Get Hosed Project

Senior Design 2017-2018

Project Proposal Feasibility Study

Team 15

Peter Betten

Reuben Saarloos

Mitchell DeBruin

Erik (Lars) Johnson

Executive Summary:

Steel reinforced hydraulic hoses are fundamental in the industrial world. Their flexibility allows them to be used in machines and designs with moving parts that regular tubing cannot handle. Additionally, their rugged and durable outer layers provide a sleek black look that can give any industrial system the clean look it needs. The problem with steel reinforced hydraulic hoses is that the hose assembly process is a dirty, time consuming, and labor-intensive procedure that inefficiently uses valuable company resources and employee time.

At engineering and manufacturing firms, people are hired for their technical skills and problem-solving abilities. A technician's time is used most efficiently when completing challenging tasks. In industry, the hose cutting process is an example of a skilled employee spending time inefficiently. Hose cutting orders are dreaded by employees because it is such a mundane and therefore unsafe repetitive task, that they struggle to feel pride in the work accomplished since their skills are not being optimized. The solution to this is an automated process resulting in a faster production rate and a happier workforce.

Our team will design and create a machine that is an engineered model, which has the potential to empower hydraulic companies across the globe, in boosting hose production to the next level. This Design concept will be known as Knight-Cut. Knight-Cut will give you control over the cut length and quantities of hoses, in an easy to use package, which can be used on a wide variety of hose sizes. Its hassle-free set up and user-friendly interface allows for any untrained employee to take command of the machine, allowing trained technicians more time to finish or improve other parts of the business. Safety features, within the machine make the risk of potential injury minimal while the machine is running. Using Knight-Cut will allow for an increase in production rate that will leave customers happier and more satisfied. Our team has partnered with MFP Automation Engineering in creating the Knight-Cut.

Our team stands behind Knight-Cut as professionals in the field of automated hose cutting. With two mechanical engineers and two electrical engineers, we are prepared for every issue that arises. With knowledge of the hose cutting process, functionality, and standards, our team promises a solution that will last. Knight-Cut will transform the underperforming process of hose assembly to a hands-free production line giving MFP Automation Engineering the value add they want.

Our team looks forward to working with MFP Automation Engineering as they embrace the changes required for growth, while also maintaining and honoring brand values and customer loyalty. With this attitude, a partnership with our team will help bring MFP to the next level in a manageable, sustainable, and profitable manner.

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1. Introduction to Design

The goal of this project is to design and construct an automatic hose cutting machine for the company MFP Automation Engineering. This project proposal feasibility study will analyze the best way to perform this task. Team organization and communication with the customer will be critical for this project to be successful. Our team will continue to schedule and budget both time and resources efficiently to guarantee the project is done by early May 2018.

The project opportunity arose as a team member was approached by MFP Automation Engineering to help upgrade their current cutting process for steel reinforced hydraulic hoses. Currently, the process is labor and time intensive. As it stands, when there is an order for a hose (or multiple hoses), the process follows the flow depicted below in Figure 1.

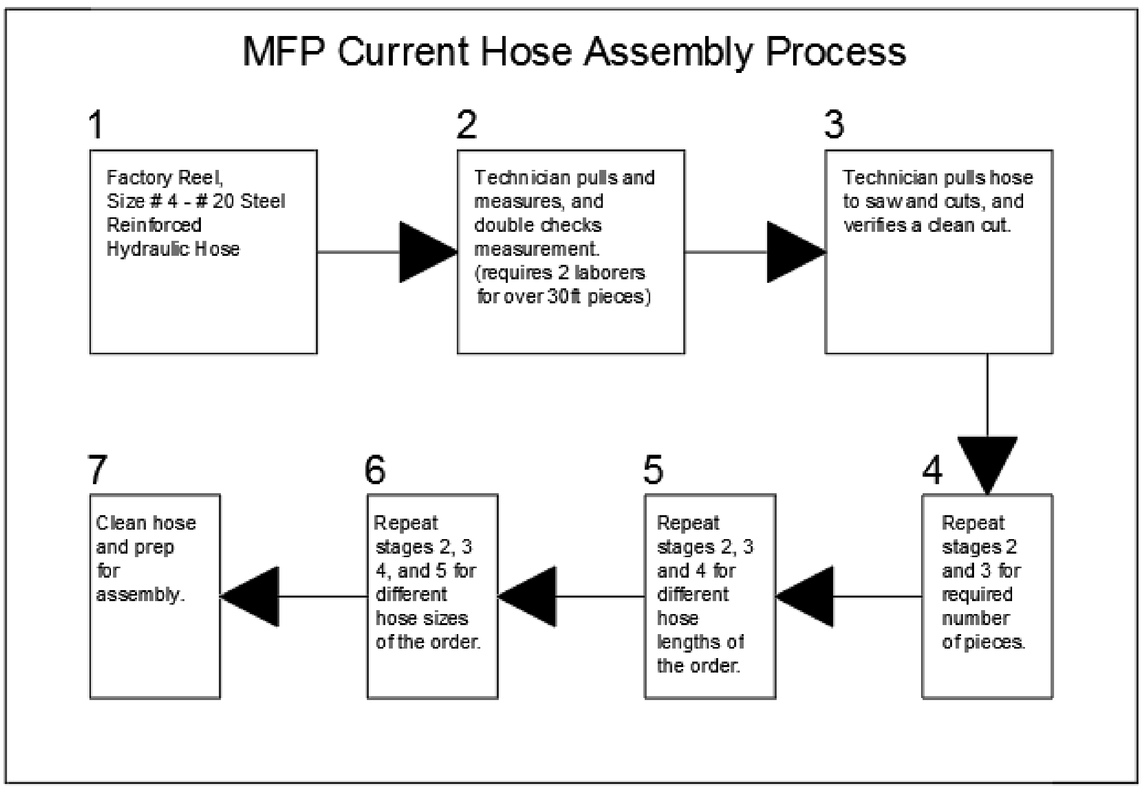

Figure 1: Flow diagram of current hose cutting process at MFP Automation Engineering.

Above, in Figure 1, is a simplified block diagram of the existing base assembly process. There are procedures happening outside the scope of our project that could easily be upgraded; however, these processes are not the goal of our machine.

Our goal is to take the flow diagram depicted in Figure 1, and simplify it to the flow diagram depicted in Figure 2. Figure 2 shows our plan to take the measuring and cutting processes away from the technician, whose time could be better utilized elsewhere. Currently, measuring and cutting are the most time and labor-intensive pieces of the hose assembly process. Our goal drops the 7-stage procedure, seen in Figure 1, to 4 steps. Additionally, the timing for this process is not quantified in the block diagrams. If you were to consider all 7 stages to be 100% of the time, then stages 2, 3, and 4 in Figure 1 would equate to approximately 75% of the process, considering one size hose and cut length. Because most orders have varying hose sizes and cut lengths, even more time will be added to the process (stages 5 and 6).

Referring to Figure 2, the previous stages of 2, 3, and 4 within Figure 1 have been reduced into one stage called machine setup. Once the proper hose size is in place, the technician only needs to input the parameters of the order: hose size, length, number of pieces, length of factory reel. After parameters are entered, the technician can walk away from the machine while it runs. This process is then repeated if the order requires different sizes of hose. Sizes of hose can range from 0.25" ID to 1.25" ID.

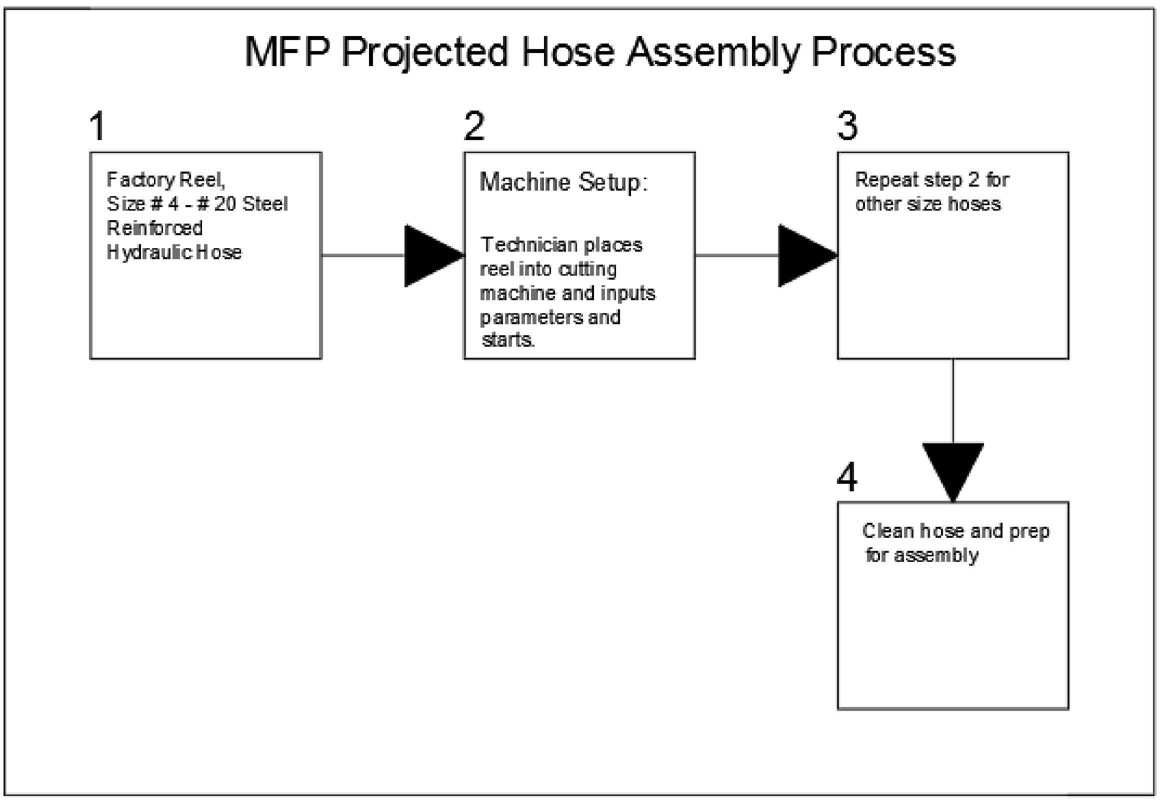

Figure 2:Flow diagram of projected hose cutting process in place at MFP Automation Engineering, after our machine is implemented.

1.1. Opportunity

MFP Automation Engineering presented our design team with an opportunity to help improve their steel reinforced hydraulic hose cutting process. MFP noticed their present cutting process had an opening for improvement. Considering the current system, the main issue of concern is that a worker needs to always be present. This worker is responsible for exchanging hose reels, measuring the length of hose, cutting the hose, and coiling the resulting piece. After reviewing this information, the most suitable solution would be to upgrade this process by creating an automatic hose cutting machine.

Our teams focus of this opportunity is to create an automatic hose cutting machine that targets the cutting process itself. This requires confirming a clean 90^{O} cut as well as implementing the appropriate safety measures. To succeed, our team will need to maintain trust, hold integrity, and be humble.

Trusting in each of our teammates is key in succeeding. MFP is also trusting our team to provide a dependable and reliable machine that will meet the requirements that they have set in place. Without trust, there is no opportunity. The integrity of each team members is also important, as our team needs to have a transparent relationship with each other and MFP. With a good relationship, the team can have a whole and undivided state of being, allowing for better communication and unity. Additionally, each team member will have to humble themselves. A humble attitude will allow work productivity to increase, knowing that each teammate is of equal importance to the team. Humbling ourselves will also allow us to use MFP's resources conservatively, while still fulfilling the purpose of this opportunity.

Overall, our team is going to take advantage of this project and design a feasible system that will efficiently cut steel reinforced hydraulic hoses for MFP Automation engineering. We have concluded that a feeding system will bring the hose to the cutting mechanism and a rotary encoder will be used to measure the precise length of hose needed. Through this opportunity our team plans to serve our customer, each other, and God overall.

1.2. Team Members

Peter Betten:

Peter Betten is a senior Electrical Engineering major at Calvin College. Peter has over 5 years of experience in a professional engineering environment as an intern in various engineering departments. Additionally, he has 9 years of experience in the industrial and hydraulic automation field in various positions, ranging from shipping and receiving, to installs. The past two summers, Peter spent interning in the automation department at MFP Automation Engineering. He gained great experience with the install team helping install, troubleshoot, and assist in start-ups of various industrial applications. With Peters experience in the industrial world, he will play a vital role in the project. He will provide the team with a better understanding of what to expect from the project. Peters abilities as a practical thinker and problem solver combined with his background in automation, hydraulics, and pneumatics will give him the ability to pull the mechanical and electrical pieces of the project together.

Reuben Saarloos:

Reuben is a senior studying Mechanical Engineering at Calvin College. Reuben is bringing his ability to understand and design systems to the project. This ability came from an internship experience where he was on quality control for the construction of a new waste water treatment plant. This construction project included all major concentrations of engineering. Reuben's on-site leadership promoted the teamwork of these contrasting fields and directly resulted in one plant that functioned together toward a common goal. Reuben's experience will be crucial to keep the team organized and prioritize tasks that need the most attention. The project will have many features involved in the design phase including both mechanical and electrical quality’s making his skills fundamental to the success of the project.

Mitchell DeBruin:

Mitchell DeBruin is a senior studying Mechanical Engineering at Calvin College. He has spent the last two summers interning at an American-based furniture company called Steelcase. Additionally, during the summer of 2015 he studied abroad at the Technical University of Berlin, Germany, giving him a cultural experience that he uses to build valuable lasting relationships with both peers and employers. Throughout his time at Steelcase, he gained great experience having to communicate with multiple departments, assisting in testing of products, and trouble-shooting unforeseen issues. Mitchell's experience as a product development and finishing engineer intern will help him play a key role in the project. His abilities of problem-solving, communication, and time management will be great assets to the team. He will be able to integrate his skills into the design and quality of the mechanical aspects toward the success of the project.

Erik (Lars) Johnson:

Lars Johnson is a senior studying Electrical Engineering at Calvin College. Lars excels at computer programming and electrical system design. Lars has 8 years of experience in working as a lighting and sound technician for events. Lars gained lots of experience controlling various systems in different venues. This experience along with several years of being a counselor at a summer camp gives him the ability to deal with solving unexpected problems individually and as a team. Lars’ experiences will be crucial in design and construction of the system controls such as automation timing, electrical communication within the system, and programming the interface.

2. Project Management

2.1. Team Organization

The team is made up of two mechanical engineers, Mitchell and Reuben, as well as two electrical engineers, Peter and Lars. Mitchell will oversee meeting minutes and be in charge of the cutting design. Reuben will be in charge of initial Cad layout and the mechanical aspect of the feeding system. Peter will be in charge of the measuring system, budget, and act as lead project manager. Lars will oversee the controls system and the schedule.

2.2. Schedule

The schedule will be managed by Lars and be updated during meetings, by using Microsoft project. When a schedule change occurs, members will be notified during a weekly meeting or immediately by text if a major problem occurs. Additionally, the schedule will be public for team members so teammates can see what is coming up. New changes will be highlighted so team members can easily see changes made.

2.3. Budget

The budget will be managed by Peter. MFP will be helping us with the budget for more specific part suggestions. This will benefit them, as they will be able to use and buy parts that they are familiar with, therefore helping them in the future with any maintenance of the machine, replication, or development of the design.

2.4. Approach

To obtain our goal of providing MFP with a working prototype for their hose cutting process. Our team must have a systematic and analytical approach to this design. Before we are able to produce an optimal design, we will have to do a lot of research into each component of the system. We will have to make the decision to purchase off the shelf parts or if the component will need to be customized by our design team. We will then provide MFP with our decisions and communicate with them if our decision is the way they want to go forward with the design. Once we get to the construction of the machine, understanding how each component will be tied together will be crucial to having a working machine as our final result. Finally understanding the potential risks involved and mitigating them to the best of our abilities will be important since we have strict specifications that need to be met.

3. Specifications

3.1. Cut Length

Cut length is the first of our specifications, as MFP provides a large range of hose sizes to customers. The maximum hose length that is needed from MFP Automation Engineering is 150 feet long, while the minimum length is set at 5 inches. Meeting these ranges of hose lengths will allow MFP to continue providing customers with the variety of parts needed. Some of MFP's customers use these hoses for medical applications and therefore the tolerance of the cut is very small. Each cut of the hose must be within ¼ inch of the specified length for it to be considered a usable part. During the testing and calibrating phase of our machine, we will test the accuracy and range of the system by running the machine through the full range of hose lengths in intervals. We will then measure the cut hoses to make sure they are within ¼ inch of the specified length.

3.2. Hose Size

Not only is there a large range of hose cut lengths, but our designed machine must also be able to handle a variety of hose sizes. MFP provides a range of hose sizes to their customers ranging from size 4 hydraulic hose (¼ inch) to size 20 hydraulic hose (1 ¼ inch) inside diameter. This means that our saw will have to be able to cut the largest size of hose without being destructive to the smaller, flimsier hydraulic hoses. Our feeding and tensioning system must also be designed for easy adjustment for ranging hose sizes. To test that our machine works for these hose sizes we will have to run various ranges of hose sizes through our machine. The hardest part will be adjusting the machine for the outside diameters since some suppliers of hydraulic hose have different thickness and braiding for reinforcement purposes.

3.3. Mobility

Another specification that is crucial in meeting MFP's needs is mobility. MFP wants the machine to have the ability to be moved around the shop. This is because not all hose reels are placed in the same area. Additionally, our machine must be able to connect with a standard power outlet of 115V AC and to regular shop air at 90 PSI. Lastly, for the whole machine to be mobile, it must be built on a single cart which is thin enough to move through a regular door frame and have two turning casters for full range rotational movement. However, the machine will need to have two foot-locks restricting the machine from moving while it is active for safety purposes.

3.4. Cut Quality

The final specification presented to our design team was the quality of the cut. This is essential to their business. To produce a clean finished cut, it must be at 90°. The margin of error that is tolerated in the industry is +/- 3° , which is quite precise considering how flexible the hoses can be. The hose must be cut square so that when the fitting is placed on the piece, the seal will complete. If it is cut at too severe of an angle, the fitting will wear much faster due to improper sealing and will become a safety hazard.

4. Design Alternatives

4.1. Design Ideas

<u>Cutting Method</u>

When deciding how we wanted to cut steel reinforced hydraulic hoses, our team had to determine the risks and rewards that go along with each alternative. The most important aspect of the machine is to create a clean cut on the hose due to safety risks. When hoses are used in the field, if they do not have a clean cut, the risk of the hoses failing increases significantly, which increases the risk of injury to a person.

The first cutting option for our machine was to bring the saw into the hose, which would be fixed in place. Although this method seems ideal, it has safety and financial risks attached with it. Having the saw move into the hose means that the machine will not only have a rotating saw, but one that is moving up and down. This increases the chance of injury if an employee is not careful. Moving the saw into the fixed hose would also cost MFP financially, as the blades would have to be replaced more often due to heavier wear and tear from the hose. The heavier wear and tear on the blade would be caused from hoses not being flexed properly while being cut, causing the blade to pinch the hose, which would also make the cut less clean.

The second cutting option for our machine would be to bring the hose into the saw, which would be fixed in place. This option would allow for the hose to have a bend, allowing for the saw not to pinch the blade as it contacts the hose. Additionally, the cut of the hose will be much cleaner due to no pinching, which will also allow the blades to have a longer lifecycle. This option is financially and mechanically preferred; however, it still has the risk of potential injury. Safety will always be a risk that our team will need to assess.

The third cutting option for our machine would be to use a guillotine to cut the hose rather than a rotating saw. The problem with this method is that by using a guillotine our machine would need to produce a lot of force on the hose to cut through the steel. Additionally, if the guillotine had enough force to cut the hose, the blade would likely be pinched causing a messy cut with a frayed end. As said before, not having a clean cut increases the risk of failure of that hose in the field, which increases the risk of injury or death of a person. This method has more risks than rewards in our team's eyes.

The cutting alternative that our team has determined best is option two: bringing the hose into the saw. This method has the lowest amount of risks within it as well as the highest amount of rewards. It makes the most sense to our team that we implement this method, as it allows us to focus in on making a clean cut, which is the point of emphasis of the machine.

<u>Feeding System</u>

The method in which we feed the hose to the saw is important for obtaining the accurate amount of length for each cut. The feeding system must accurately be able to bring a wide range of hose lengths and diameters to the saw. The difficulty in this, is that the feeding system needs to be consistent across the whole range of hoses. From research, we learned that a popular feeding system is a double conveyor system that will push the hose to the saw. This system is pictured below in Figure 3. This method is popular because it maximizes the amount of surface area that the hose is in contact with. This will minimize the amount of slippage. The risk with this system is that it will be difficult to obtain the full range of hose diameters since each time the hose size changes, the height of the conveyors will also need to be changed.

Figure 3:Conveyor Feeding Mechanism

A pulley system driven by belts was also considered as an option; however, we don't believe that this system will be ideal for feeding because there is a much higher risk for lower amounts of accuracy. This is because there is more slippage expected within this design due to more forces acting on the hose to keep it in tension and less surface area from the pulley's connecting with the hose. The benefit from this machine is that it will reduce the amount of elastic rebound from the hose, which will be trying to return to the shape of the hose reel.
Another alternative was to leave the measuring system manual. This involved changing nothing from the current process or inputting a hand crank system. The reason to implement this alternative would be to focus entirely on automating the cutting aspect. However, measuring and cutting are so intertwined that this alternative was rejected.

The final alternative was to create a conveyor system that had clamps to attach to the hose. These clamps would clamp onto the hose as it came around the belt and release the hose as it got to the end of the conveyor to start another rotation. There would be multiple clamps so that one is always pulling the hose. The risk involved with this system is the timing between when the clamps should be clamped and released would be very difficult for each individual clamp. Additionally, another risk is that if the clamp happens to end up under the blade due to a needed measurement, we would have the potential to damage the system and lose accuracy. The reward for the system is that there would never be any slippage and the system would be extremely accurate.

<u>Hose Measuring Method</u>

Measuring the length of hose needed to be cut will be the biggest challenge of our design. This is due to the very small tolerances that are required. The first design system that we thought about was a vision system. This system would be able to measure the length of hose based off of the number of patterns counted, which are factory printed specific to the manufacturer. This system would be difficult to implement since the hose would likely spin throughout the process. If the hose spins the vision system would be unable to have continued sight to the product pattern and lose its accuracy. Therefore, we opted not to use the vision system.

The second alternative we looked at was to use a loop controller to measure the hose length. This system is different in the sense that it doesn't necessarily measure the hose specifically, but instead uses a formula relating output feed from the conveyor system and the amount of time passed since the previous cut. The loop controller measures the output of the hose from the conveyor belt, compares it to the feeding rate of the conveyor belts, and then adjusts according to the error involved. An illustration showing this process is pictured below in Figure 4

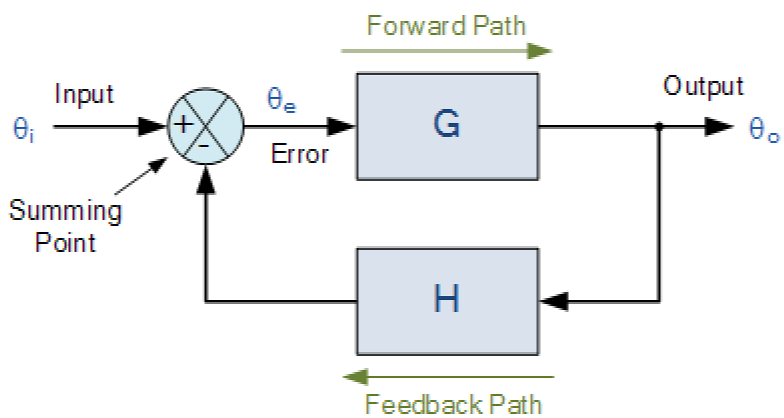

Figure 4:Closed-Loop Controller diagram

The final measurement alternative considered was a rotary encoder. This consists of a disk that has a series of different patterns etched into it. These patterns are designed so that at every point along the disk there is a new pattern; therefore, the position is always known. The major risk involved with using a rotary encoder is the fact that there must be physical contact between the encoder and the hose at all times. There are ways that this can be accomplished, so we plan on using this method in the tensioner system to measure the amount of slack in the system. Since the hose is in tension, forcing constant physical contact will be much more practical.

<u>Control System</u>

The control system for our design has a few alternatives that could potentially benefit the project. The focus to consider when picking a system will be the power and the robustness of the system. A major aspect to consider when it comes to the systems power will be that the control system needs to have enough power to turn on the motors for both the feeding and cutting system. Additionally, a second aspect which needs to be considered would be the robustness of the system. Because our system will be used in industry, our team needs make sure that the system would last.

The first control system option is a PLC controller with HMI interface. The benefits of this system are that it is widely used across industry and used in most automated processes showing the robustness of the system. This is also the system that MFP is most familiar with using, making it easier for them to modify the system and add further systems in the future. The problem of the PLC is the cost for this controller, but overall the PLC is the best control system for our design.

The second control system option is a Raspberry Pi with keyboard and screen. The benefits of this control system are that it is cheap and has a lot of open source coding; however, the system doesn't respond great in real time with information from sensors. The system is also like a small computer, allowing it to perform complex activities. Other issues with Raspberry Pi are that it is not widely used in industry and although it is able to run complex programs, the system that we are using doesn't need that complex of a program to run the system.

The last control system option is an Arduino board with a keyboard and screen. The benefits of this control system are that it is cheap and has a lot of open source coding. The system is also a micro controller with a fast response time; however, it only uses simple programs. The problems with this system are that it is not as robust as the PLC controller and MFP will need to develop infrastructure around it for support, as opposed to the PLC, which already has infrastructure around it. This makes the PLC controller most preferred in the long run, as it is the best control system for industry and therefore for our project.

4.2. Final design Choice

The final design choice was decided based off the design alternatives that best fit the opportunity presented from MFP. Our team designed our cutting process to bring the hose to a stationary saw. This alternative was chosen because it will be much easier to implement a safety feature for the saw if it is stationary. Bringing the hose to the saw will provide a cleaner cut since this method will provide a bend radius in the hose, restricting a pinch point on the blade.

The feeding system we chose to pursue includes a tensional pulley system in combination with the conveyor belt feeding system. The tensional pulley system will straighten out the hose, which will minimize the hose from returning to its original position. The tensional pulley will then feed into the conveyor belt system. This transition will allow for some slack in the hose, so that when the feeding system stops to get cut, there will be less strain on the system when it slows down. The conveyor system will feed at a set rate and will be a variable in the measuring system.

The measuring method will consist of two alternatives: a rotary encoder and closed loop encoder. The rotary encoder will be incorporated with the pulley system as a method to vary the speed of hose that is taken off the factory reel. The closed loop encoder will be used to measure the length of the hose being fed to the saw by using the input of the conveyor feed rate and the measured exit velocity of the feeding system.

5. Safety

Safety could potentially be an issue with a couple components of our mechanism. Therefore, we must be conscious of these issues and design a system that will limit the amount of risk involved. The three main safety issues we are concerned about with the machine is the saw, the toxins released from cutting the hose, and the cumulation of moving parts in the system. The saw is the most injury prone device. In fact, an MFP employee cut off multiple fingers in a past incident while using the same saw we intend to utilize. Our design for the saw will have a safety guard over the blade that will be spring loaded so that only when the hose is pushed with a large amount of force onto the blade that the guarding will be moved allowing for only the hose to be cut.

The toxins released from the coating of the hose, during the cut, could be an issue if employees are subject to long term exposure. MFP's existing saw has a large hood placed directly behind where the saw is mounted, allowing for the soot to be vented and filtered out of the area. This method is works effectively at disposing the toxins out of the building. Our goal in this design is to utilize that vent primarily but in addition, we may add an attachment for a shop vacuum to be applied for when the cart is mobile.

All the other moving parts in the system that have the potential to catch a loose piece of clothing or hair, must be guarded to mitigate any injury. As an additional safety feature, we plan on incorporating an emergency system shutdown mechanism (E-Stop) that will stop the whole machine from running. Lastly, we plan to provide an adequate outline for O.S.H.A. approved "Lock Out Tag Out" consisting of energy control procedures to ensure that before any employee performs any servicing or maintenance on the machine where the unexpected energizing, startup or release of stored energy could occur and cause injury, the machine can be isolated from the energy source and rendered inoperative.

6. Business Plan

6.1. Pricing

These machines range from a price of $9,000.00- $15,000.00. The cost of each system is heavily dependent on how many additional components are included within the system. Our team has obtained a quote from one possible supplier for the Uniflex EM 115.3, which can be seen below in Appendix D. This quote has determined that the price of the Uniflex EM 115.3 will cost around $14,000.00, which is in the general range that we have predicted. Specifications for the Uniflex EM 115.3 and another similar product can also be found in Appendix D.

7. Future Work

- ERP interface: MFP Automation Engineering would like us to implement a second stage of design into the system, where instead of using a number pad and LCD screen (or in combination/ sequence with) we would be able to interface our system to use data from the existing ERP (Enterprise Resource Planning) system. This means that we could use either a work order number or a barcode scan to give our system all the necessary parameters to complete a job.
- Rotary Table: Originally part of the main design scope, we would like to be able to implement a rotary table as a way to coil the larger lengths of hoses that will be going through our system. This challenge doubles the scope of the process as it deals with TAKT time (Takt time is the maximum amount of time in which a product needs to be produced in order to satisfy customer demand) and system timing, meaning communication between the feeding system and the rotary table.
- Blade Change: Lastly, MFP spoke of the convenience of incorporating an interchangeable blade system into the design. This would mean the feasibility of swapping between a rotary blade (a blade that uses rotational inertia to cut through material) and a guillotine blade (a blade that uses raw force to pierce material) with minimal work necessary for the swapping of the two blades.

8. Acknowledgements

This project expended a huge amount of work, research and dedication. Still, implementation would not have been possible if we did not have the support of many individuals and organizations. Therefore, we would like to extend our sincere gratitude to all of them.

First of all, we are thankful to MFP Automation Engineering for their financial and logistical support and for providing necessary guidance concerning our projects implementation. Specifically, our project mentor and manager Scott Wanta, who helped to give the project footing and lead the project at MFP Automation Engineering. Nate Hinkle, an Automation Engineer at MFP Automation Engineering, who helped to point us in the right direction and pick out the best products and processes for the project. Specifically, he helped to direct us to which servo motor, feedback system, and PLC to use in order to control our system.

We would like to extend a thank you to Professor Renard Tubergen whose guidance and technical knowledge helped to keep our project moving forward. His guidance in project management and his technical expertise were instrumental in the completion of this project, and would not have been probable without his support.

Without their superior knowledge and experience, the Project would lack in quality of outcomes, and thus their support has been essential.

Nevertheless, we express our gratitude toward our families and colleagues for their kind co-operation and encouragement which help us in completion of this project.

9. Conclusion

To conclude, our goal for this project is to design and manufacture a machine for MFP Automation Engineering, that will efficiently cut steel reinforced hydraulic hoses. The main focus of our design will be the cutting and measuring processes for the hose. After exploring various design alternatives, we have decided to create a machine that will bring the hose into a saw because more safety applications can be applied. Additionally, we have decided to implement a tensioning pulley system in combination with the conveyor belt feeding system. The tensioning pulley system will straighten out the hose, which will minimize the hose from returning to its original position. A rotary encoder will be incorporated with the pulley system as a method to vary the speed of hose that is taken off the factory reel. The closed loop encoder will be used to measure the length of the hose being fed to the saw by using the input of the conveyor feed rate and the measured exit velocity of the feeding system. Overall, our system as a whole will communicate together to properly cut and measure the hose.

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1. Appendices

1.1. Appendix A: Schedule

Table 1: Task List

Task Mode	Task Name	Duration	Start	Finish	Resource Names
Manually Scheduled	Motor, Plc, and Saw	19 days	Tue 1/2/18	Fri 1/26/18	Mitch,Peter
Manually Scheduled	Day 1 begin of Spring Semster	2 days	Mon 1/29/18	Tue 1/30/18	Start
Manually Scheduled	Tensioner Design	10 days	Mon 1/29/18	Fri 2/9/18	Reuben
Manually Scheduled	measure system research	10 days	Thu 2/1/18	Wed 2/14/18	Peter
Manually Scheduled	Tensioner control	10 days	Thu 2/1/18	Wed 2/14/18	Lars
Manually Scheduled	Feeder Design	10 days	Fri 2/9/18	Thu 2/22/18	Reuben
Manually Scheduled	measure system Design	20 days	Wed 2/14/18	Tue 3/13/18	Peter
Manually Scheduled	Feeder Control	10 days	Wed 2/14/18	Tue 2/27/18	Lars
Manually Scheduled	Cutting design	10 days	Thu 2/22/18	Wed 3/7/18	Mitch
Manually Scheduled	Feeding system order	7 days	Thu 2/22/18	Fri 3/2/18	Reuben
Manually Scheduled	Cutting control	10 days	Tue 2/27/18	Mon 3/12/18	Lars
Manually Scheduled	Assemble of Feeding system	14 days	Thu 3/1/18	Tue 3/20/18	Reuben
Manually Scheduled	Clamp Design	5 days	Fri 3/2/18	Thu 3/8/18	Mitch
Manually Scheduled	Clamp control	5 days	Thu 3/8/18	Wed 3/14/18	Lars
Manually Scheduled	Cutting system order	7 days	Thu 3/8/18	Fri 3/16/18	Mitch
Manually Scheduled	Assembly of Cutting system	14 days	Fri 3/16/18	Wed 4/4/18	Mitch
Manually Scheduled	Controls wiring	4 days	Wed 4/4/18	Mon 4/9/18	Peter
Manually Scheduled	Layout Placement	4 days	Wed 4/4/18	Mon 4/9/18	Mitch
Manually Scheduled	Controls testing	15 days	Mon 4/9/18	Fri 4/27/18	Peter

Manually Scheduled	Senior Design Night	2 days	Sat 5/5/18	Sun 5/6/18	End

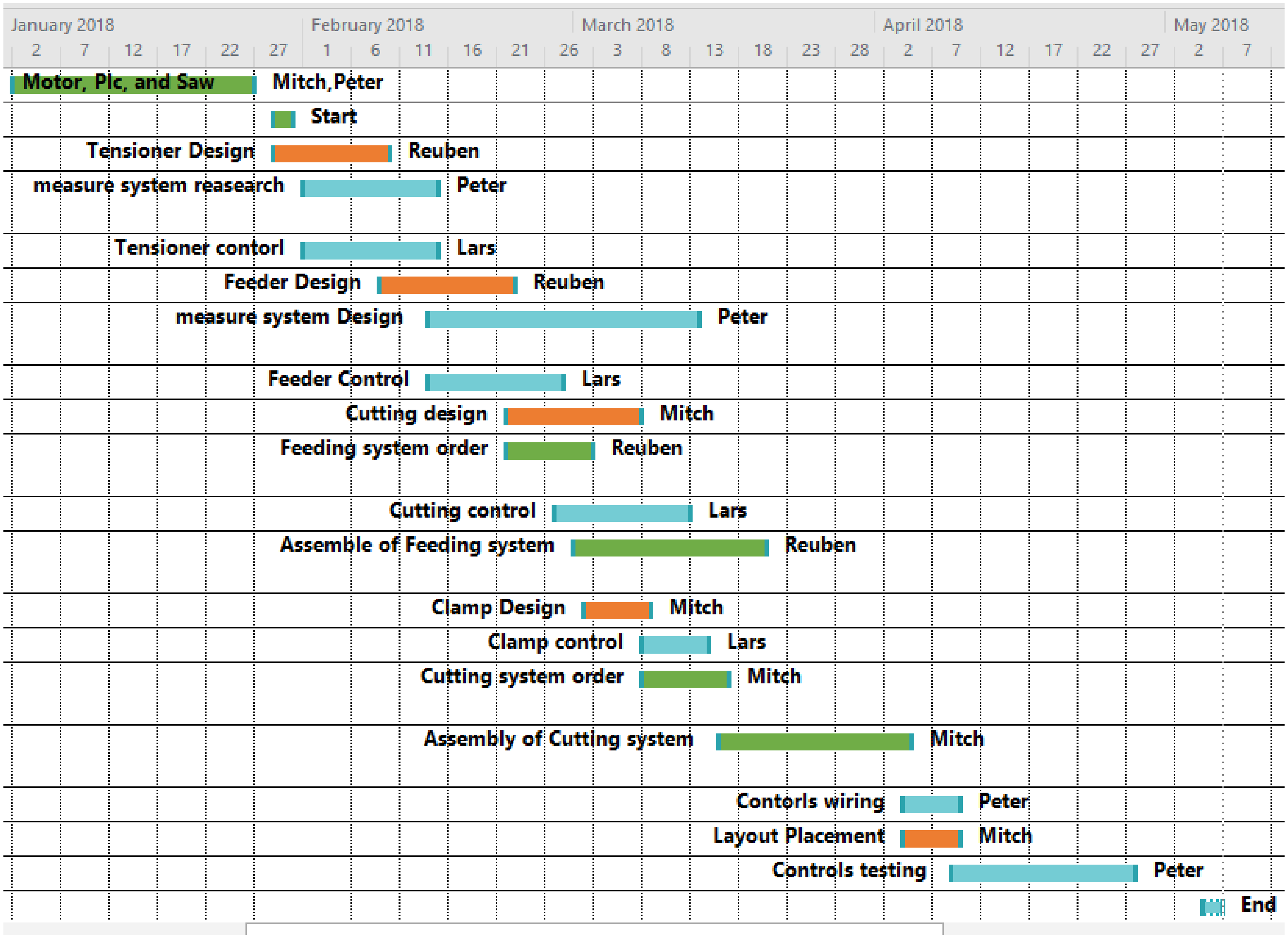


Figure 1: Gannt Chart

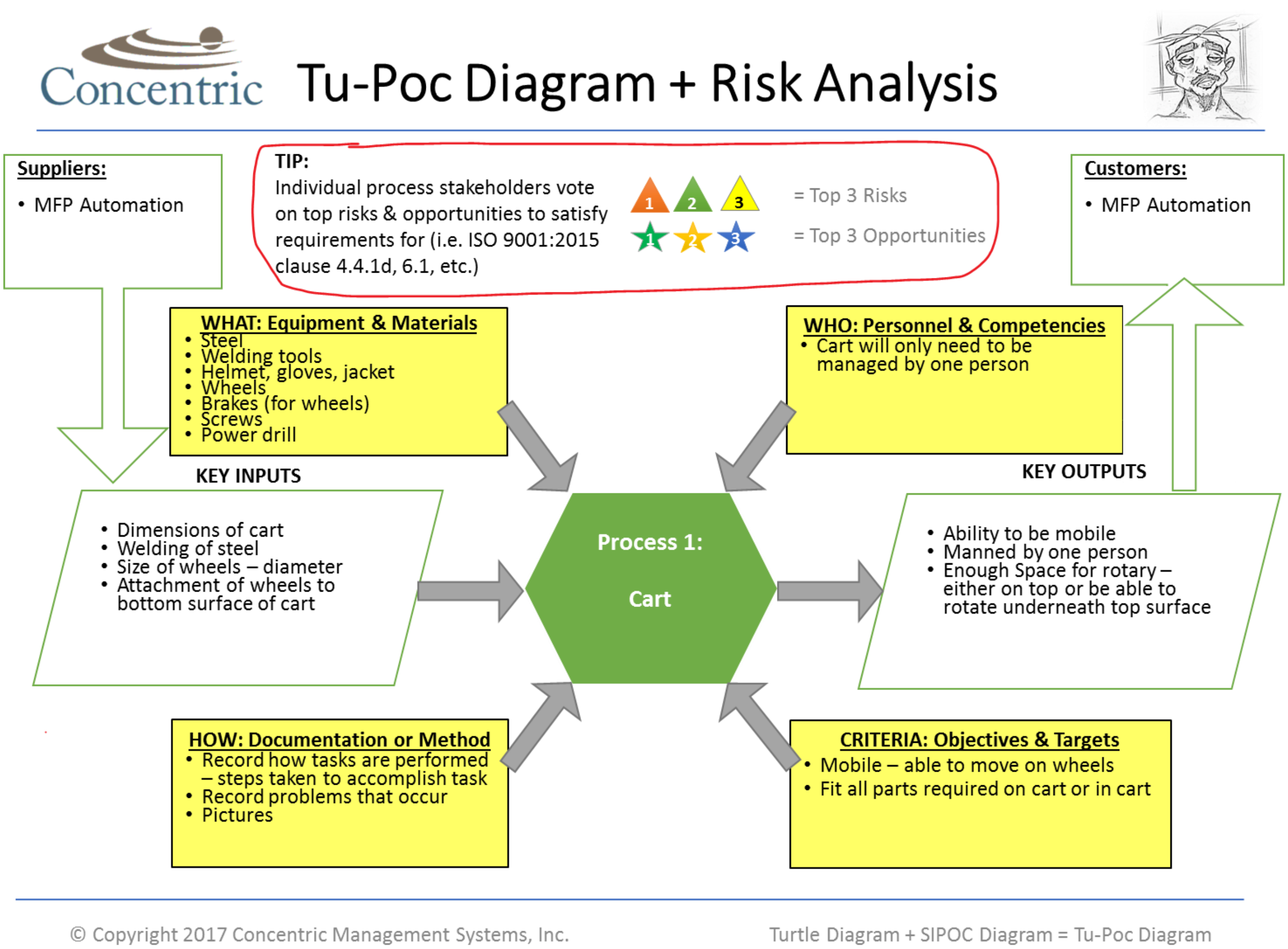
1.2. Appendix B: Budget

QTY	Part	LIST PRICE
1	CLICK PLC HEAD UNIT	$18.00
1	8DI/8DO DISCRETE MODULE	$24.00
1	POWER SUPPLY 24VDC 10A (240W) 3-PH	$127.00
1	SERVO MOTOR	$7.25
1	LINEAR ACTUATOR	$90.29

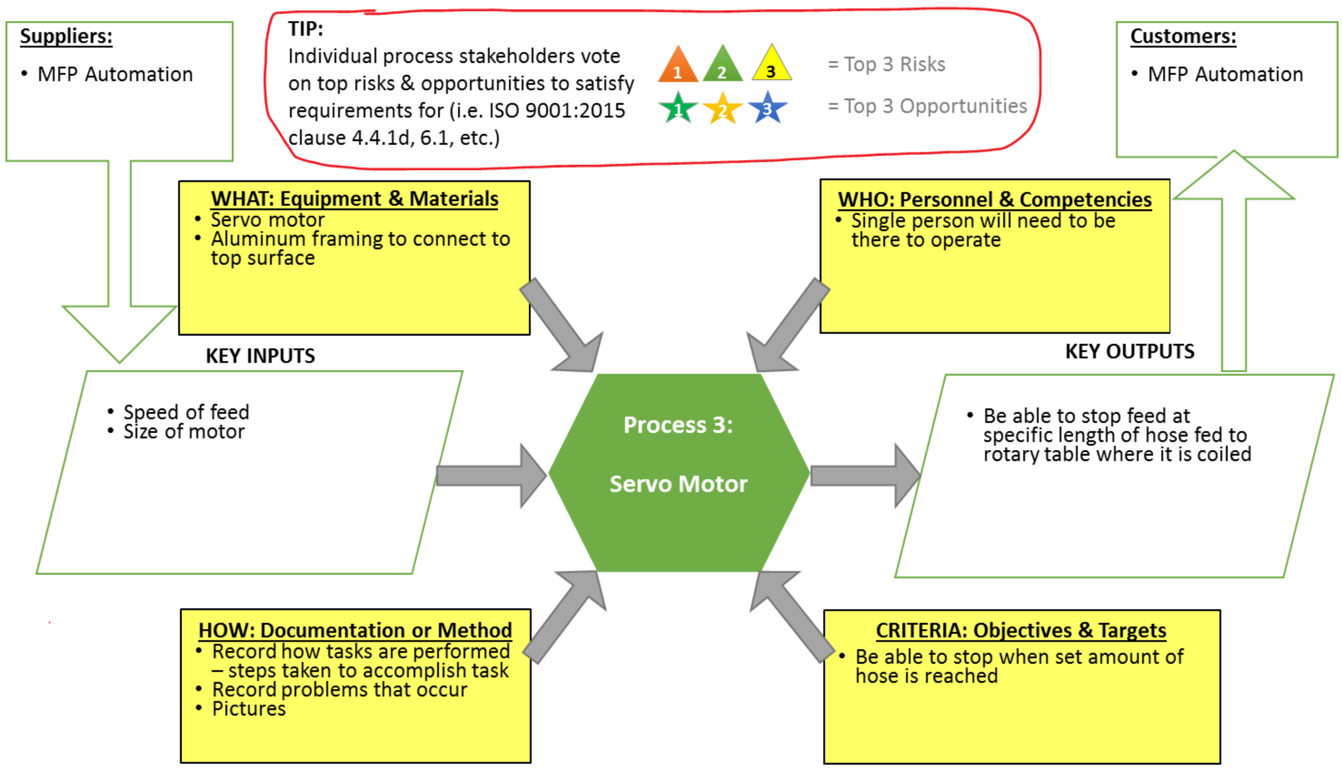
1	DIGITAL INTERFACE	$375.00
8	DOUBLE-DECK TERMINAL BLOCK	$2.77
1	END PLATE FOR DOUBLE-DECK TERM BLOCK	$0.62
3	2 POLE TERMINAL BLOCK	$1.70
2	2 POLE GROUND TERMINAL BLOCK	$4.24
1	END PLATE FOR 2P TERM BLOCK	$0.59
1	CORDSET, 4 POLE, FEM, STRAIGHT, 20FT, 15 AMP	$77.74
1	20X16X8 ELJ ENCLOSURE	$157.76
1	SUBPANEL, FLAT	$19.96
1	3.62"X3.62" FILTERED VENT	$11.00
1	XT MANUAL MOTOR PROTECTOR, 2.5-4A	$96.21
1	ROT HANDLE MECH ELECTRONIC MMP IP65 RED	$59.21
1	MALE RECEPTICLE, 4 POLE, 3 FT	
6	SOCKET WITH MINIATURE SWITCHING RELAY	$12.26
3	15 AMP B CURVE CIRCUIT BREAKER	$19.73
		$5.00
10	4 POSITION DIN RAIL MOUNT TERM BLOCK	$1.85
1	2 CONDUCTOR FUSE DISCONNECT FOR 5X20MM FUSE	$9.16

1	END PLATE 2MM THICK FOR FUSE TERMINAL BLOCK	$0.79
1	10A 250V FAST ACTING FUSE 5 X 20MM	$2.62
9	CONNECTOR ACCESSORY, JUMPER	$1.68
1	MAIN CIRCUIT BREAKER	$24.50
	total	$1,150.93

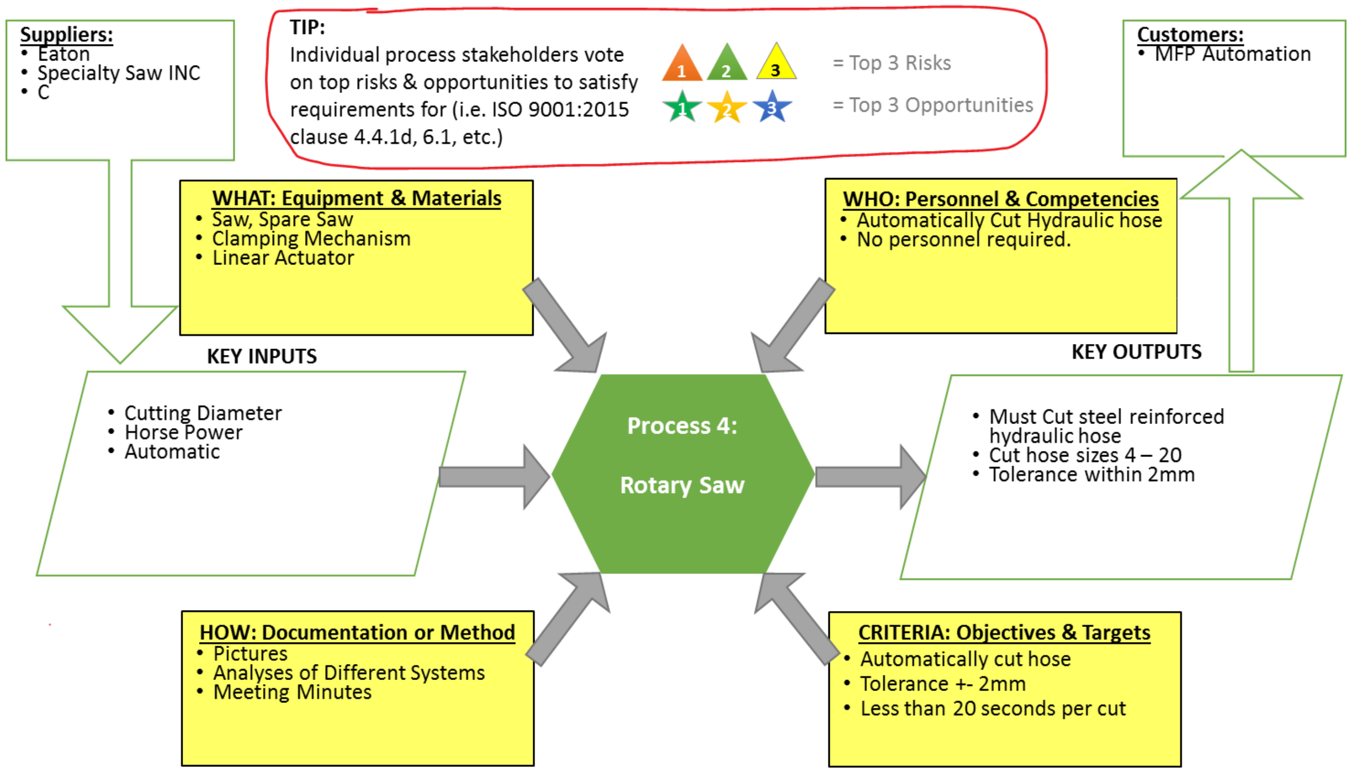
1.3. Appendix C: Turtle Diagrams



Tu-Poc Diagram + Risk Analysis

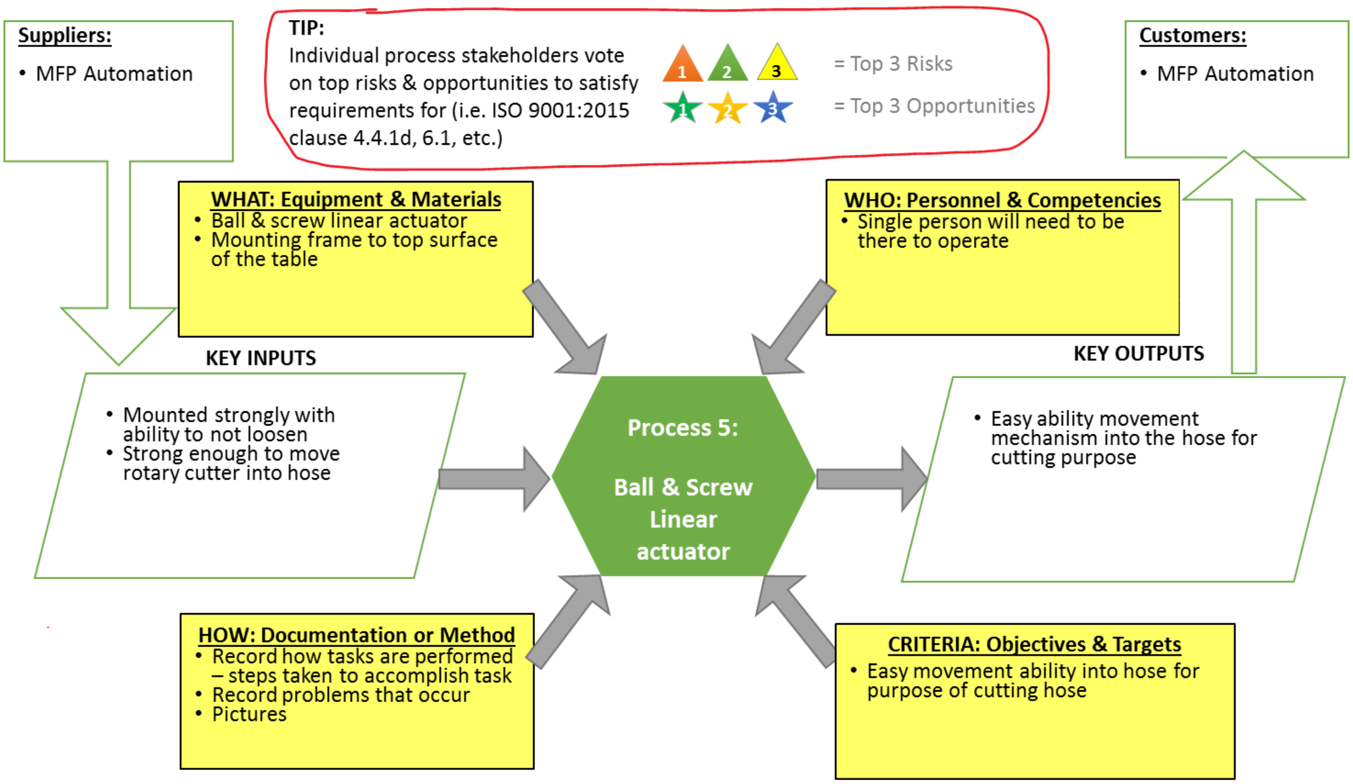


Tu-Poc Diagram + Risk Analysis



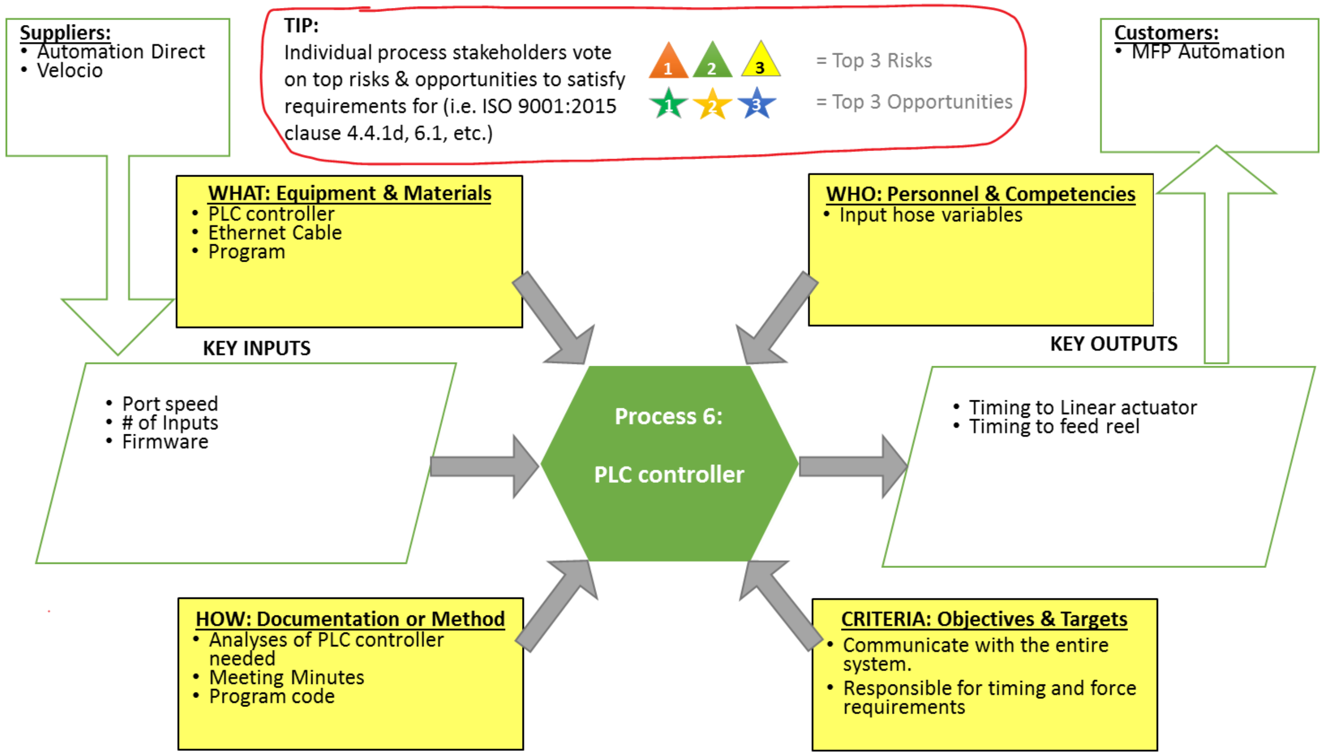
Turtle Diagram + SIPOC Diagram = Tu-Poc Diagram

Tu-Poc Diagram + Risk Analysis



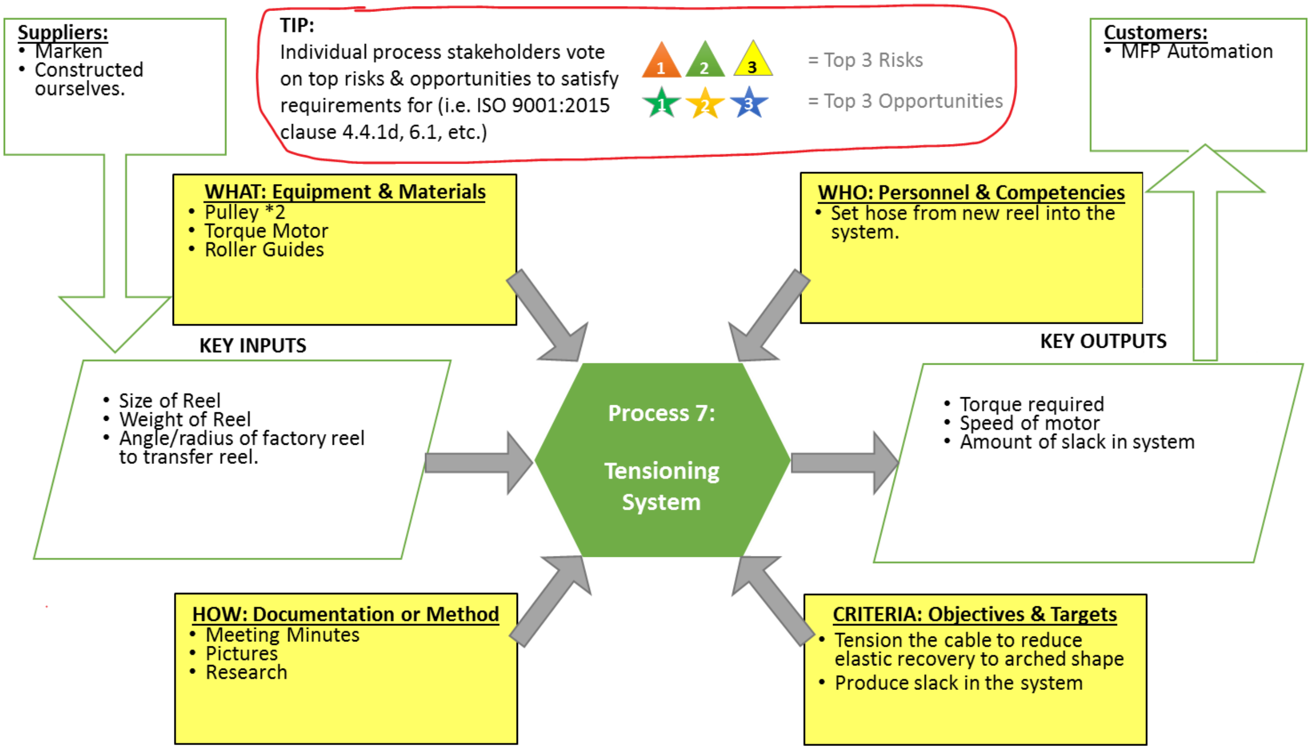
Turtle Diagram + SIPOC Diagram = Tu-Poc Diagram

Tu-Poc Diagram + Risk Analysis



Turtle Diagram + SIPOC Diagram = Tu-Poc Diagram

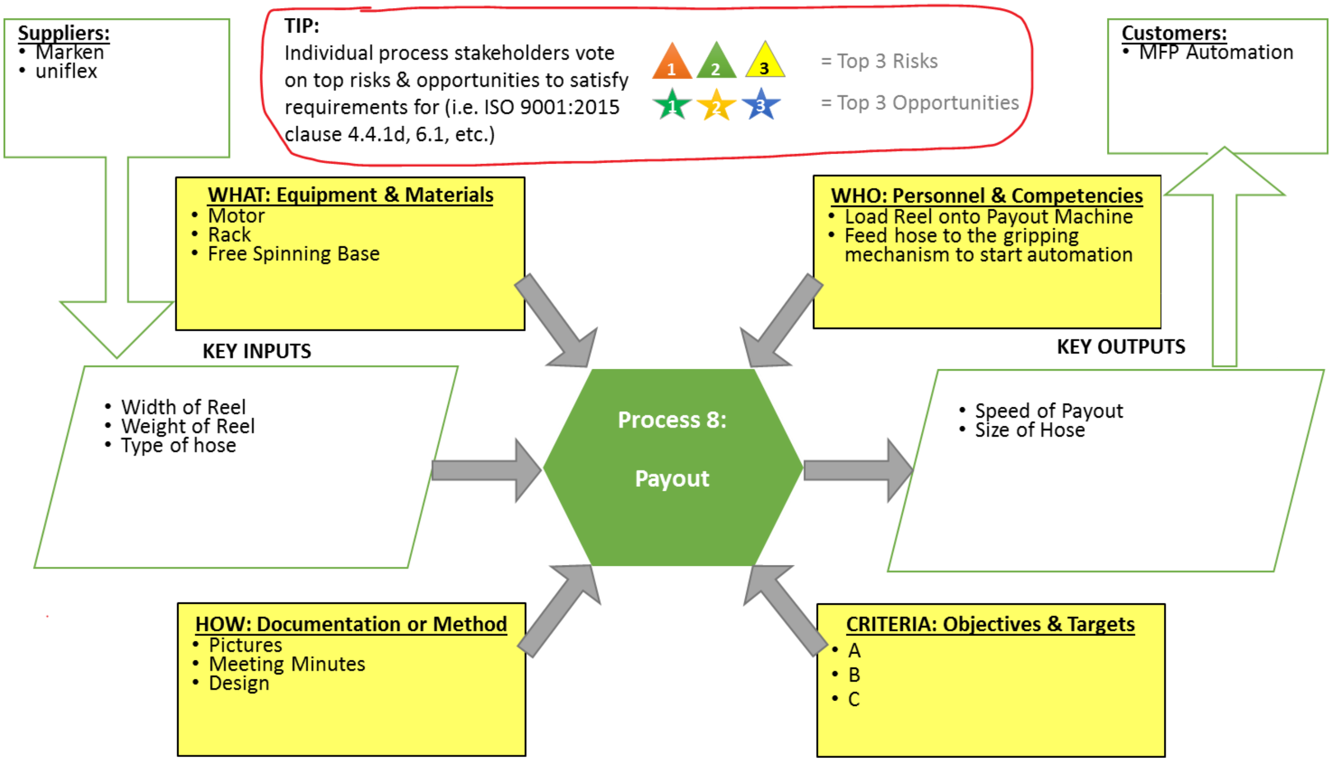
Tu-Poc Diagram + Risk Analysis



Turtle Diagram + SIPOC Diagram = Tu-Poc Diagram

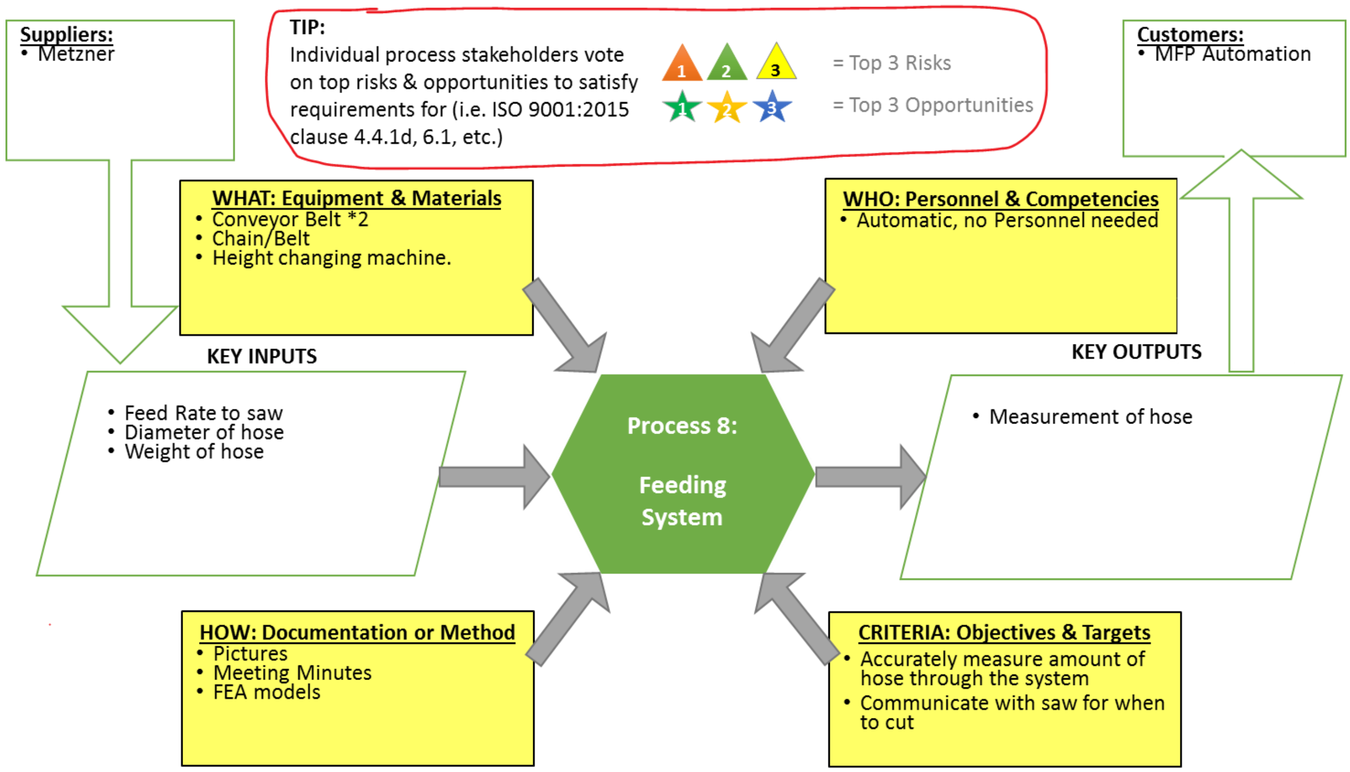
Concentric

Tu-Poc Diagram + Risk Analysis



Concentric

Tu-Poc Diagram + Risk Analysis



Turtle Diagram + SIPOC Diagram = Tu-Poc Diagram

1.4. Appendix D: Uniflex quote

The best Return on Investment
Since 1972

UNIFLEX

UNIFLEX of America LLC.
1088 National Parkway
Schaumburg, IL 60173

Phone: (847) 519 1100
Fax: (847) 519 1104
E-Mail: sales@uniflexusa.com

Machines for the Manufacture of Hose Assemblies

Michigan Fluid Power
Roger Betten Jr
4404 Central Parkway

Hudsonville, MI 49426
United-States

Prepared by:
Bryan Xu

Proposal / No. XRPUQ1811

10/24/2017

Dear Roger ,

Thank you for your interest in our products. Please find below the quotation for your requested items.

Uniflex machines are grease free providing exceptional life, clean production, operator safety and ease of use, reduction in costly maintenance and delivers consistent performance, all adding up to the best return on investment in the industry.

Fixed six o'clock die for improved ergonomics in the assembly of large bore assemblies decreasing scrap while increasing productivity and safety of the operators.

Pos.	Description	Qty	Unit Price	Price
1	EM 6.2 P hose cutting machine (220-240V-50/60Hz-3Ph) Feed of the hose is pneumatic For use in seriel production up to 1.25" SAE R13 and SAE R15 hose OK to use in some intermittent production for up to 2" SAE R13 and SAE R15 hose Can also do 2" industrial hose Uses TM C 350x3x30 cutting blade CE Safety certified NOTE: Many voltages are available and must be specified at the time of the order. Prices for non standard voltages could have a price increase to above quoted prices.	1	$4,935.00	$4,935.00

Pos.	Description	Qty	Unit Price	Price
2	EM 115.3_MVA hose cutting machine (220-480 V-50/60Hz-3Ph) Pneumatic feed of the hose into the cutting blade Speed of the feed is adjustable For use in seriel production up to 2" SAE R13 and SAE R15 hose OK to use in some intermittent production for up to 3" SAE R13 and SAE R15 hose Can also do 3" industrial hose Uses TM C 520x4x40 cutting blade Has brake motor to slow blade quickly for safety CE Safety certified NOTE: Many voltages are available and must be specified at the time of the order. Prices for non standard voltages could have a price increase to above quoted prices.	1	$9,758.00	$9,758.00
3	UWT 2.1_22_23 - Electric winding table with foot pedal 230V 50Hz single phase Electric driven hose coiling reel with foot pedal control for easy winding and unwinding of hoses up to 1 1/4" LxWxH = 800x900x1600 mm	1	$3,197.00	$3,197.00
4	UMS 4 Hose length measuring device Use with Uniflex floor mounting stand 514.1 for ideal height and stability Also can be mounted to bench or table	1	$805.00	$805.00
5	514.1 Floor stand for UMS 4 (840 mm)	1	$203.00	$203.00

Prices are in addition to our terms of payment and delivery.

validity of offer: 30 days
FOB: Schaumburg, IL
Payment Terms : 50% down, Net 30 days for remaining balance

delivery time: 1-12 weeks

State Sales and Use Tax will be charged to customers within the U.S. unless a Tax Exemption Certificate is provided.

An international buyer of these goods is responsible for all export taxes, duties and brokerage fees that may apply.

We would be pleased, if this quotation meets your requirements. In case of any further questions, please do not hesitate to contact us.

Best regards,

Bryan Xu
Uniflex of America
Cell: 847-436-0403

Uniflex EM 115.3

- Pneumatic feed of the hose into the cutting blade
- Speed of the feed is adjustable
- Has brake motor to slow blade quickly for safety
- CE Safety certified
- Can cut up to 2" of steel reinforced hydraulic hose
- 220-480 Volts 3phase power
- Must be used with additional component called UMS 4, which is a hose length measuring device

Metzner CCM 4

- Electric conveyor feeding system
- Speed of feed is adjustable
- Can cut 1 ¼ " of steel reinforced hydraulic hose
- 3-400 Volts 3phase power
- Includes length measuring system