. Issues that arise as the process is being completed are affected by both noise factors and design parameters, so separating the two throughout the process can aid in deciding what factors to eliminate.

The third step in the process is to construct a design of experiments (DOE's). The Design of experiments is used to define the relationship between inputs and outputs, also known as the process. The goal is to maximize the signal to noise ratio in order to maximize the signal, or meaningful information, and to minimize the noise, or the unwanted data. This step is often completed through orthogonal arrays dependent on the number of experiments, number of variables, and the number of variable levels. These three factors are used to create the array in order to determine the effect of each on the entire system. The design of experiments theory does have limitations, including that the theory assumes no interaction between the design parameters and the noise factors and also assumes continuous functions throughout the entire process. Because of this, the theory is very difficult to implement into real world examples. It can still be used to observe the process, though other techniques should also be used.

The fourth step of the process is to eliminate the determined factors in order to increase the quality of the process. This can be done one factor at a time or multiple factors, as long as analyzing the impact of each factor can be done effectively. The final step is to analyze the results and the impact of each eliminated factor on the process. The entire Taguchi Method can be repeated infinitely to continue to reduce the variability throughout the process, and therefor increase the quality of both the process and the product. Figure 15 shows the Taguchi Method process as a block diagram to give visual understanding.

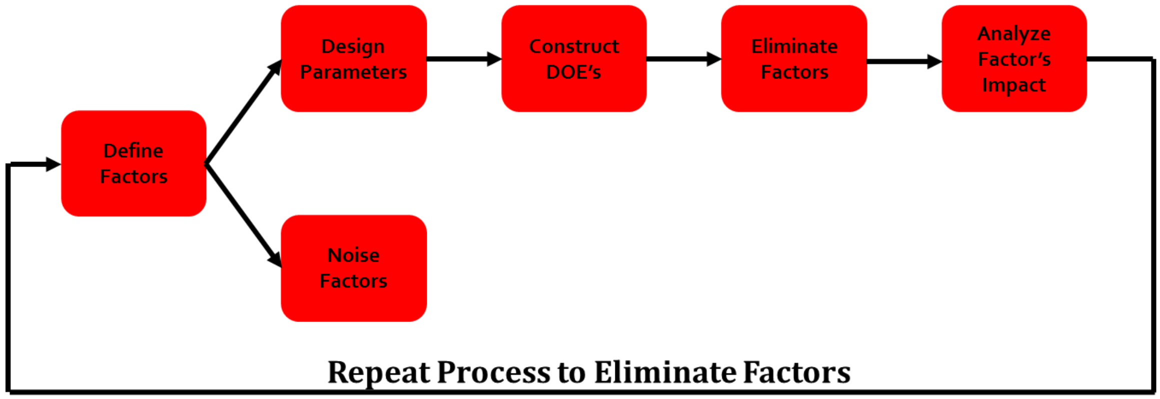

Figure 16: Taguchi Method Model

CHAPTER 10

IMPLEMENTATION OF FEEDBACK LOOP

After the Visual Studio program is functional and has been used at Halton Company for enough time to verify and validate the program, implementation of the optimizing process can begin.

Implementation will require several barcode scanners, a barcode printer, and additions to the Visual Studio program in order to create a separate input that just manual inputs and analyze the data as it is collected. Barcodes shall be placed on each product after the engineering portion of the process. The barcodes will be recognized as part of the entire job as well as an individual unit. At each stage in the process, the model's barcode shall be scanned before the single process begins as well as at the end of the process. In theory, the scanned barcode at the beginning of the process will be considered an "on" function, and the scanned barcode at the end of the process will be considered an "off" function.

The time elapsed between each scan is the amount of the time taken to complete the process. This time can be analyzed through an Excel sheet to determine if the time value fits within the tolerances set by management. The tolerances differ among employee, as stated in previous sections. As data is collected and analyzed, time values that do not fall within the time parameters will trigger the code to notify management where and when the problem occurred, including information such as the model, employee, and possible corrective and preventive actions for the future. The program shall be able to recognize when the same error occurs more than once either by the same employee or by the process. These results will relate back to Root Cause Analysis studies to determine if the cause of the problem is personnel, policy, or process.

Each barcode scanner will connect to its specific process, although they can be changed to correspond with another process. This will be important in the event of an employee forgetting to scan the part before or after they complete their work. The most recent processes will always override the previous process completed so that time on a single process does not read as infinity. As soon as the next scan, the barcode scanner will be able to know exactly where the part is and be able to report the status accordingly. For example, if the employee completing plate roll process scans the beginning of the process but forgets to scan the end, as soon as the press brake barcode scanner scans the part, the plate roll process will be ended in the program and the press brake process in the program will begin. The program shall send a notification to management if the employee forgets to scan the barcode, and the data will not be used in the time analysis functions.

Other functions of the barcode scanner include a function to account for creating a part that was not completed correctly. This is very important for when a part is made incorrectly as it shall then restart the time process, allowing the job to be completed in a reasonable time instead of including the time taken to complete the incorrect part as well as the correct part. This function will send a notification to the management as soon as the employee realizes that the part is made incorrectly, and management can then decide the process as to how to recreate the part correctly.

The notifications sent to the management shall be brief and only include the issue at hand, model, employee, location, and time it occurred. Comments can be made on each notification and be shared throughout the plant. They can also be moved into a "completed" bin once the correction has been made by any of the management, and this shall be updated on all of the manager's iPads.

Several example tables are listed below to further exemplify the process that the barcode scanning data would undergo in order to analyze the data using the Root Cause Analysis techniques. Table 2 shows results using an example process time of fifty minutes. The employee levels are defined by management, and these values can be found in the process time column. The tolerance of process is again set by management and can vary depending on the process, but it is always a percentage of the 100% process time. This means that it is not dependent on the employee level. The input of time duration is calculated by determining the difference between the end time and start time of the process, and the tolerances of the process, process time, and employee levels are used to define the relation to tolerance column. Depending on the time duration's relation to tolerance, an output of sending a notification is given. If the relation to tolerance is within the bounds, no notification is sent. If the relation to tolerance is higher than the defined bounds, a negative notification is sent to management. If the relation to tolerance is lower than the defined bounds, a positive notification is sent to management.

Employee Level	Process Time (min)	Tolerance of Process (%)	Input: Time Duration (min)	Relation to Tolerance	Output: Send Notification
1 (120%)	60	10	65	Same	No Notification
2 (110%)	55	10	62	Higher	Negative Notification
3 (100%)	50	10	50	Same	No Notification
4 (80%)	40	10	33	Lower	Positive Notification
5 (70%)	35	10	32	Same	No Notification

Figure 17: 50 Minute Process Example

The notifications given from Table 2 will feed into Table 3 to aid in deciphering if the occurrence is personal, process, or policy related. If no notification is sent, then it is assumed that no occurrences of processes being completed outside of the set tolerances have been observed. If a negative notification is sent, several observations shall be made by the program. If negative notifications are being sent pertaining to a single employee with multiples negative instances, then it is determined that the issue at hand is a personnel issue. Likewise, if positive notifications are being sent regarding a single employee with multiple positive notifications, it can be determined that the issue at hand is a personnel issue. If negative notifications sent are seen to be several employees with single notifications, it can be determined that the issue at hand is either a process or policy issue. Likewise, if positive notifications are being sent regarding multiple employees with single notifications, it can be determined that the issue at hand is either a process or policy instance. These are visually defined in Table 3.

Error Notification	**Personnel**	**Process**	**Policy**
No Notification	No Notification	No Notification	No Notification
Negative Notification	Single Employee, Multiple Notifications	Multiple Employees, Single Notifications	Multiple Employees, Single Notifications
Positive Notification	Single Employee, Multiple Notifications	Multiple Employees, Single Notifications	Multiple Employees, Single Notifications

Figure 18: Notification References Chart

After being evaluated within the Notifications Reference table (Table 3), the notifications are sent to the management with potential corrections of the issue. These actions can be seen in Table 4. If not notification is sent, then no action needs to be completed as the process itself is being completed correctly.

If the negative notifications are determined to be personnel related, the suggested actions would include to mentor the employee to confirm that the issue is an ability problem instead of a motivation problem. If the employee knows how to perform the task, the next action to implement would be to encourage or push the employee to perform at their best abilities. The third suggested action would be to demote the employee as they are not performing at their capabilities, resulting in possible pay cuts or punishments. On the other hand, if the positive notification sent are determined to be personnel related, the suggested action would be to notice the employee, or simply mention to them that you have noticed their diligent work. The second action is to praise the employee and continue to show them their importance in the company. The final suggested action would be to promote the employee to the next employee level, resulting in possible pay raises.

If the negative notifications are determined to be related to process, the first suggested action would be to analyze the process to find the error in how the process is being completed, and the second action would be to adjust the process accordingly. This can be done using Root Cause Analysis and validation and verification techniques. If negative notifications are being sent, it is an urgent message to fix the process. If the positive notifications sent are determine to be related to process, the first action again is to analyze the process. The second action would be to adjust the process, although it is not as dire to adjust the system because the process is still being completed correctly and on time. Adjustments would most likely be to complete the process more quickly. Adjustments to negative notifications shall be made before adjustments to positive notifications.

If the negative notifications are determined to be related to policy, the first suggested action is to restructure the guidelines followed by employees to complete each process. The second action is to keep improving the guidelines until no error is given related to policy errors. If a positive notification is determined to be related to policy, no action will be taken as this simply means the guidelines given are very well completed.

Error Notification	**Personnel**	**Process**	**Policy**
No Notification	No Action	No Action	No Action
Negative Notification	1. Mentor employee 2. Push Employee 3. Demote employee	1. Analyze process 2. Adjust process	1. Restructure guidelines 2. Improve guidelines
Positive Notification	1. Notice employee 2. Praise employee 3. Promote employee	1. Analyze process 2. Adjust process	No Action

Figure 19: Notification Actions Chart

CHAPTER 11

FUTURE TIMELINE

Although the current program has made several advancements, a timeline has been implemented to continue the growth of the program in future semesters with future team members. The summer of 2016 shall be the time that the functionality of the program is completed and the implementation of the program at Halton Company shall occur. As the program is implemented, functionality will continue to be improved as real world errors occur, requiring constant adjustments of the program. The employee scheduler shall be implemented over the summer as well in an attempt to further fir the customer's needs. The final large scale task to be completed is the application of the Taguchi Method by the engineering design team. This will be considered during the summer, but changes to designs or processes will only be made by management or engineers.

The next phase shall begin in fall of 2016. This phase shall include the implementation of the barcode system into the plant as well as the program. As soon as the barcode system is functioning and giving numeric results of time, the root cause analysis section of the program shall be written to begin the feedback loop ask for by Halton Company. The final major addition during this time period shall be the "What If" analysis, a section of the program that allows the users to add jobs to the queue in order to determine its effect on the rest of the schedule and current jobs.

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APPENDIX

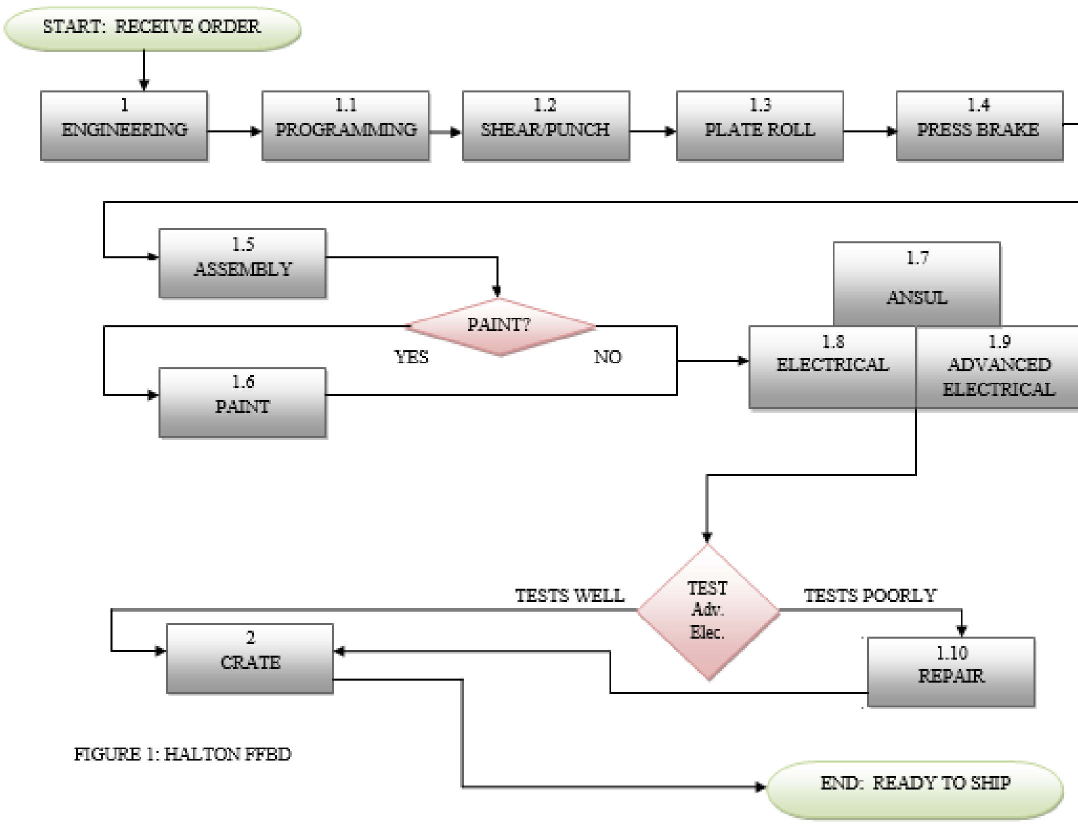


Figure 1: Functional Flow Block Diagram of Halton Company

FUNCTION 1 Hood Model X Manufacturing Process												
Function		Minutes										
Number	Name	Average Duration (Minutes)	60	120	180	240	300	360	420	480	540	600
1	Engineering Design	60										
1.1	Program Build of Hoods	30										
1.2	Shear	15										
1.2	Punch	15										
1.3	Plate Roll	15										
1.4	Press Brake	15										
1.5	Weld and Assembly	30										
1.6	Paint	30										
1.7	Install Fire Supression	30										
1.8	Install Electronics	30										
1.9	Install Advanced Electric	30										
1.1	Repair If Needed	60										
2	Crate and Ship	60										
*NOTE: Chart is not accurate; need time studies to be complete												

Figure 2: Timeline Analysis

	Steps		Employee 1	Employee 2	Employee 3	Employee 4	Employee 5
KVE	Engineering	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Programming	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Shear/Punch	x	Level 0	Level 0	Level 4	Level 0	Level 0
	Rolling		Level 0	Level 0	Level 4	Level 4	Level 0
	Brake Press	x	Level 0	Level 0	Level 0	Level 5	Level 0
	Assembly	x	Level 4	Level 5	Level 0	Level 0	Level 0
	Paint		Level 0	Level 0	Level 0	Level 0	Level 0
	Electrical	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Ansul	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Advanced Electrical		Level 0	Level 0	Level 0	Level 0	Level 2
	Test / Inspect	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Crate	x	Level 0	Level 0	Level 0	Level 0	Level 0
KVR	Engineering	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Programming	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Shear/Punch	x	Level 0	Level 0	Level 4	Level 0	Level 0
	Rolling	x	Level 0	Level 0	Level 4	Level 4	Level 0
	Brake Press	x	Level 0	Level 0	Level 0	Level 5	Level 0
	Assembly	x	Level 4	Level 5	Level 0	Level 0	Level 0
	Paint	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Electrical	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Ansul	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Advanced Electrical		Level 0	Level 0	Level 0	Level 0	Level 2
	Test / Inspect	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Crate	x	Level 0	Level 0	Level 0	Level 0	Level 0
KVM	Engineering	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Programming	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Shear/Punch	x	Level 0	Level 0	Level 4	Level 0	Level 0
	Rolling		Level 0	Level 0	Level 4	Level 4	Level 0
	Brake Press	x	Level 0	Level 0	Level 0	Level 5	Level 0
	Assembly	x	Level 4	Level 5	Level 0	Level 0	Level 0
	Paint		Level 0	Level 0	Level 0	Level 0	Level 0
	Electrical	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Ansul	x	Level 0	Level 0	Level 0	Level 0	Level 2
	Advanced Electrical		Level 0	Level 0	Level 0	Level 0	Level 2
	Test / Inspect	x	Level 0	Level 0	Level 0	Level 0	Level 0
	Crate	x	Level 0	Level 0	Level 0	Level 0	Level 0

Figure 3: WKU Level Matrix

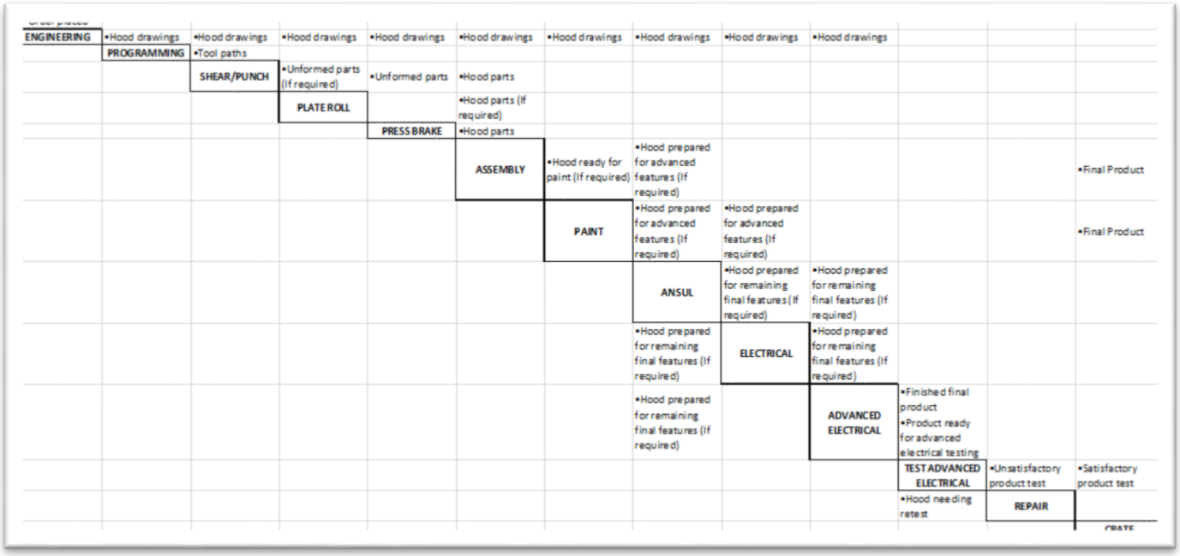


Figure 4: N2 Diagram

CRITERIA
C1= Accessible in many forms (program, app etc.)
C2= Interfaces with other programs well
C3= Intergrateble System
C4= General Maintenance Friendly

EIGENVECTORS						
	C1	C2	C3	C4		Comparison
VS	0.5714	0.5385	0.5333	0.5714	C1	0.2435
Access	0.4286	0.4615	0.4667	0.4286	C2	0.1826
	0	0	0	0	C3	0.2087
Total	1.0000	1.0000	1.0000	1.0000	C4	0.3652

RANKINGS	
VS	0.5575
Access	0.4425

VISUAL STUDIO IS THE WINNER OF THIS AHP CHART WITH AN EIGENVECTOR VALUE OF .5575. THIS PACKAGE GIVES YOU EVERYTHING YOU NEED TO CREATE THE SOFTWARE TO CONTROL YOUR SCHEDULE!

Cost to Benefit							
Access	399		0.4438			0.997105	
Vis studio	500		0.5562			1.00231	
	899		1.000				

This is the cost to benefit ratio. The two are so close when compared like this it is hard to tell which is better. Visual Studio Squeaks out another win here and if we think about continous improvement in the future we agree with the data and Visual Studio is the winner.

Figure 5: Analytical Hierarchy Process Summary

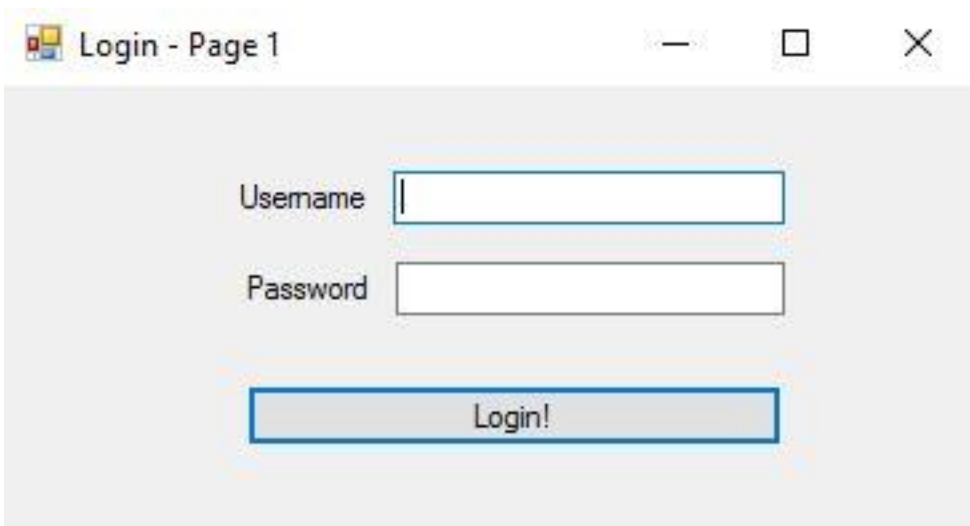


Figure 6: Login Page

Figure 7: Software Active Jobs Page

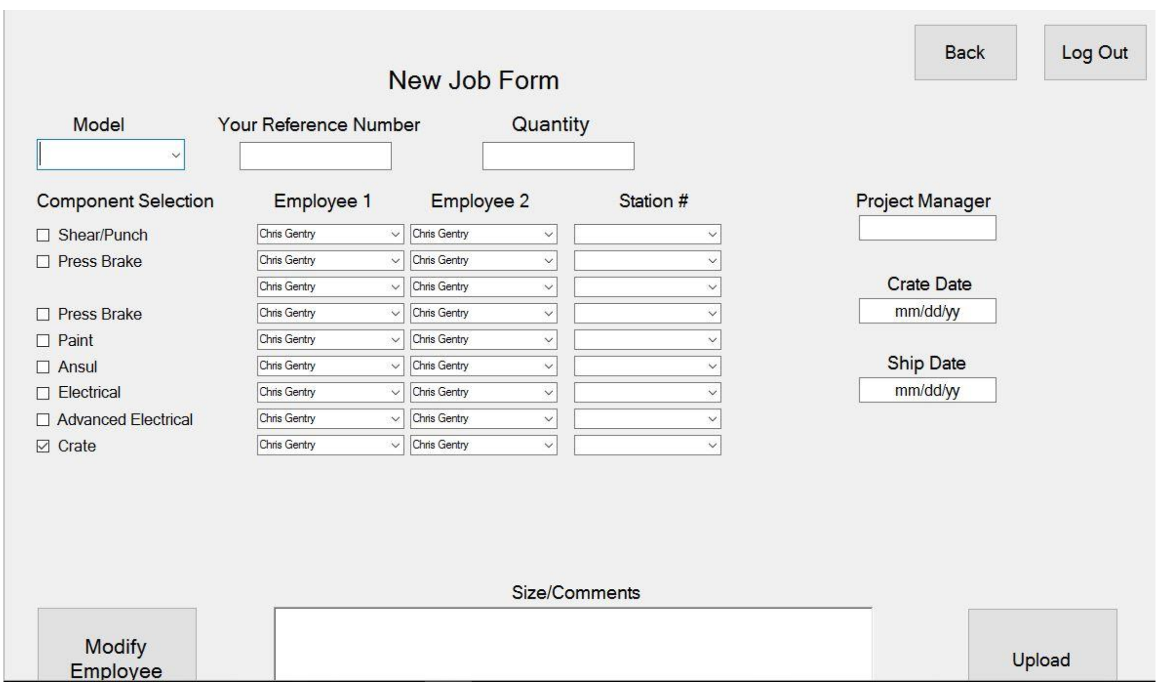


Figure 8: Software New Job Form Page

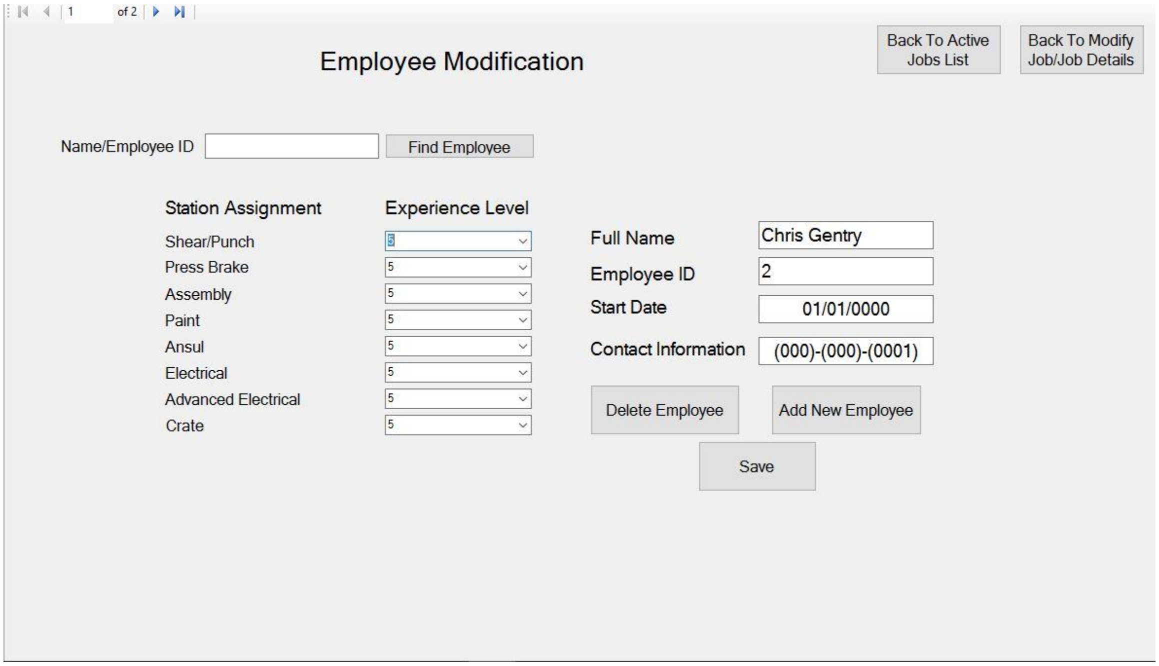


Figure 9: Software Employee Modification Page

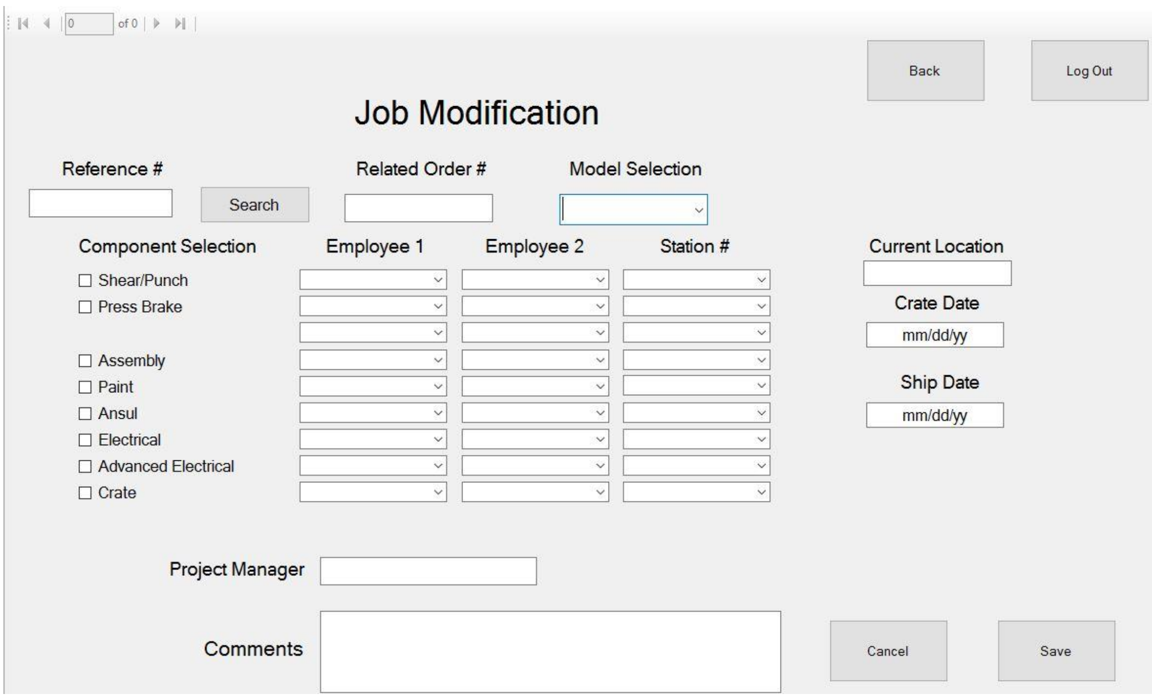
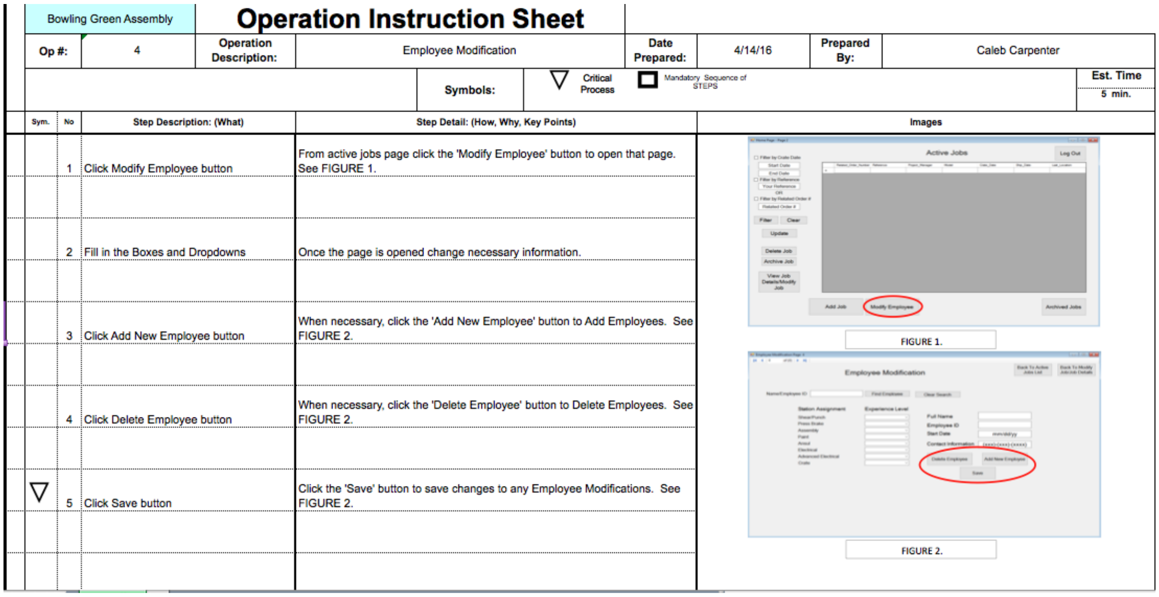


Figure 10: Software Job Modification Page



Bowling Green Assembly		Operation Instruction Sheet					
Op #:	4	Operation Description:	Employee Modification	Date Prepared:	4/14/16	Prepared By:	Caleb Carpenter
		Symbols:	▽ Critical Process	☐ Mandatory Sequence of STEPS			Est. Time 5 min.

Sym.	No	Step Description: (What)	Step Detail: (How, Why, Key Points)	Images
	1	Click Modify Employee button	From active jobs page click the 'Modify Employee' button to open that page. See FIGURE 1.	FIGURE 1.
	2	Fill in the Boxes and Dropdowns	Once the page is opened change necessary information.	
	3	Click Add New Employee button	When necessary, click the 'Add New Employee' button to Add Employees. See FIGURE 2.	
	4	Click Delete Employee button	When necessary, click the 'Delete Employee' button to Delete Employees. See FIGURE 2.	
▽	5	Click Save button	Click the 'Save' button to save changes to any Employee Modifications. See FIGURE 2.	FIGURE 2.

Figure 11: Operation Instruction Sheet – Employee Modification

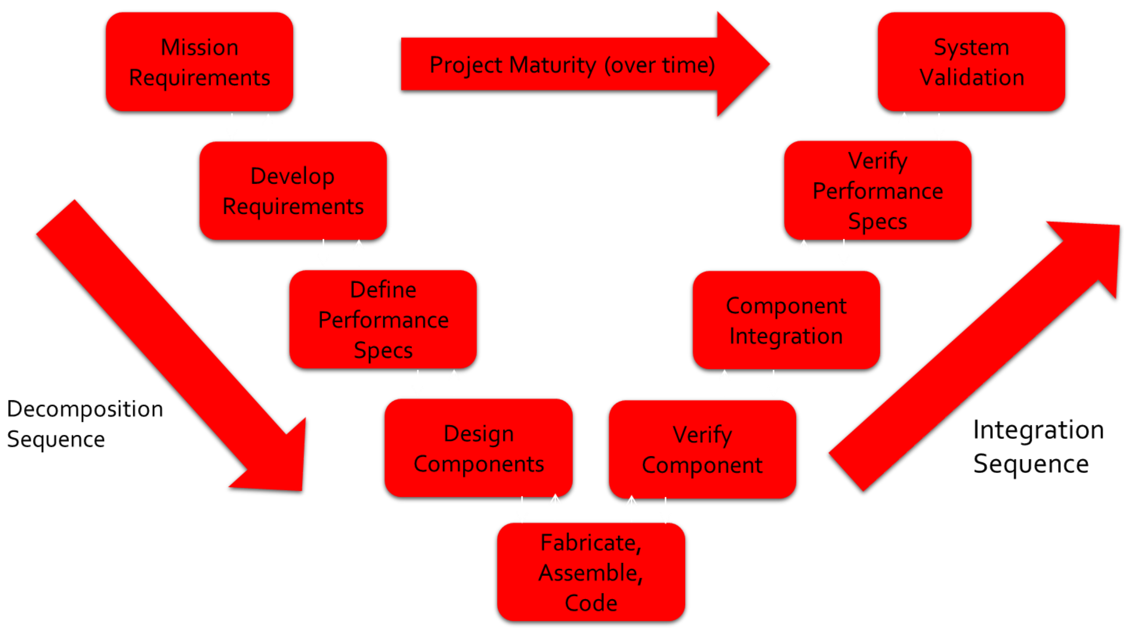


Figure 12: Verification and Validation Model

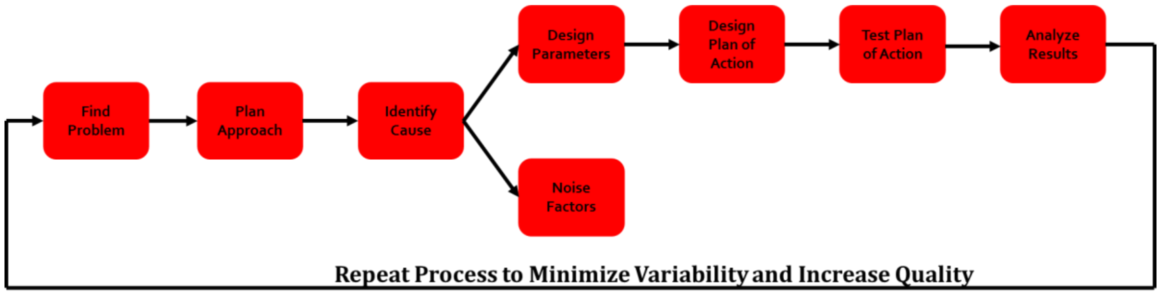


Figure 13: Root Cause Analysis Eight Step Process

Figure 14: Root Cause Analysis Chart

Causal Description	Paths	Recommendation
-Factors effecting/effected -Background -Information in order for reader to address the addressed issue	-Shows all factors associated with defected factor	-Addresses corrections for each root cause involved in each path

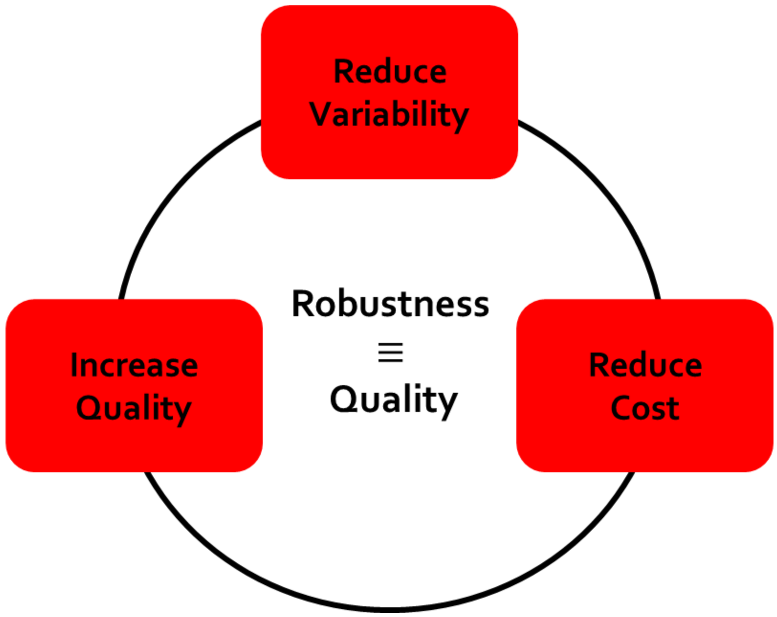


Figure 15: Taguchi Method Factors

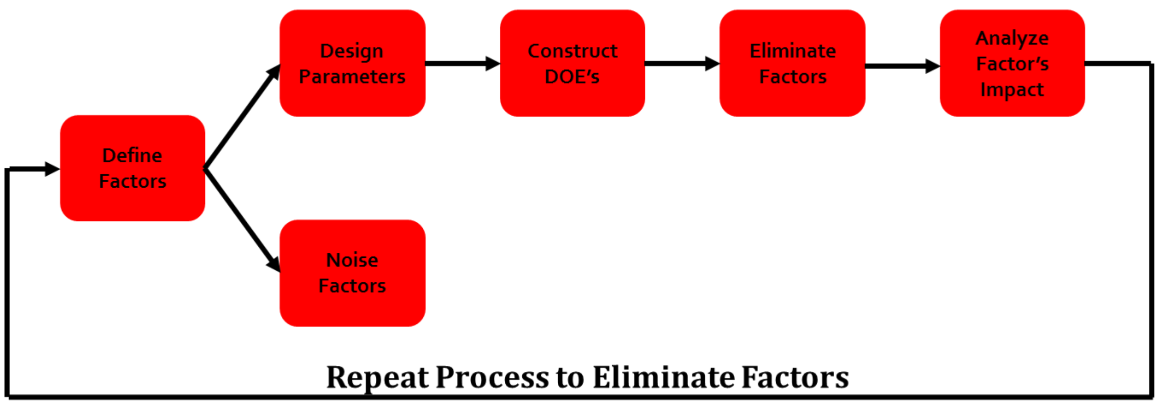


Figure 16: Taguchi Method Model

Employee Level	Process Time (min)	Tolerance of Process (%)	Input: Time Duration (min)	Relation to Tolerance	Output: Send Notification
1 (120%)	60	10	65	Same	No Notification
2 (110%)	55	10	62	Higher	Negative Notification
3 (100%)	50	10	50	Same	No Notification
4 (80%)	40	10	33	Lower	Positive Notification
5 (70%)	35	10	32	Same	No Notification

Figure 17: 50 Minute Process Example

Error Notification	Personnel	Process	Policy
No Notification	No Notification	No Notification	No Notification
Negative Notification	Single Employee, Multiple Notifications	Multiple Employees, Single Notifications	Multiple Employees, Single Notifications
Positive Notification	Single Employee, Multiple Notifications	Multiple Employees, Single Notifications	Multiple Employees, Single Notifications

Figure 18: Notification References Chart

Error Notification	**Personnel**	**Process**	**Policy**
No Notification	No Action	No Action	No Action
Negative Notification	4. Mentor employee 5. Push Employee 6. Demote employee	3. Analyze process 4. Adjust process	3. Restructure guidelines 4. Improve guidelines
Positive Notification	4. Notice employee 5. Praise employee 6. Promote employee	3. Analyze process 4. Adjust process	No Action

Figure 19: Notification Actions Chart