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EML4551-2

Team 15: Evidence Book

Ryan Gaylord, Alex Glazer, Donald Phillips, Nestor Rigaud, Christopher Ruiz

FAMU-FSU College of Engineering 2525 Pottsdamer St. Tallahassee, FL. 32310

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ABSTRACT

Tree harvesting practices create great risk for human injury and damage to surroundings. For example, many trees have fallen on cables, nearby houses, and people. In addition, harvesting trees is expensive to the average consumer due to these dangers that arise. Our team is engineering a machine that can climb, de-limb, and section a tree. A worker controls this machine, at a safe distance, to avoid falling limbs. The machine's name, The Bear, comes from the way it climbs a tree like a bear. Hydraulics power The Bear, which consists of two clamps to grip the tree trunk. The top clamp acts as the bears arms and the bottom clamp acts as the bear legs. The Bear climbs up the tree, using these two clamps. The top clamp has a de-limbing blade to remove limbs as the device climbs. Once The Bear nears the top of the tree, it will begin to section the tree from the top as it climbs down.

PROJECT SCOPE

Project Description

Modify a total tree harvester, a machine used to fell, de-limb, and section a tree, to climb a tree while de-limbing branches. Once at a certain height, the tree harvester will cut off sections of the tree.

The project description changed over the course of the 2018 year. Rather than using the total tree harvester head, the scope has been changed to develop a device that is able to climb and de-limb a tree.

Key Goals

- Climb a tree
- Remove limbs
- Cut off sections of tree (this was eliminated from the scope of the project due to the needs of our sponsor. This is now a stretched goal)
- Remotely controlled by user
- Attach to a skid-steer, a small engine powered machine with rigid lifting arms, for mobility and power (Be powered using a powering system at a safe distance)

Market(s)

- Landscaping industry
- Construction
- Timber (Removed because machine is not profitable compared to current methods used by the timber industry)
- Private investors

Assumptions

- The given motors are capable of an optimal RPM to be able to climb tree. (The given motors are no longer used since a total tree harvesting head is no longer used)
- Tree is almost completely upright, no bends or Y shaped trees.
- The tree can withstand the weight of the ROV.
- Ideal weather conditions when operating.
- The machine is scalable from the final prototype (the prototype is scaled roughly as half as the goal machine)

Stakeholders

Jeff Phipps - Sponsor

Dr. Shayne McConomy - Project overlook

Dr. Chiang Shih - Project overlook

Dr. Jonathan Clark - Engineering Consultant

CUSTOMER NEEDS

The initial scope of our project was to design a base for a tree limbing and felling harvester. We would have been given a set of wheels that our sponsor provided to design around. After our first meeting, there were set conditions and needs that was required from our sponsor. After meeting with our sponsor to look at the wheels and equipment he was providing us, ~~A~~a change in scope was made. After much discussion, the scope was changed to what is now the project description and what our senior design team will be moving forward with. The first table below was the initial customer requirements made from the initial meeting with our sponsor. The following table is the updated and new customer requirements that will be used for our project.

Original Customer Requirements Table

Customer Statement	**Interpreted Need**
I want the harvester to climb a pine tree fast enough to shear limbs	The RPM of the wheel motors are large enough to climb and shear limbs
I want this to be remotely controlled by user	The controller is able to move the harvester up and down, open and close, and saw
I want to be able to attach this to a skid steer	Modify the ROV (Remotely Operated Vehicle) to have a universal skid steer attachment
A robotic arm must be used to cut off tree sections	The design will include an attachment for a hydraulic robot arm for cutting the tree
I don't want a bunch of wires from the ROV to the skid steer	Radio over electric over hydraulic controls
When cutting the sections of the tree off, they must not hit machine on its downfall	ROV will cut tree to avoid the machine
I want a camera set up to overview the operation	A crevice will be designed to place a small camera for monitoring use
I want the user to have enough chord to back up in the skid steer at a safe distance and climb a 60 ft tree	100 ft or more of chord to ensure safety for the user
I want the source of power to come from the skid steer	A power line will be used connected to the skid steer to provide electricity to the ROV

New Customer Requirements Table

Customer Statement	Interpreted Need
I want the harvester to climb a pine tree fast enough to shear limbs	The RPM of the wheel motors are large enough to climb and shear limbs
I want this to be remotely controlled by user	The controller is able to move the harvester up and down, open and close, and saw
I want to be able to attach this to a skid steer	Modify the ROV to have a universal skid steer attachment
I don't want a bunch of wires from the ROV to the skid steer	Radio over electric over hydraulic controls
When cutting the sections of the tree off, they must not hit machine on its downfall	ROV will cut tree to avoid the machine
I want the user to have enough chord to back up in the skid steer at a safe distance and climb a 60 ft tree	100 ft or more of chord to ensure safety for the user
I want the source of power to come from the skid steer	A power line will be used connected to the skid steer to provide electricity to the ROV

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FUNCTIONAL DECOMPOSITION

- Secure the ROV to the tree
    - Open up ROV arms
    - Align ROV to the base of the tree
    - Fasten ROV to the tree
    - Adjust ROV grip as the tree diameter changes
- Channel ROV through the tree
    - Transfer ROV up and down the tree
- Remove limbs from the tree
    - Align cutting tool at base of limb
    - Detach limb
- Remove sections of the tree
    - Orient cutting tool to proper angle
    - Extend and retract cutting tool
    - Cut off sections

TARGET SUMMARY

In the appendix, targets with numerical values were selected for each component in our functional decomposition as well as other targets that were desired. The first function was to "Secure to Tree", where we gave a target value for the minimum and maximum width the ROV can open, the maximum clamping pressure, and the minimum clamping forces to climb a tree and to shear its limbs. The minimum opening width of the ROV was assigned to be 8 inches while the maximum opening width was assigned a target of 25 inches. The minimum opening width was assigned this value from constraints given to us by our sponsor Jeff Phipps. After researching for the smallest diameter of pine trees in the southeast United States, 25 inches was about the average diameter found. The maximum clamping pressure was assigned a target value of 790 psi. This was assigned because the maximum compressive strength of a loblolly pine perpendicular to the grain was 790 psi. Therefore, anything greater than this pressure would compromise the mechanical properties and strength of the tree and could potentially puncture the tree and cause safety risk factor to the user. The reason for researching properties of a loblolly pine is because it's a commonly found pine tree in southeast United States and chosen as our target tree. The minimum clamping force for the ROV to climb a tree was determined to be 200 lbf. This was correlated to weight of the ROV which will be discussed later. The minimum clamping force to shear limbs was determined to be 5,371 lbf. This was calculated by applying the sum of the forces to the weight of the ROV and the force required to shear limbs.

The following step in our functional decomposition was to "Climb the Tree", where a target value of the rate of climbing the tree was chosen. This rate was determined to be 30 feet/minute. Our team concluded this was an appropriate target because we wanted a slow enough rate for a user to control safely, while also being able to channel up a tall pine tree in a timely manner. A target was also assigned to what the maximum height the ROV should be able to climb. The height was 60 ft., and was assigned based off the averages heights of pine trees in the southeast part the United States.

The next component in our functional decomposition was to “Delimb the Tree” and this function had multiple targets assigned. The first target was the precision of the delimbing tool, or how close to the tree the branch was to be delimbed from. This was given a value of 0.5 inches from the tree and was decided because this value would allow a small enough obstacle from the tree that the ROV would be able to climb over and delimb the branches above it. The next target was the force required to shear a limb and although it has not been decided that shearing is the best method for delimbing, we thought it was important to include considering our options. The target value for the force required to shear a limb was determined to be 23 kN. This was calculated by averaging two values, one of which was found by researching the max force of other total tree harvesters, and the other found using an equation found in the book “Tree Harvesting Techniques” which solved for the force needed to shear off limbs of a certain diameter. The next target that was given to this function was the rate of delimbing, and this was given a value of 10 seconds per limb. This would allow a tree to be delimbed at a relatively fast pace while also retaining the required degree of precision. A target for the minimum and maximum diameter of the limbs that will be detached was assigned to be 1 and 5 inches, respectively. This was determined by researching the average diameters of branches of pine trees.

The last component in our functional decomposition was “Sectioning the Tree”, where a target rate of 30 seconds per cut for sectioning a tree. Our team decided that this would be an optimal amount of time to section a tree while still allowing the user to operate in a safe manner. It also provides efficient power consumption using less power to cut faster risking overheating or overworking the guiding tool.

Aside from our functional decomposition, we assigned targets to other aspects of the ROV. The first being a target for the weight. Our team decided the weight of the ROV should not exceed 200 lbs. This value was chosen because we wanted the ROV to be portable and because the average man can deadlift 155 lbs., we felt that two people could carry 200 lbs. or that the ROV itself could be disassembled and carried in parts. This would also be a workable weight to roll using a wheeled mechanism. Next, a target for the maximum number of controls was assigned to be 10. This was decided upon because we counted 7 controls (up, down, open, close, delimb, section, and on/off) that we needed and wanted to give ourselves some leeway. The next target was the power the ROV will consume. The was found by benchmarking other total tree harvesters and was decided that our ROV will consume no more than 130 kW. A target for the operation time per tree was determined to be 1.5 hours. A target for the range of the controller was determined to be 150 ft., allowing the user to control the ROV at a safe distance away. A development cost target number was assigned at $5,000 considering there will still be enough left-over for the given budget.

CONCEPT GENERATION

Table 1. Concept Generation

Customer Requirements	Functional Parameters	Concepts or ideas or solutions that satisfy function		
Climbs	**Securing**	Hydraulics	Pneumatics	Motor
	Movement Type	Wheels	Track	Bear Hug
	Direct	Straight	Spiral	
Limbing	**Type**	Shear	Chainsaw	Circular Saw
	Guide	Tracks	Stationary	Prismatic
Electrical	**Controller**	Wired	Radio	Bluetooth
Sectioning	**Type**	Shear	Chainsaw	Circular Saw
	Cutting Approach	Horizontal	45 Degree Angle	V Cut

Note: For a more detailed concept generation, see Appendix B

Customer Requirement: Climbing

Securing

Hydraulics

The benefits of the hydraulics are~~is~~ a very large force output for the weight and being capable of maintaining constant force. However, since fluids are used to maintain the force the chance of fluids leaking are possible. If the fluids leak a loss of pressure will occur. Another disadvantage to hydraulics is the extra parts. Fluid compressors, lines, and the fluids themselves would all have to be carried by the ROV adding to its payload because if the compressors and fluids were stored separately the fluids would have to overcome the force of gravity to reach the ROV. Since the ROV is climbing the force due to gravity will be constantly changing.

Pneumatics

The benefit is the simplicity and precision compared to the hydraulics. Since are is used as the driving fluid the compressor and lines can be a separate component from the ROV greeting reducing the payload. Much like hydraulics pneumatics run the risk of leaks and pressure losses as a result. They also have less pressure and therefore produce less force than hydraulics.

Motor

Since there are no fluids/air involved using motors, there are no leaks therefore no loss of pressure. As in the pneumatics this is highly precise but may cost more than either hydraulic or pneumatic. Motors also run the risk of overheating if continuously used, and will provide less force than either hydraulics or pneumatics.

Movement type

Wheels

The wheels would be attached to the motors and would be able to climb up and down the tree. The use of spikes on the wheels may be considered and would be able to be more sturdy and climb over 0.5 inches of obstacles. The benefit of using wheels is a lower cost and simpler design, but the use of spiked wheels are harder to find and not as standardized.

Track

The track would be attached to a motor to climb up and down the tree. The tracks would allow for more traction than the wheels and are better for rough terrain, but will most likely cost more and add more weight.

Bear Hug

For the bear hug design, there would be two different clamps. One would be clamped at a time. For example, the bottom clamp would be forced onto the tree while the top clamp would move upwards through the use of a prismatic joint. Then the top clamp would be forced onto the tree and the bottom would move upwards through the use of the prismatic joint. The clamps will be controlled by either a hydraulic, pneumatic, or motors.

Direction type

Straight

The ROV would move straight up the tree, this would make for a simple up and down control.

Spiral

The ROV would move in some Spiral way, this would be more complex than the straight climbing but could eliminate the use of a robotic arm or moving saw.

Customer Requirement: De-limbing

Type

Shear

Shearing would cause the least amount of moving parts since the mechanism could wrap around the tree and shear any limbs in that range of the tree. Shearing though would require the most amount of force.

Chainsaw

The chainsaw would involve having a chainsaw mounted on the top of the ROV oriented parallel to the tree. While the chainsaw is running the blade will revolve around the tree on a circular track removing the limbs as it goes. This would require less force than shearing however it would be more complicated with a lot more moving parts.

Circular Saw

The circular saw would be mounted so that the blade of the saw is perpendicular to the limbs. As the circular saw spins it will rotate around the tree on a circular track. The circular saw would require as many moving parts as the chainsaw, and require less force than the shearing method. Due to the geometry of the blade the de-limbing precision may suffer in this design.

Guide

Tracks

To guide the where the blade will cut the limb, there will be a track that will allow some rotation so that the limbs could be cut. This would require a sensor or camera to locate the limb.

Stationary

This would be rigid to the ROV. The downside of using this rigidity is it puts more stress on the ROV.

Prismatic

For a prismatic guide for de-limbing, the cutting mechanism would be attached to the ROV by a prismatic joint. This would reduce the stress on the ROV.

Controller

Wired

Would be the simplest but would have line running from the ROV to remote. The early prototypes will be wired and designed as that they can be easily adapted to radio, or bluetooth later.

Radio

Would be wireless but require the use of radio waves.

Bluetooth

Wireless, but would require bluetooth adaptable hardware.

Customer Requirement: Sectioning

Type

Shear

Shearing the tree would require using a wedge and high pressure to shear sections of the tree. This would require a large amount of force but would require very few moving parts and the overall design would be simple.

Chainsaw

The chainsaw will be mounted on a rotating arm so the blade of the chainsaw will be perpendicular to the trunk of the tree. Once at the appropriate height the chainsaw will turn on and the arm will move the chainsaw blade so that it will cut through the tree. The cut section of tree will fall and the arm will make the chainsaw return to its original position.

Circular saw

The circular saw would have a saw blade mounted so that the edge if the blade is perpendicular to the tree trunk. The blade would spin and then make contact with the tree. The blade would continue until it cut completely through the tree and the tree section would fall. This would require a lot of moving parts and the circular saw blade would have to be quite large to be able to cut through the whole tree.

Cutting approach

Horizontal

Would be the easiest method to place on the ~~ROV but~~ROV but one the section is cut there would be no telling where the section would go and it could hit the ROV.

45 Degree angle

Would be more difficult than the horizontal approach but the direction could be controlled to avoid the ROV.

V cut

Would be the most difficult approach but the direction could be controlled to avoid the ROV and more precise than the 45 degree angle.

Designs (Appendix C)

For all of these designs the concepts can be mix and matched

Design 1

The first design that was proposed used spiked wheels for movement type and rigid blades for shearing off tree limbs. The wheels will also be used as the clamping tool due to the spiked edges extending perpendicular to the wheel surface and will have an applied pressure to channel up and down the trunk. The pressure will come from a motor clamping system designed with a gear train that will contract and expand the distance between each wheel. In order to shear the limbs, two motors will be placed at each shaft connected to both wheels and shoot up the tree at a high velocity. Using the momentum from the velocity and weight of the

ROV, enough force is generated to shear off the limbs. Under the rigid blades is a chainsaw connected by a revolute joint to cut across and section the tree.

Design 2

The second design will use treads for the movement type and ~~a~~an electric chainsaw on a track to de-limb. An electric motor will be used to provide the clamping force to secure the ROV to the tree. Once the motor has secured the ROV to the tree, two more motors would drive the tracks. This would cause the ROV to climb the tree. The chainsaw will be oriented parallel to the tree’s trunk. Once the ROV reaches the first set of limbs the chainsaw will be turned on. When the chainsaw is tuned on another motor will drive the chainsaw around the tree removing the limbs. After all the limbs at that height have been removed, the chainsaw will turn off and the tracks will continue driving the ROV up the tree. Once all the limbs have been removed the motors will drive the tracks in reverse making the ROV climb down the tree. A second larger chainsaw will be attached to an arm on a revolute joint. When the ROV is at an appropriate height the second chainsaw will be turned on and a motor on the arm will drive it so that the chainsaw will cut through the section of tree.

Design 3

The third design uses two clamping mechanisms connected through a prismatic joint in order to move up and down and shear the limbs of the tree. The clamps and the movement of the prismatic joints are accomplished through hydraulics to generate enough pressure to hold to the tree and cut the limb. The limbing is done through shear force. The process involves the bottom clamp being held in place while the upper clamp would channel up transferring the force and impacting the branches causing them to shear off the tree. The climbing is accomplished in a similar way. After the top clamp fully extends, it then secures around the tree while the bottom clamp opens and channels up contracting the hydraulic arm to its initial position. The bottom clamp once again secures itself around the tree. After limbing the tree, the ROV would come back down and a chainsaw would be attached at the top. This chainsaw will be used to section the tree from top to bottom.

CONCEPT SELECTION

Methods Used

A house of quality and a ~~pugh~~Pugh matrix are important tools in the design concept and selection phase. Both tools utilize the needs and requirements of the customer.

House of Quality

Direction of Improvement			DOWN		DOWN	UP		Competitor Assessment			
Customer Information		Engineering Characteristics									
Customer Requirements	Customer Importance	Material Selection	Number of Controls	Movement Type	Moving Parts	Feedback Monitoring	Power Source	Chainsaw	T.T.H.	Axe	Planned
Light weight	2	10						4	1	4	3
Intuitive Interface	4		10		6	10		4	2	5	4
Easy to Install	3			6	10	3		5	3	5	3
Performance	5	6	6	10	6	3		2	5	1	4
Portable	3	6		10	3		3	4	1	4	3
Cost	1	10	3		3	3	3	4	1	5	3
Safe to use	4			6	3	6	3	2	5	3	4
Score		78	73	122	108	91	24				
Weight		15.73%	14.72%	24.60%	21.77%	18.35%	4.84%				
Rank		4	5	1	2	3	6				
Technical Assessment	Chainsaw	Various	2	user	1	1	gas/electric				
	Total Tree Harvester	Various	7	controller	4	5	gas/electric				
	Axe	Various	0	user	0	1	user				

Legend:
T.T.H. = Total Tree Harvester

Figure 1. House of Quality

The house of quality identifies the customer requirements, as well as the importance of those requirements, and then correlates the engineering characteristics that may be relevant to those requirements. This is simply a relationship matrix that translates what the customer wants into engineering characteristics. By studying the customer requirements, we can identify and manage design tradeoffs. In our house of quality, the customer requirements were again found and ranked by discussing with our sponsor as well as a team. By correlating these requirements to our engineering characteristics, we could find which engineering characteristics were most important. With the use of these two tools and analytical discussion within the team, we were able to decide on the best design, and also the most important characteristics of that design.

Pugh Matrix

Table 1. Pugh Matrix

Pugh Matrix			
Highest Ranked Engineering Criteria	Concepts		
	Design 1 (Datum)	**Design 2**	**Design 3 (Target)**
Movement Type	wheels and shear	track	bear hug and shear
Moving Parts	4	9	4
Number of Controls	5	7	7
Feedback Monitoring	encoders and pressure	Camera and pressure	Camera and pressure
Highest Ranked Customer Requirements	Scale: 0 = base / 1 = better than base / -1 = worse than base		
	Datum (Original)	**Design 2**	**Design 3 (Target)**
Light weight	0	-1	1
Intuitive Interface	0	-1	-1
Easy to Install	0	-1	0
Performance	0	0	0
Portable	0	-1	1
Cost	0	-1	-1
Safe to use	0	0	0
Total	0	-5	0

The ~~pugh~~Pugh matrix allows our team to evaluate a few different concepts. The strengths and weaknesses of these concepts are assessed against a datum, or a base design. It also creates stronger concepts, eliminating weaker ones, and creates an optimal hybrid concept. A ~~pugh~~Pugh matrix is beneficial at this stage in design because it does not require a large amount of qualitative data. For our ~~pugh~~Pugh matrix the base design was modeled after a standard total tree harvester. This is a wheeled design that shears the limbs by the momentum of the machine itself. The customer requirements that were used were decided by talking to our sponsor, Jeff Phipps, and discussing amongst ourselves what was required. The most important of these requirements include movement type, moving parts, and feedback monitoring.

Comparing Designs

After using the tools mentioned before and discussing the general pros and cons within each design, a detailed analysis was done to determine the best design fit to accomplish the customer needs and fulfill the tasked goals. The original design known as our datum was based off a basic total tree harvester. This design was considered as a datum because its concept had already been proven to work. The major difference with that design was that the chainsaw component to section the tree was an add-on feature to the ROV. This would allow less weight on the motors when the ROV is de-limbing the tree. The flaw that is introduced with the initial design is the fact that the ROV will have to climb at a high velocity to move the shearing blades with enough momentum to shear the limbs off. What was also taken into account is that the ROV is climbing upward against gravity which will demand large amounts of power from the wheels and make it harder for the ROV to reach high speeds. In the ~~pugh~~Pugh matrix used, the datum design was ranked with lowest number of controls at 5 (including sectioning of the tree). This was one of the advantages that the initial design had over the other 2. A big reason this design did not pass for further design improvements was the lacking in safety that was required by the customer. When working with a high velocity machine, feedback monitoring can be quite inefficient and expensive when reacting towards a potential malfunction as the tree-limbing process occurs. This is because of how dangerous and unpredictable an accident can happen when working at high speeds. Another negative factor about the design was the multiple mechanical systems. The wheels were controlled by electric motors while the clamps for shearing were controlled by a pneumatic system. This setup causes complexity when designing the controls of separate systems.

The second design solely used motors to control the moving and locking systems of the ROV. This is advantageous because it simplifies designing the controls for the user to operate the ROV. When the second design was considered, safety was a big factor sacrificing speed and was more focused on completing the functions required. The tread movement system allowed for better gripping and better mobility over obstacles. One of the disadvantages of this system was that more weight would be added to the machine. Another disadvantage that could potentially cause major malfunctions in the climbing process is the open frame design that would hold the ROV together. A potential hazard can occur if a branch that was delimbed fell in between the crevices blocking the tread from climbing the tree. Though the open frame design permits a lightweight ROV, it can also leave open areas that could hinder some moving parts. A possible solution would be applying a covering plate before the framework converges into the rotating chainsaw track. This ROV design unfortunately had the highest number of moving parts compared to the other two having a total of 9. This was due to having multiple wheels in tread belts, two chainsaws, and a rotating track for one of the chainsaws. This design did not satisfy a lot of the other customer requirement evaluations when compared to the datum and 3rd design. Factors such as the weight, installment feasibility, and portability were rated worse than the 2 other designs.

The third design was actually modeled after a different total tree harvester. The design involved relies solely on hydraulics for climbing and clamping which allows for a more feasible control system and avoid the complexity of having multiple moving systems with different sources of power. Much like the datum design, the shearing motion was used to delimb the tree branches. The critical difference on how the third design delimbs the branches of the tree is that instead of shooting up at a high velocity, the ROV will drive up in a stroking motion by a hydraulic cylinder. This method will ensure the necessary force to shear off the branches and avoid any high risk malfunctions by not reaching dangerous velocities. This design performed better in the ~~pugh~~Pugh matrix than the second design in almost all aspects. When compared to the datum design, it lacked in some of the customer requirement ratings such the intuitive interface and cost. This is due to the fact that the datum design has the least number of moving parts which also relatively reduces the complexity of the controls used by the operator. The third design was an attractive choice due to its simplicity and effectiveness. Ideally one hydraulic cylinder would be used to climb and delimb the tree. For security purposes, extra hydraulic cylinders would probably be included for climbing and limbing if it were to be chosen as the final design. Much like the second design, since the ROV will have a detachable component where the shearing blades can be removed and a chainsaw attachment can be placed for sectioning, it increases the portability and weight of the ROV. One disadvantage that this design could run into is a potential leak in the hydraulic line causing a pressure drop and potential failure within the hydraulic system. This can be potentially avoided by benchmarking the correct lines to withstand the pressures produced from the hydraulic pump.

Considering all factors and requirements from the ROV, the third design was chosen as the best candidate to move forward with for the project. It was proven in the ~~pugh~~Pugh matrix to be as effective as the datum design and better than the second design which had a score of -1. The simplicity of the design was a very attractive feature that allowed for simple user control having a hydraulic system as the source power and fewer moving parts. As for the safety aspect of the ROV and the user controlling it, the third design is ~~layed~~laid-out where safety measures can be taken with enough time to react to potential problems that are presented. An example of this is that the user will be dealing with comfortable speeds when the ROV is climbing the tree using a hydraulic cylinder to move in a stroke pattern. Sustainability was also an important factor that the third design presented compared to the other two designs. Having only 4 moving parts, less maintenance would be necessary compared to the second design having 7. Replacing parts would be simplified since clamps and blades are commonly used in the timber industry. Though wheels and tread are also tools used in the timber industry, they are generally more expensive and make the maintenance of the ROV a more expensive and lengthy process. As a team, the decision to choose design three as the best candidate for the ROV was done with confidence considering all the variables presented and the requirements given from our sponsor.

Project Plan

ACTIVITY	PLAN START	PLAN DURATION (DAYS)
Spec'ing	8-Jan	7
Sub-Prototype	8-Jan	14
Risk Analysis	15-Jan	7
Material Selection	15-Jan	14
Final Cad	22-Jan	21
Purchasing/shipping	5-Feb	28
Assembly	19-Feb	50
Prototyping	5-Mar	38
Final Testing	9-Apr	21
Senior Design Day	12-Apr	7
Finals	30-Apr	7
Graduation	5-May	1

Task owner ownership

Team member that is mainly responsible for the given task. Note: most tasks require the entire team to be active

- Spec'ing: Chris
- Sub-prototype: team 15
- Risk analysis: Donald
- Material selection: Ryan
- Final CAD: Nestor
- Purchasing/shipping: Alex

- Assembly: team 15
- Prototyping: team 15
- Final testing: team 15

Budget

Currently the budget of our sponsor is $2000. The estimated total of all the components are the $1711. This was the price that we calculated for the final prototype. Our sponsor, though has several of the hydraulic components so we are currently not in risk of going over budget.

Largest current and future issues:

- Getting the controls to work (the hydraulics are complex and have several different lines coming to and from the hydraulic reservoir)
- Making sure that the hose is in correct position so that there will be no “kinks”
- Parts that we assume are compatible but when they are shipped do not fit as they are intended to
- Ensuring that that the stresses do not deform the materials due to the action of the ROV
- Having a battery life long enough to be able to climb up the tree, remove limbs, and return to the base

APPENDIX A – Code of Conduct

Mission Statement

The objective of team 15 is to satisfy the needs of its clients using the best knowledge and resources to its disposal. While always following proper work ethics with its client and team members. Providing always a positive, respectful and professional environment for its client and team members.

Roles

Every member of team 15 is allotted a role depending on their specific skills. The roles assigned to each team member can be seen below.

Team Leader – Chris Ruiz

The leader must ensure that each tasked assigned to all the members are reasonable with their skill set and allow for sufficient aid to make sure deadlines are met. The leader must also have a well-structured relationship with the sponsor to ensure that everyone is on the same page with the same goal in mind.

Financial Advisor – Donald Phillips

The financial advisor is responsible for the budget of the project. They will keep records of all expenses and transactions. They will also ensure that the project does not go over budget.

Lead Communications – Ryan Gaylord

The Lead Communications is responsible for ensuring that all members are communicating. Communications takes notes during the meetings and relays information to any absent members.

ME Design – Nestor Rigaud

The ME design is in charge of managing, organizing, and recording the designs that the members of the team presents. They will analyze the designs for feasibility, advantages and disadvantages, compiling this information to present back to the team for final design selection. They will also make sure that any design alterations suggested after the final design is chosen are feasible, advantageous, and will not affect the time schedule.

ME Programming – Alex Glazer

The ME programmer is in charge of writing the computer code that will run and control our chosen design. The lead programmer does all of the computational aspects of the project and oversees the technical specifications of the project. They will be in charge of writing the code for the design through programs such as MATLAB.

All Members of Team 15

- Fulfill the tasks provided for them
- Stay open minded to ideas
- Be active in communicating with the team
- Respect the other team members' roles and ideas
- Maintain a positive working environment

Communication

Team 15 will communicate primarily through the use of GroupMe. This will be used for the day to day messaging and email will be used as a secondary form for issues that are not as urgent. Data will be shared through the use of Dropbox and Google Drive. Google Drive will be the major data sharing component when the team is working on the initial drafts, such as word document and pictures. The final drafts will be uploaded to Dropbox.

Each team member must have GroupMe, Dropbox, and Google Drive. Team members are expected to be active in communication on GroupMe and email. Team members should also be responsible for checking their email twice a day (beginning and end of the day). If a meeting is to be canceled, team members must inform of this during the meeting times or at least 24 hours in advance on GroupMe. In the case that a team member cannot attend a meeting, that team member must notify in advance that they will be absent.

Ethics

Members of team 15 must be familiar with and strictly follow the NSPE Engineering Code of ethics. Members of the team will be honest with each other about the progress of individual parts of the assignments. Members of team 15 will be truthful with other team members about ability and skill level when accepting individual work.

Dress Code

The members of team 15 are to dress in casual attire during meetings. Meetings with the sponsor and presentations will be business casual or formal will be decided by the team prior to the event. As for business casual attire goes, khakis and a button down is what expected. Ties will be discussed if necessary depending on situation. Formal attire requires at least slacks and a jacket along with a button down and tie. Any other modification is optional but not discouraged.

Meeting Times

The members of team 15 have decided to meet from 2-6 p.m. on Tuesdays and ~~Thursdays~~ ~~.~~Thursdays. We will also meet on ~~mondays~~Mondays between the time 11:30 ~~a.m~~a.m. and 3 p.m.

Hours on ~~monday~~Monday will be based on the availability and necessity for all members to be present. If more meeting times are required, members have agreed to a meeting day on the weekend which would be decided during the week.

Decision Making

It is conducted by consensus and majority of the team members. Should ethical/moral reasons be cited for dissenting reason, then the ethics/morals shall be evaluated as a group and the majority will decide on the plan of action. Individuals with conflicts of interest should not participate in decision-making processes but do not need to announce said conflict. It is up to each individual to act ethically and for the interests of the group and the goals of the project. Achieving the goal of the project will be the top priority for each group member. Below are the steps to be followed for each decision-making process:

- Problem Definition – Define the problem and understand it. Discuss among the group.
- Tentative Solutions – Brainstorms possible solutions. Discuss among group most plausible.
- Data/History Gathering and Analyses – Gather necessary data required for implementing Tentative Solution. Re-evaluate Tentative Solution for plausibility and effectiveness.
- Design –Design the Tentative Solution product and construct it. Re-evaluate for plausibility and effectiveness.
- Test and Simulation/Observation – Test design for Tentative Solution and gather data. Re-evaluate for plausibility and effectiveness.
- Final Evaluation – Evaluate the testing phase and determine its level of success. Decide if design can be improved and if time/budget allows for it.

Work Schedule

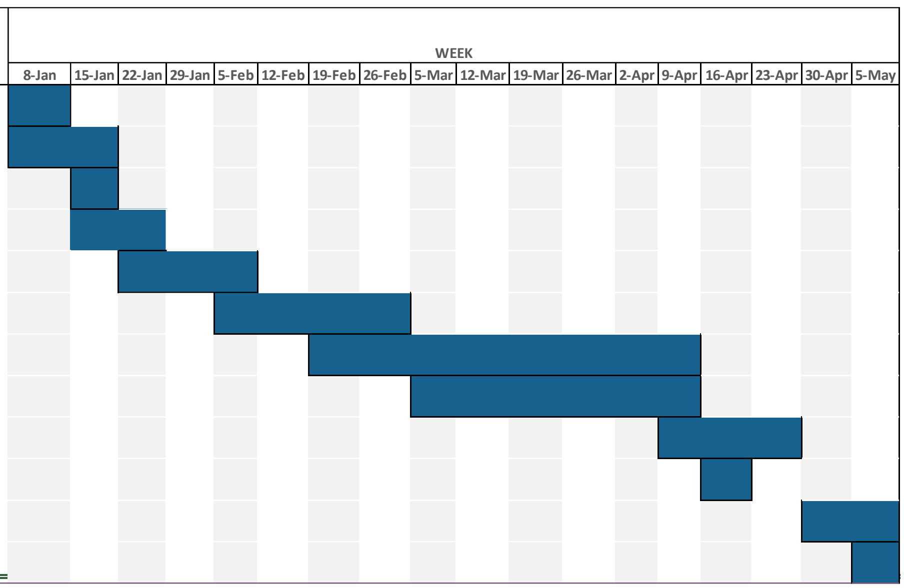
Block Work Schedule For Tree Limbing and Harvesting ROV

	Days of the Week						
Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
8:00 AM							
9:00 AM							
10:00 AM				Nestor			
11:00 AM	Donald		Donald	Nestor	Alex		
12:00 PM	Donald	Ryan	Donald	Ryan	Alex		
1:00 PM	Donald	Ryan	Donald	Ryan	Chris		
2:00 PM	Alex	Team meeting	Alex	Team meeting (if necessary)	Chris		
3:00 PM	Alex	Team meeting	Alex	Team meeting (if necessary)	Nestor		Team meeting (if necessary)
4:00 PM	Nestor	Team meeting	Ryan	Team meeting (if necessary)	Nestor		Team meeting (if necessary)
5:00 PM	Nestor	Team meeting	Ryan	Team meeting (if necessary)			Team meeting (if necessary)
6:00 PM	Chris	Team meeting	Chris	Team meeting (if necessary)			
7:00 PM	Chris		Chris				
8:00 PM							
9:00 PM							
10:00 PM							
11:00 PM							

Legend	
Names:	**Color:**
Alex Glazer	Blue
Ryan Gaylord	Green
Donald Phillips	Purple
Nestor Rigaud	Orange
Chris Ruiz	Red
Team meeting	Gray

~~Project Plan~~

ACTIVITY	PLAN START	PLAN DURATION (DAYS)
Spec'ing	8-Jan	7
Sub-Prototype	8-Jan	14
Risk Analysis	15-Jan	7
Material Selection	15-Jan	14
Final Cad	22-Jan	21
Purchasing/shipping	5-Feb	28
Assembly	19-Feb	50
Prototyping	5-Mar	38
Final Testing	9-Apr	21
Senior Design Day	12-Apr	7
Finals	30-Apr	7
Graduation	5-May	1



Organization

	Team Leader	Financial Advisor	Lead Communications	Lead Programmer	Lead Design
Ryan Gaylord			X		
Alex Glazer				X	
Donald Phillips		X			
Nestor Rigaud					X
Chris Ruiz	X				

Once more roles are required of each team member, more will be added to this organization chart.

Conflict Resolution

In the event of discord amongst team members the following steps shall be respectfully employed:

- Communication of points of interest from both parties will addressed.
- Administration of a vote, if needed, favoring majority rule.
- Team Leader will intervene if needed
- Instructor/Advisor will facilitate the resolution of conflicts

Process to Amend the Code of Conduct

If a member decides they want a part of the code of conduct the team will take this into consideration and take it into a vote. The decision must be unanimous to change any part of the code of conduct.

Statement of Understanding

By signing this document, the members of Team 15 agree the all of the above and will abide by the code of conduct set forth by the group.

Name	Signature	Date
Alex Glazer	Alex Glazer	9/25/17
Ryan Gaylord	[illegible]	9/25/17
Donald Phillips	[illegible]	9/25/17
Nestor Rigaud	[illegible]	9/25/17
Christopher Ruiz	[illegible]	9/25/17

APPENDIX B – TABLES

Target Catalog

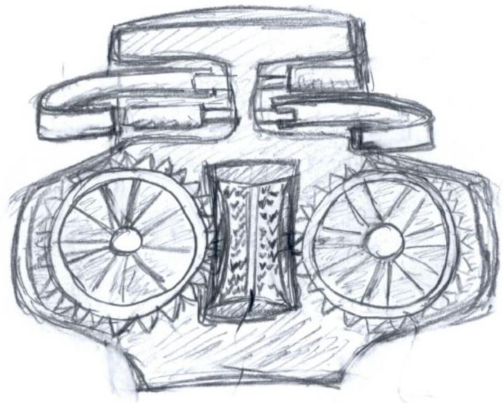
Metric	
Max Weight	200 lbs
Maximum Opening	25 in
Minimum Opening	8 in
Minimum Clamping Force to climb tree	200 lbf
Minimum Clamping Force to shear limbs	5,371 lbf
Rate of Climbing Tree	30 ft/min
Precision of Limb Shearing	0.5 in. from tree
Force to shear limbs	5171 Lbf
Operation time per tree	1.5 Hours
Max number of Controls	10
Power Consumption	130 kW
Range of controller	150 ft.
Length of Power Cord	100 ft.
Rate of sectioning tree	30 seconds
Maximum clamping pressure	790 Psi
Maximum limb diameter	5 in.
Minimum limb diameter	1 in.
Maximum tree height	60 ft.
Delimbing rate	10 seconds/limb
Maximum development cost	$5,000.00

Concept Generation

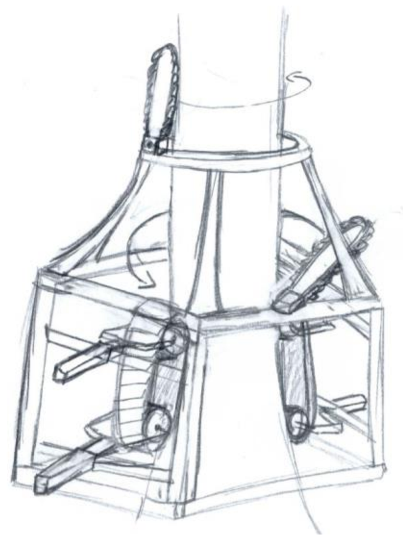
Customer Requirements	Fuctional Parameters	Concepts or Ideas or Solutions that Satisfy Function					
Climbs	Securing	**Springs**	**Hydraulics**	**Pneumatics**			
	Movement Type	Wheels	Track	Bear Hug	Robotic Legs		
	Direct	Straight	Spiral				
Limbing	Type	Shear	Chainsaw	Circular Saw	Scissors	Water/Air Jet	
	Guide	Tracks	Stationary	Prismatic	Roboitc Arm	Rollers	
Electronic Configuration	Controller	Wired	Radio	Wifi	IR		
	Feedback Monitoring	Sensors	Camera	Encoders			
Power Source	Type	Gas	Generator	Battery	Electrical Outlet	Steam Powered	Hybrid
Sectioning	Type	Chainsaw	Band Saw	Circular Saw			
	cutting approach	Horizontal	45 Degree Angle	Cross Cut	V Cut		

APPENDIX C – Figures

Designs



Design 1



Design 2

Design 3. Naarva s23

Risk Assessment

Safety Plan

Project information:

Tree Limbing and Harvesting ROV	3/2/18
Name of Project	Date of submission

Team Member	Phone Number	e-mail
Chris Ruiz	(305) 283-5951	Car13k@my.fsu.edu
Ryan Gaylord	(850) 368-3339	Reg14b@my.fsu.edu
Alex Glazer	(407) 590-2729	Ang14f@my.fsu.edu
Donald Phillips	(850) 570-4216	Dap15c@my.fsu.edu
Nestor Rigaud	(786) 838-3698	Nar14b@my.fsu.edu

Faculty mentor	Phone Number	e-mail
Dr. Shayne McConomy		Skm0832@my.fsu.edu
Dr. Jonathan Clark		jeclark@fsu.edu

I. Project description:

Design a tree limbing and harvest ROV that is able to climb, de-limb, and section a tree.

II. Describe the steps for your project:

-Pick up ROV and move it to tree
-Turn on hydraulic pump and electrical components
-Clamp ROV to tree with remote
-Ensure that the ROV is securely attached to tree
-Back up to a safe distance (around 30 ft)
-Use controller to climb and delimb the tree
-Once the tree is at the top reverse the controls on the controller (ROV will climb down the tree)
-When the ROV is at the base of the tree open the clamp and detach ROV from tree

III. Given that many accidents result from an unexpected reaction or event, go back through the steps of the project and imagine what could go wrong to make what seems to be a safe and well-regulated process turn into one that could result in an accident. (See examples)

-Injury by sharp shearing blade
-Hydraulic leaks/ruptures
-Clamping body part or clothing
-Limb may fall on user
-Limb may fall on ROV
-ROV may fall on user
-ROV may get stuck on limb
-Tree may buckle and fall due to weight of ROV

IV. Perform online research to identify any accidents that have occurred using your materials, equipment or process. State how you could avoid having this hazardous situation arise in your project.

-Hydraulic leaks are very common. This is not completely avoidable but to help prevent this, hydraulic lines must be strong enough to withstand a falling limb. Also the majority of the hydraulic lines on the ROV will be protected by a box.
-To prevent injury by a sharp blade, the user should wear heavy-duty gloves and long clothing.
-To ensure that body parts or clothing will not be clamped, user needs to be aware of their surroundings and clothing should not be loose.
-User must wear hard hats at all time during the operation
-Ensure that the tree is strong enough to hold up ROV before climbing the tree

V. For each identified hazard or “what if” situation noted above, describe one or more measures that will be taken to mitigate the hazard. (See examples of engineering controls, administrative controls, special work practices and PPE).

-ROV will come with an instruction manual. The user must read this before using the ROV.

-Safety feature on the ROV so that if the ROV malfunctions while performing the task, the ROV will stay on the tree.

-Stop function so that that the ROV will stop if it was not able to shear through a limb.

-Relief valve so that the pressure build ups in the hydraulics do not exceed the maximum pressure wanted.

VI. Rewrite the project steps to include all safety measures taken for each step or combination of steps. Be specific (don’t just state “be careful”).

-User must have long clothing, heavy-duty gloves, safety glasses, and a hard helmet on before performing the task

-Follow instruction manual and go through the steps to turn on the hydraulics and electrical components

-Before clamping to the tree with remote, ensure that all clothing and body parts are out of the way of the ROV

-Ensure that the ROV is securely attached to tree. Do not press button for the ROV to climb the tree

-Back up to a safe distance (around 30 ft)

-Use controller to climb and delimb the tree

-Once the tree is at the top reverse the controls on the controller (ROV will climb down the tree)

-When the ROV is at the base of the tree open the clamp, and follow the instruction manual to detach ROV from tree

VII. Thinking about the accidents that have occurred or that you have identified as a risk, describe emergency response procedures to use.

-Analyze how severe the injury is

-If severe injury call 911

-If the injury is moderate seek first aid

-If possible ensure that the ROV is completely turned off to avoid any further injury

-Ensure the safety of non-injured members after recognizing a possible accident

VIII. List emergency response contact information:

- Call 911 for injuries, fires or other emergency situations
- Call your department representative to report a facility concern

Name	Phone Number	Faculty or other COE emergency contact	Phone Number
Jeff Mitchell	(850) 251-4421	Shayne McConomy	

IX. Safety review signatures

- Faculty Review update (required for project changes and as specified by faculty mentor)
- Updated safety reviews should occur for the following reasons:
  1. Faculty requires second review by this date:
  2. Faculty requires discussion and possibly a new safety review BEFORE proceeding with step(s)
  3. An accident or unexpected event has occurred (these must be reported to the faculty, who will decide if a new safety review should be performed.
  4. Changes have been made to the project.

Team Member	Date	Faculty mentor	Date
Christopher Ruiz	03/01/18		
Alex Glazer	03/01/18		
Ryan Gaylord	03/01/18		
Donald Phillips	03/01/18		
Nestor Rigaud	03/01/18		

Report all accidents and near misses to faculty mentor.