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TNR's Automated Duck Blind

Project Report

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ABSTRACT

A duck blind is defined as a shelter built to create a hiding place for hunters to use while in pursuit of their target game of ducks. Although duck hunting using a duck blind is meant to be enjoyable with friends and family, the downside to owning and using a duck blind is the amount of time needed to assemble and disassemble the blind. The key to hunting is time, as ducks are on a schedule of when they migrate from one area to another. In essence of saving time and being reliable, the idea of an automatic deploy and retract duck blind was envisioned. As mentioned in later sections of the proposal, the duck blind itself will be a completely automatic and convenient system that allows hunters to take the time saved and apply it to other aspects of their hunt. This project will cover the various parts of the design and construction of the automated duck blind including: background information, comparisons, requirements and specifications; conceptual and system design, system breakdowns of the chosen system, construction of the chosen system, and chosen safety features and implementation; testing results, concluding statements; and recommendations to the user for the future manufacturing.

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<u>FALL 2024 SENIOR DESIGN:</u>

TNR'S AUTOMATED DUCK BLIND

1 INTRODUCTION

Duck blinds have been a part of duck hunting since the beginning of the sport. A duck blind is a shelter designed to give hunters the proper hide from their targeted game of ducks. From standing up against a tree fully clothed in camouflage, to building a blind up from scratch, the many different styles of blinds are limitless. The one style of blind that is underdeveloped is boat blinds. Boat blinds are a specific form of duck blind structured to be used on a boat, giving hunters a proper hide in open water. Many of the boat style blinds are either too large or not strong enough to withhold enough camouflage. Two examples of boat blinds that span the range of options are scissor style blinds and box blinds built by hand. Blinds built by hand are perfect for strength, durability and withstanding excessive amounts of weight, and do not have to be disassembled after each hunt. Conversely, scissor style blinds are not as strong, have limited durability, and must be disassembled by hand after each hunt. Scissor style blinds do have the capability to hold enough camouflage to make a duck feel safe to land into the decoy spread. Using automation, this project is designed to bridge the gap between the different style boat blinds. By providing hunters with an easy and efficient way to have a strong blind without the hassle of fabricating or frequent disassembly, the art of building boat style duck blinds will be redefined and revolutionary.

2 BACKGROUND

Modern duck hunting was not the beginning for duck hunting. The history of duck hunting dates back many years before most people realize. Based on an article from Riceland, “Modern day duck hunting is vastly different from the earliest traces of the sport. There is prehistoric evidence to suggest that duck trapping was a sport nearly twelve thousand years ago” (Riceland)[1]. In many opinions, modern duck hunting has taken the hunting community by storm. With more hunters embarking on duck hunting every year, the population of duck hunters is growing significantly. According to Bill Miller with Delta Waterfowl, statistics show that the population of duck hunters across the United States in the 2020-2021 season was 1.04 million hunters, which was an increase from the 2019-2020 season of 989,500 hunters (Miller). The technology involved with duck hunting has evolved over the years, from flintlock shotguns, cork decoys, and below average blinds to semi-automatic shotguns, decoys with UV-light technology, and many styles of blinds. Duck blinds come in many shapes, forms, and styles, but all meet one definition: a shelter designed to give hunters a way to hide from the target game of ducks.

Figure 2.1: Duck Blind in the Hole (https://www.americanhunter.org)

The different ways a duck blind can be designed and built are only limited to one’s imagination. With current technology, there are opportunities to improve duck blinds. Specifically related to on-boat style duck blinds, or boat blinds, there never seems to be the perfect blind, since boat blinds are either strong and bulky or compact and weak. Blinds that are strong enough to hold a lot of camouflage are bulky and reduce the space within the boat, making it hard to be mobile in the boat. Scissor style blinds allow for maximum room when they are not in use and provide sufficient cover for hunters when deployed; however, this style of boat blind is not very strong. The most significant issue is that the original scissor style designs are not able to hold a sufficient amount of camouflage weight to increase the hide for duck hunters. TnR's Automated Duck Blind gives hunters the advantage of a good blind on the water and the ability to relieve hunters from having to manually assemble and disassemble the blind in the field. As a part of the University of Southern Indiana's Systems Engineering and Analysis curriculum, the design of TnR's Automated Duck Blind was conceptualized. Riley Harris, a manufacturing engineering student, performed the design of the frame, lift system, safety measures, and set the Technical Performance Measures for the project to be tested once completed. Tyler Spence, a mechanical engineering student, performed calculations based on the given design and Technical Performance Measures, including the weight the frame could hold without failure, the minimum amount of strength required of the lift system to raise the maximum amount of frame weight. The Technical Performance Measures and values set the standard for the design and production of the best possible model for the mechanism of the blind and hunting ability for the duck hunters.

3 DESIGN AND CONSTRUCTION

3.1 DESIGN PHASE

During the Design Phase, a problem statement was created, and system and subsystem breakdowns were established, including the process flow. Alternative evaluations were considered, resulting in design requirements, specifications, and evaluation criteria.

3.1.1 Problem Statement

The main issue in duck hunting is that it requires an extensive amount of time and effort, especially when it comes to building a blind for a boat. If a hunter does not choose to build a stationary blind, called a box blind, the other option is a scissor style blind. There are issues that come with the scissor style blind, with the main obstacle being that the blind must be deployed and retracted by hand. This design project creates a solution to the issues in standard scissor style boat blinds. The problem statement for this project is to use automation to create an improved and more efficient version of a boat style duck blind.

3.1.2 System Breakdown

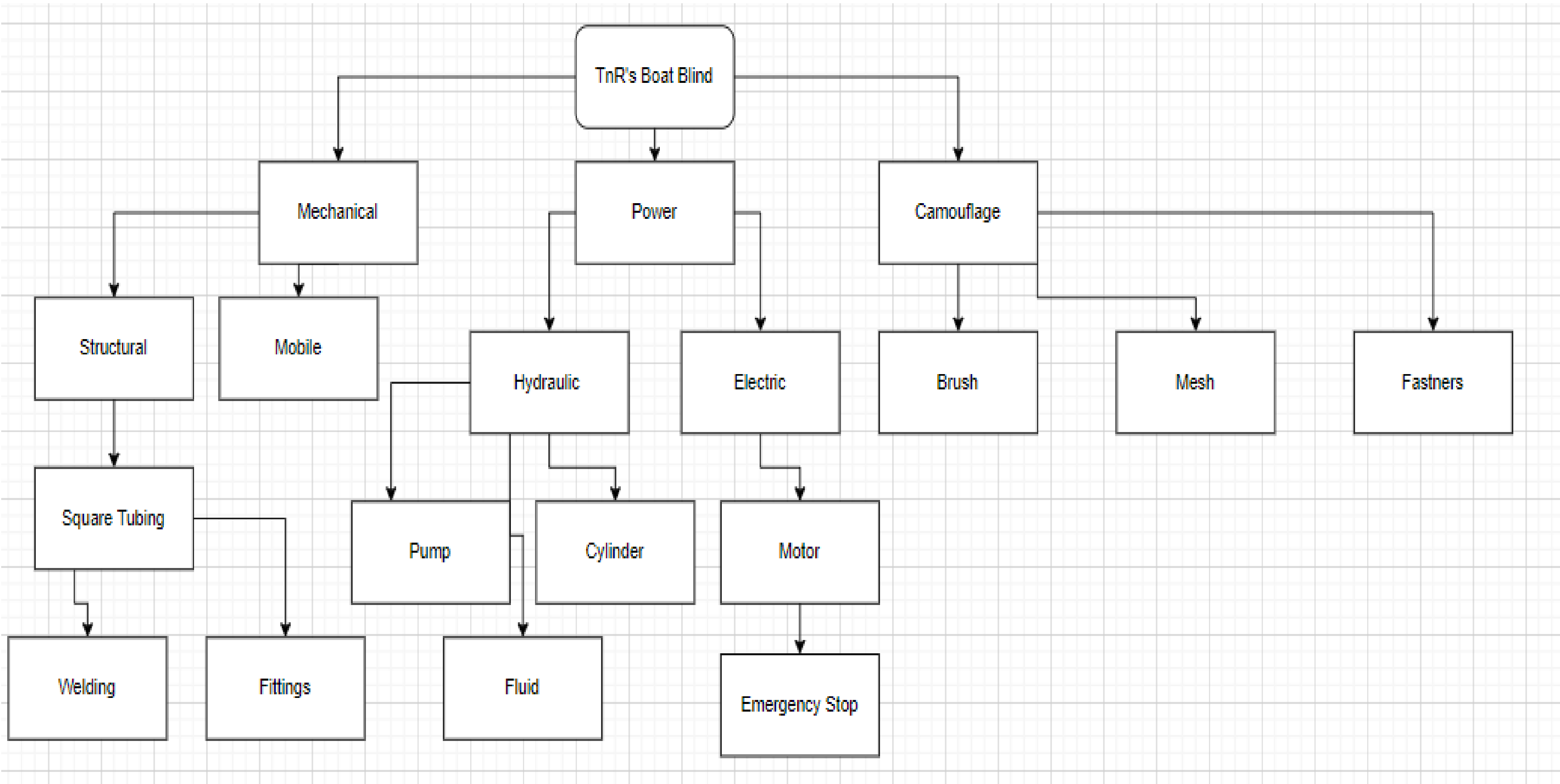

Figure 3.1: System Breakdown

In Figure 3.1 above, the system hierarchy is presented, from the main components of the automated boat blind product to the inputs and raw material components. This is a four-level system with the first level being a broad portion of the three major systems breaking to subcomponents at each level. All four levels of this project are critical to the final design and implementation of the project.

3.1.3 Subsystem Breakdown

The subsystem hierarchy shows the levels of the different components of the automated boat blind. For this project, there are two subsystem hierarchies that are subject to change based on testing during the process. The first is the hydraulic lift system breakdown, as shown in Figure 3.2 below. The second hierarchy is the component breakdown of the blind frame and is displayed in Figure 3.3.

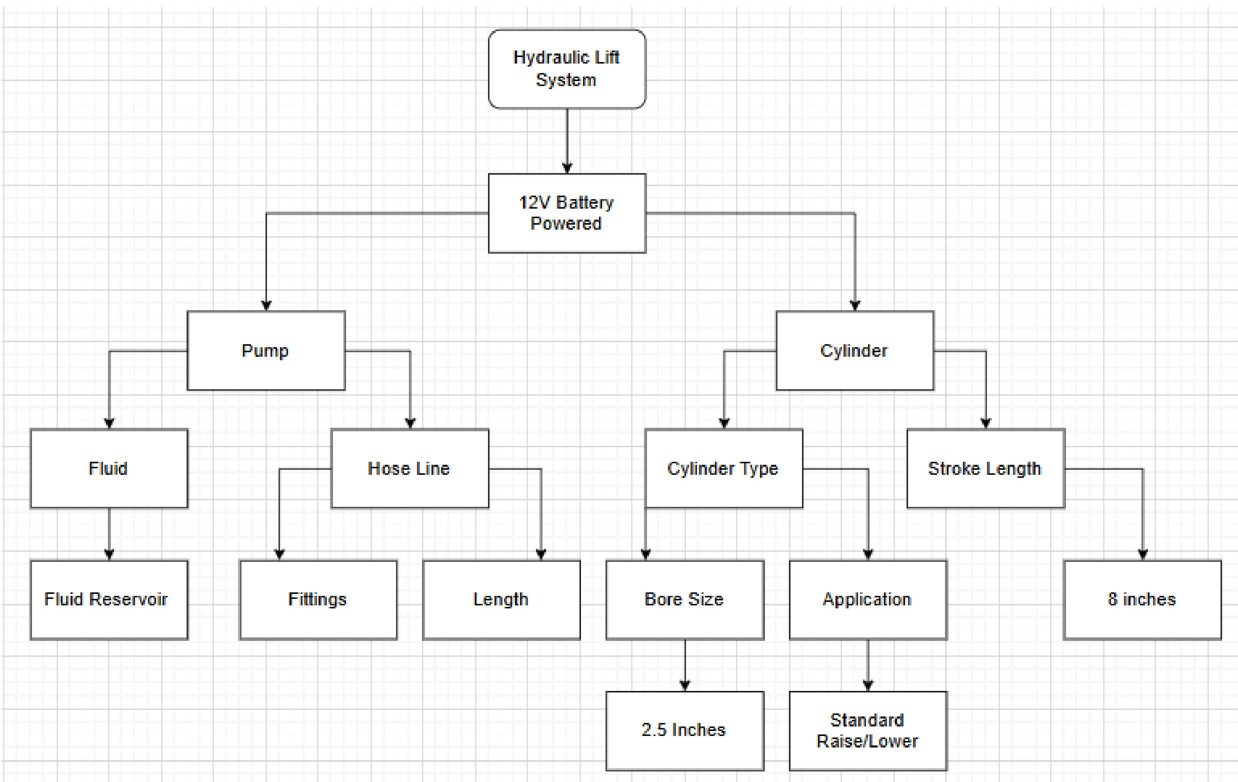

Figure 3.2: Hydraulic Lift System Subsystem Breakdown

The hydraulic system is a five-level subsystem including the power source, the pump and cylinder, and the components that follow. The pump has two proceeding component levels, and the cylinder has three proceeding component sublevels. Each component of the subsystem is essential to the subsystem that ensures the hydraulic lift operates properly.

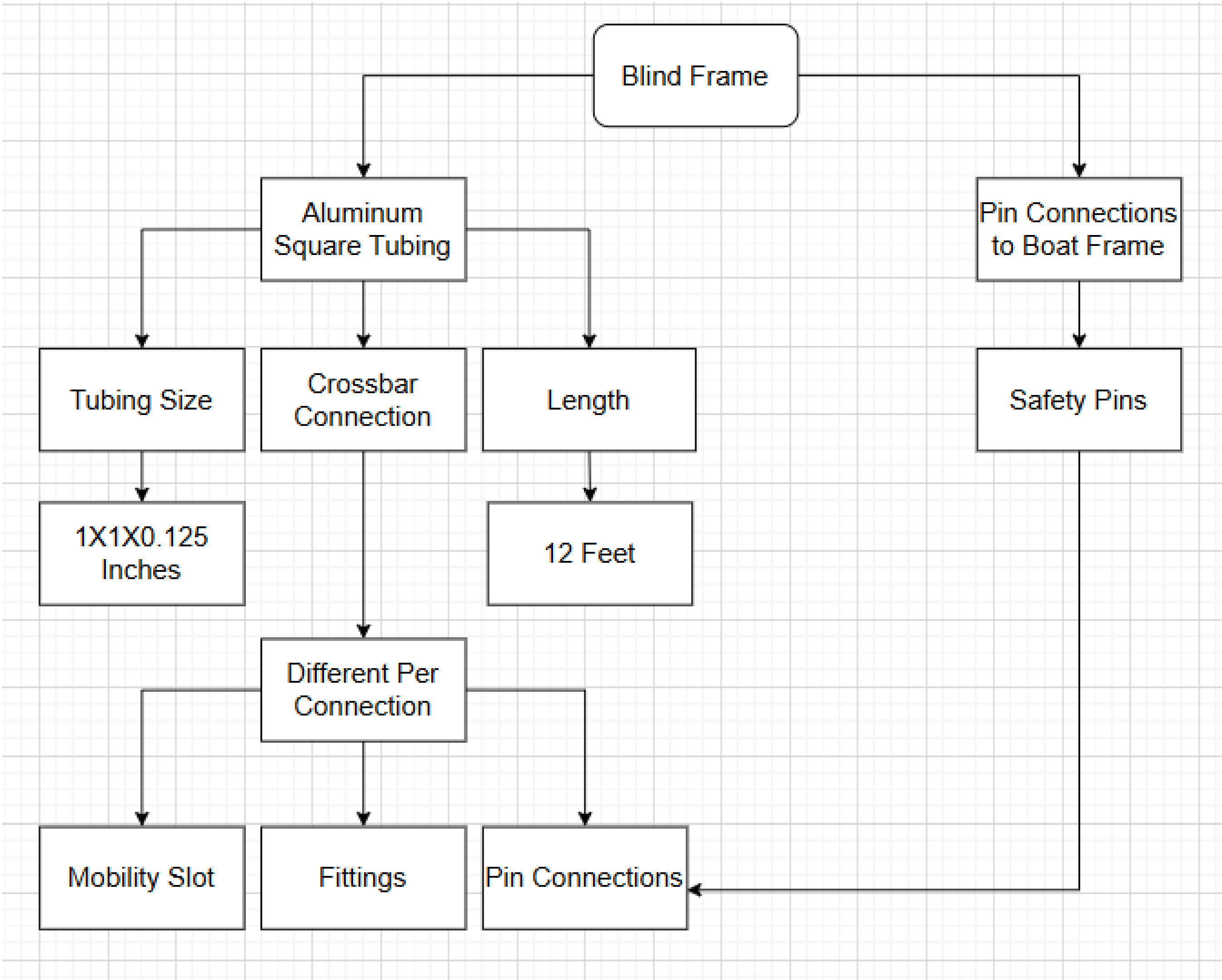

Figure 3.3: Blind Frame Subsystem Breakdown

The second subsystem hierarchy is the blind frame, Figure 3.3. This subsystem is a four-level subsystem listing the components for the assembly of the blind frame. The components of the blind are in place to ensure safety and strength of blind.

3.1.4 Process Flow

The process flow diagram shows the steps of how the blind is built, including the final step of boat installation. An image of the process flow diagram, Figure 3.4, is shown on page 11.

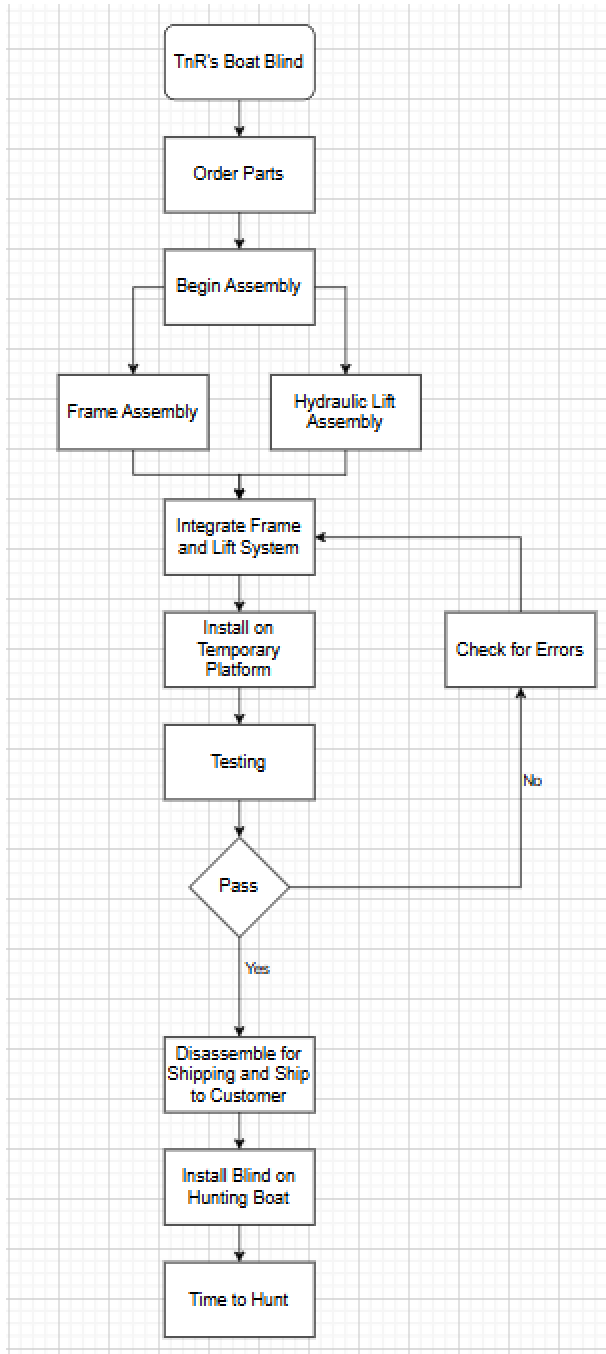

Figure 3.4: Process Flow Diagram

After ordering parts, an important step in the process flow is integrating the frame and lift system together and testing. Integrating and validating the system are vital to the project because if the system is unable to run through the proper number of cycles once integrated, the system must repeat the process flow until it functions properly through the pre-determined number of cycles. Testing is a vital part of the process flow. Specific tests are used based on the different components of the system. The blind frame is placed on a scale to ensure it meets the weight benchmark, and a statics and strength of material formula is used to find the maximum amount of weight placed on the blind without breaking the frame. The fully integrated system is tested by running through a minimum of 60 cycles to ensure it will last at one full duck season, as set by the U.S Department of Fish and Wildlife. An FMEA, located in section 3.2 Frame Design, shows the potential failures, level of severity and occurrence, and the way to repair and test to help the manufacturer and user understand the possible failures and solutions.

3.1.5 Alternative Evaluation

There were three primary options assessed for constructing the blind: hydraulic lift system, electric motor driven lift system, or a linkage system comparable to a handicap swing door. Additional alternatives were also considered: for example, a winch system, as shown in Figure 3.5 below, and a spring-loaded system.

Figure 3.5: Automatic Winch (https://www.amazon.com)

The winch system allows for controllable lifting and lowering, as well as providing strength to hold the blind into position. The disadvantage to a winch system is that it requires a post placed in the middle of the boat to provide either the winch or the cable a height advantage to ensure that the blind is raised and lowered properly. Although the post provides additional height, it takes up space in the boat and both the post and the cable running through the post are potentially a tripping hazard to hunters, which violates the first requirement of safety. The second alternative is to use compliant mechanisms. A spring-loaded system is an option for deploying the blind into the raised position and to hold it in position. The drawback of a spring-loaded system is that it challenges multiple requirements. The spring-loaded system automatically deploys; however, human action is required to lower the blind. The spring-loaded system is more difficult to control during the lift, and the position may not be consistent, requiring manual intervention. Additionally, this option may place additional wear and tear on the blind.

3.1.6 Requirements and Specifications

The requirements and specifications in this section are set to create benchmarks and allow for success of the blind in the field. The requirements and specifications are explained by using the defined TPMs. There are a total of eight requirements listed in Table 3.1, ordered by level of importance.

Table 3.1: Requirements and Specifications

Requirement	Specification
Safety	System warns operator if obstructed and can be shut down if necessary
Automated deploy and retraction	No human intervention required
Controlled deploy and retraction	Range of 4-8 seconds
Reliability	Must complete a minimum of 60 cycles
Positioning ability	Must hold a specific position
Strength	Must lift and hold a minimum of 100lbs
Speed	Must not exceed 4in/s, with adjustability
Weight	Must not exceed 100lbs, excluding camouflage

The are various reasons for the selection of these specifications. Some of these specifications, such as strength, positioning ability, and weight, emanate from personal experience. In the field, if a scissor style blind is built from PVC, the structure may strain to hold enough camouflage weight without sagging. Additionally, the positioning ability is not easily completed without adding extra components, and the weight of the camo is too heavy for manual deployment and retraction. The other specifications are benchmarks that are essential to production. Safety is always the first performance indicator that must be considered and implemented to certify that the end product is safe for use. To ensure the safety of the system, the system includes proximity sensors so that people and objects are clear of the blind. If the sensors fail, an emergency stop is included in the system as a fail-safe to shut the entire system down. Automated deployment and retraction are the purpose of this proposal; therefore, if the system does not deploy and retract automatically, then the project is a failure and mitigation efforts must be implemented. Controlled deployment and retraction will keep the blind from breaking and the speed of the lift aids in the control of the deployment and retraction. The reliability specification ensures that the blind lasts at least one season, minimum of 60 cycles, as the length of duck season set by the U.S. Fish and Wildlife Service is 60 days.

3.1.7 Design Framework and Evaluation

There are three main topics in the design framework for this project: safety, automation, and reliability. The safety of this project is the priority because this product, if not designed, tested, and optimized properly, may potentially harm to hunters. For the safety of the hunter, proximity sensors, alarm, and an emergency stop are implemented into the system. The proximity sensors ensure that there are no people or objects that obstruct the area surrounding the blind when it is deploying and retracting, and the alarm will sound if there is something obstructing the system. The emergency stop is essentially a last recourse to avert injury. If any part of the system including the proximity sensors and alarm fails, the emergency stop is used to cut all power to the system. The manual override is then used to deploy or retract the blind into the desired position. The automation of the blind, as stated previously, is the charter of this project, and is essential for the success. By implementing a hydraulic system, the blind deploys and retracts with the press and hold of a single button. The hydraulic lift system provides enough strength to lift and hold the minimum 100-pound benchmark, as stated in Table 3.1. Reliability is the third design framework and is set to ensure that the system cycles through at least 60 deployment sequences, stipulated by the 60-day duck hunting season. The reliability aspect of this project is central to the success, as the product would cost prohibitive if it is unable to last through one season of hunting. For evaluation of the project, specific tests are performed and documented for all the requirements and specifications. Once the blind is complete, the proximity sensors are obstructed to see if the alarm will sound and light up right immediately and the emergency stop button is engaged before the cycle is started to test if the blind with run unless it is disengaged, and during the cycle to test if it will shut the power down stopping the system at the point it is engaged. This strength of the blind is verified once the blind is produced, and camouflage is added to the frame. The overall product weight is tested after the blind is fully assembled, confirming it is under the 50-pound benchmark. The weight of the blind is important due to the fact that you do not to put more weight in the boat than needed therefore, you want to be as light as possible without losing the proper amount of strength.

3.2 FRAME DESIGN

The frame of the project is designed as a scissor style boat blind, see Figure 3.6 below for an example.

Figure 3.6: Scissor Style Boat Blind (https://www.duckhuntingchat.com)

It is composed of two different sections containing three parts each. There are two pieces of one-by-one aluminum square tubing at a length of six feet and the third piece is an 18-foot cut of the same material. The two six-foot pieces are used as the frame's hypotenuse, having two different types of connections: a pin connection, which is placed directly to the boat and allows for rotation of the frame, and fitting connections that connect the six-foot pieces to the 18-foot piece at a 90-degree angle. The 18-foot crossbeams create the length of the blind. During construction phase, it was found that the 18-foot crossbeams had a natural deflection without any added weight, and this was fixed with a change in the length to 12-foot crossbeams. These pieces are intended to hold the camouflage for the blind, providing the user with an optimal place to hide from the targeted game. Figure 3.7 shows an example of the frame using a SolidWorks diagram assembly.

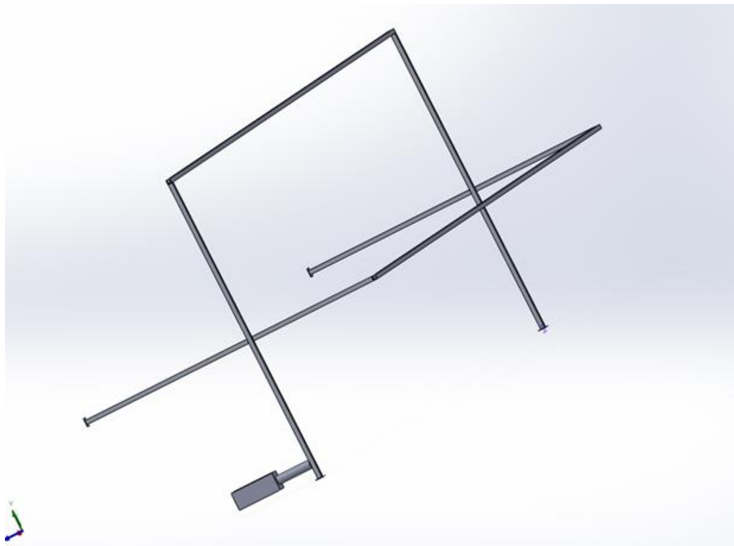

Figure 3.7: SolidWorks Frame Assembly

In Figure 3.7 above, there are four pin connections directly connected to the boat and the 90-degree angle direction change is obtained by fittings.

During the design phase, a bending failure analysis was performed to determine the maximum weight the aluminum square tubing can withstand before failure. The equation for bending stress can be applied:

$$\sigma = Mc/I$$

where M is determined by summing moments about the origin and c is one-half of the height of the square tubing. *I* is calculated using the following equation for square tubing:

$$I = (W^4 - w^4)/12$$

where W is the outermost length of the tubing and w is the innermost length of the tubing.

By using the dimensions of a 1x1" outer tubing and 0.875x0.875" inner tubing, the moment of inertia equates to:

$$I = 0.035\ in^4.$$

By summing moments of the origin, with an approximated length of about 18 feet of framework that the pump force is applied across, the free weight of the framework is calculated using:

$$W = (241 * 12)/216$$

where W in this instance is the weight at the free end. The resultant weight is:

$$W = 13.4\ lbs.$$

From there the maximum moment can be calculated by taking W and multiplying it by its moment arm of 18 feet (216 inches) and getting a maximum moment of 2894.4 lb-in. Substituting this back into the bending calculation, the bending moment is:

$$\sigma = (2894.4 * 0.5)/0.035$$

This gives a bending stress that is less than the yield strength for the chosen material, aluminum.

$$\sigma = 41.35\ \mathrm{k}si < 45\ ksi\ (yield\ strength)$$

After the evaluation, it is determined that 1x1" and 1/8" wall is sufficient for the frame of the blind, allowing for final assembly of the frame. However, these calculations were used for the initial iteration of the design. After further testing, the calculations had to be updated in order to have correct values to compare in final testing phases as seen below.

Force required to lift frame: 200 lbf.

Pressure rated for pump: 100 psi.

To size the pump:

$$A = \frac{F}{P}$$

$$A = 2in^2$$

To find the bore diameter:

$$D = \sqrt{\frac{8}{\pi}}$$

$$D = 1.6\ in$$

Recommended Size: D=1.75 in.

Static Analysis:

Force Required to support the arms:

Point Load force: 3.2 lbs.

Reaction force on right side:

$$Ry2 = \frac{3.2lbf * 48"}{96"}$$

$$Ry2 = 1.6lbf$$

Reaction force on left side:

$$Ry1 = 3.2lbf - 1.6lbf$$

$$Ry1 = 1.6lbf$$

Maximum moment:

$$M = 48" * 1.6lbf$$

$$M = 76.8\ lb - in$$

Moment of inertia:

Square tubing: 1” x 1” x 0.125”

$$I = \frac{1^4}{12} - \frac{(1 - 2 * 0.125)^4}{12}$$

$$I = 0.057\ in^4$$

Bending Stress:

$$\sigma = \frac{76.8\ lb - in * 0.5 in}{0.057\ in^4}$$

$$\sigma = 673.3\ psi$$

Yield Strength: 37000 psi

Safety Factor:

$$\eta = \frac{37000\ psi}{673.3\ psi}$$

$$\eta = 55$$

Estimating cycles to failure:

Ultimate Strength: 26 kpsi

Se’ = 10 kpsi

Marin Factors:

$$ka = 2 * 26^{-0.217}$$

$$ka = 0.99$$

$$ke = 0.814$$

Fully corrected endurance limit:

$$Se = 0.99 * 0.814 * 10$$

$$Se = 8.06\ kpsi$$

Cycles to Failure:

Sf=36.8 kpsi

$$a = \frac{(0.9 * 26\ kpsi)^2}{8.06\ kpsi}$$

$$a = 67.94$$

$$b = -\frac{1}{3}\log\left(\frac{(0.9 * 26\ kpsi)}{8.06\ kpsi}\right)$$

$$b = -0.15$$

$$N = \left(\frac{36.8\ kpsi}{67.94}\right)^{-\frac{1}{0.15}}$$

$$N = 60\ cycles$$

After the additional calculations, we found that theoretically, our minimum number of cycles will be achieved. In the final assembly, the same pin connections to the boat and the fittings are included in this assembly. The blind is allowed to deploy and retract freely without any external assistance. This is completed by slots cut into two of the four six-foot pieces of square tubing and then connected to the other two six-foot pieces using a safety pin. The slot and safety pins are shown in two different positions in Figure 3.9 and Figure 3.10.

Figure 3.9: Retracted Position


Figure 3.10: Deployed Position

After assembly, as seen in Figures 3.9 and 3.10, there is a natural bend in the 18-foot cross beam. To combat this issue, support beams may be installed to dampen or eliminate the bending; however, due to time constraints, the crossbeams were cut down to 12-foot pieces to eliminate natural bending. In addition to the natural bending of the 18-foot crossbeams, there was an issue in the original 90-degree fittings. The first iteration of the fittings was a thin-walled design that lacked strength when the blind was deploying and retracting continuously breaking. Due to this issue the second iteration of the fittings was designed to be solid to increase strength and reduce the chance of failure. A figure of iteration one and iteration two of the fittings is shown below in Figure 3.11.

Figure 3.11: Fittings

The adjusted length of the crossbeams is seen below in the deployed and retracted positions in Figures 3.12 and 3.13.


Figure 3.12: 12’ Retracted Position

Figure 3.13: 12' Deployed Position

A Finite Element Analysis was conducted on the 12-foot crossbeams and the results are shown Figures 3.14 and 3.15.

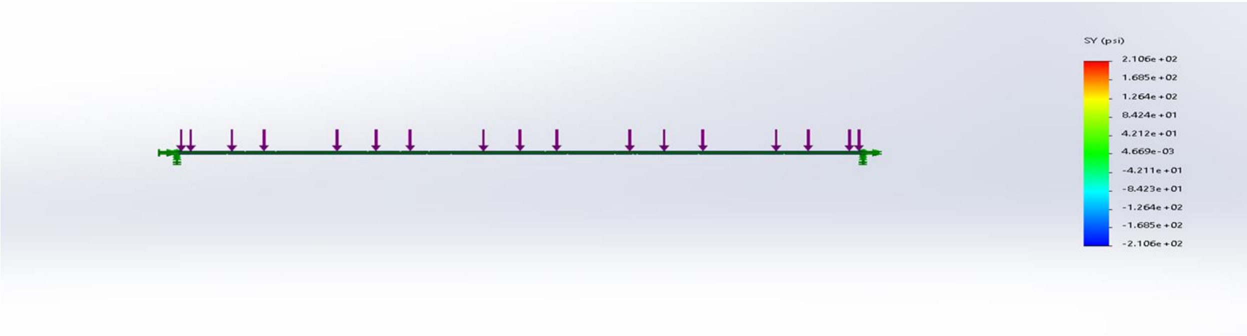

Figure 3.14: Stress Plot

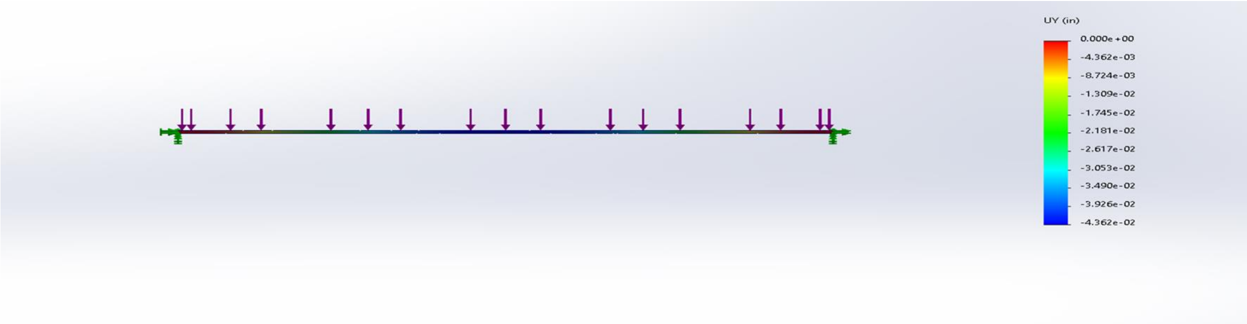

Figure 3.15: Displacement Plot

Figure 3.14 shows the stress plot with a 100-pound distributed load placed on the blind. It was determined that the crossbeams only have $2.11X10^{-2}$ psi of stress on each beam. Under the same load, a deflection plot is shown in Figure 3.15 and the result is that the cross beam will deflect $4.4X10^{-3}$ inches.

3.3 LIFT SYSTEM DESIGN

For implementation of a lift system, there are three system considerations in the market today: Power Pole Shallow Water Anchor, hydraulic lift table, and handicap swing doors. The first, the Power Pole Shallow Water anchor shown in Figure 3.16, is used as an anchor to keep boats in a desired position.

Figure 3.16: Power pole Shallow Water Anchor (https://www.amazon.com)

The Power Pole uses a hydraulic system to deploy and retract when commanded by a remote or step buttons placed on the front deck of the boat. Although the Power Pole is not used for manufacturing the boat blind, the hydraulic system used for raising and lowering is comparable to the system necessary for the boat blind. An image of the Power Pole hydraulic system is illustrated in Figure 3.17.

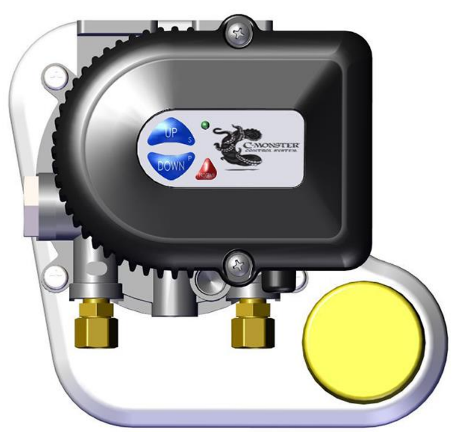

Figure 3.17: Power pole Pump (https://hydrillagear.com)

The second comparison for the automated duck blind is a hydraulic lift table that is found in many manufacturing facilities. These lift tables enable workers to use less effort lifting heavy components or parts out of a crate or off a pallet. The hydraulic lift table system is closely related to the conceptual ideas for the automated duck blind. A lift table uses a hardwired switch to raise and lower the table, making it effortless for the user. This functionality is the basis for the objective of the automated duck blind. Figure 3.18 shows an image of a hydraulic lift table to provide an example of the hydraulic system that could be implemented into the automated duck blind.

Figure 3.18: Hydraulic Lift Table (https://www.wiscolift.com)

The third and final comparison of systems is a handicap accessible swing door. This swing door provides a different approach to the automated duck blind since it is not controlled by hydraulics. The swing door uses an electric motor that is connected to a linkage to open the door. To close the door, the motor is set to a timer, allowing for a specific setting for completion of the system. A swing door is shown in Figure 3.19 below.

Figure 3.19: Automatic Swing Door (https://www.magnumdoorsolutions.com)

All three of these considerations are applicable to the design of automated duck blind. A cost analysis of each of the three considerations is shown in Table 3.2 below.

Table 3.2: Comparable Systems Costs

System	Cost
Power Pole Blade Shallow Water Anchor	$2200
Hydraulic Lift Table	$2500-$4500 (depending on size)
Handicap Swing Door	$4000-$6500

Due to the flexibility in positioning, strength, and simplicity for the user, a hydraulic lift system was chosen for the final product for this project. The original hydraulic pump chosen was the Magister Hydraulics Bidirectional Pump. See Figure 3.20.

Figure 3.20: Original Hydraulic Pump (https://www.magisterhyd.com)

After receiving the pump, it was determined that the selected pump did not include the proper components to perform the task needed for the project. The bidirectional pump, as seen in Figure 3.19, was missing solenoid valves and a solenoid coil that allows the system to be controlled by the remote. The proper solenoid valve is a 12-volt double acting with a sizing of 0.25-inch threaded hole. This solenoid valve is shown below in the bottom of Figure 3.21.

Figure 3.21: Solenoid Valve and Solenoid Coil (https://www.ordertrailerparts.com)

The solenoid coil, top of Figure 3.21, is connected directly to the remote and given a charge when the up or down button of the remote is engaged, creating a magnetic field that opens the preferred up or down solenoid valve. This function allows the blind to deploy and retract automatically. Due to time constraints, a new pump was ordered with the solenoid valve and coil included, as shown in Figure 3.22. The new pump is a VEVOR six-quart double acting dump trailer pump with a power rating of 1.6 kilowatts, 16-20 megapascals pressure range and runs off a 12-volt, 200-amp direct current battery.

Figure 3.22: New Hydraulic Pump (https://www.vevor.com)

The hydraulic cylinder used is a magister hydraulics AG Clevis cylinders with a 2.5-inch bore with an 8-inch stroke length. This cylinder can be seen in Figure 3.23 below and was chose due to the ability to properly attach the cylinder to the square tubing due to the spacing being a perfect fit for the tubing to sit.

Figure 3.23: Hydraulic Cylinder (https://www.magisterhyd.com)

4 SAFETY

In this project, safety is a top consideration. Two OSHA regulations are assessed for the hydraulic pump and the pinch points of the blind frame. For pinch points, OSHA states "one or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point-of-operations, ingoing nip-points, rotating parts, flying parts, flying chips and sparks. Examples of machine guarding are barrier guards, two-handed tripping devices, and electronic safety devices" (paragraph 2). For the hydraulic pump, OSHA states in standards 1910.305(j)(4)(ii)(d) and 1910.305(j)(4)(ii)(e) that disconnect means are readily accessible and clearly labeled for the operator to know whether the system is on or off (Table 1).

4.1 Proximity Sensors and Red-Light Alarm

Proximity Sensors are used in the system to meet the OSHA regulations on pinch points. The proximity sensor used is a through beam sensor with an emitter and receiver and is placed just below the frame, which provides the system with a method of avoiding objects or people from getting in the way or blind when it is deploying and retracting. If the sensor is obstructed, a signal is sent to the red-light alarm where it sounds off and lights up red, providing the operator with a warning that there is an obstruction. An image of the sensor and the red-light alarm is shown with a hand obstructing the through beam and lighting up the red-light alarm.

Figure 4.1: Sensor and Alarm

4.2 EMERGENCY STOP

To address the issues of OSHA regulations 1910.305(j)(4)(ii)(d) and 1910.305(j)(4)(ii)(e), an emergency stop is used to completely shut down the system, if required. The emergency stop is placed next to where the operation is controlling the system, allowing for easy access. The emergency stop used is shown in Figure 4.2.

Figure 4.2: 12-Volt DC Emergency Stop

As seen in the figure above, the emergency stop is clearly labeled, leaving no mistake as to the location and purpose of the emergency stop.

5 ENVIRONMENTAL CONSIDERATIONS

5.1 CAUSE AND EFFECT

There are many components to the system that could affect the environment in a negative way. In Table 5.1 below, you can see the possible component failure that could negatively affect the environment.

Table 5.1: Environmental Cause and Effect

Cause	**Effect**
Leaking Hydraulic Fluid	Oil based Water Pollution, Flammable
Leaking Battery Acid	Toxic, Fire Hazard
Lift System Fire (pump and cylinder)	Human and Environmental Harm through Fire
Broken Aluminum Falls into the Water	Creates a reaction that creates a hydrogen gas
Electrical Fire	Human and Environmental Harm through Fire

As seen in Table 5.1, there are five big concerns for the environmental effects that the system will have. The leaking hydraulic fluid which is oil based would pollute the water and if any animals were to swim through, or drink the water, it would have many negative effects on the animal's health. Hydraulic fluid and battery acid are very flammable which would possibly lead to forest fires that could become much more dangerous affecting a massive portion of the environment and even human harm. Like all machines, they can catch fire the result could be similar to the previous two creating a forest fire. Aluminum when mix in water for an extended period of time begins to have a chemical reaction that as a product, creates aluminum hydroxide and a hydrogen gas that is toxic to marine life and is also highly flammable. An electrical fire can start in places as simple as your own home, but in the case of the boat blind, it would not only harm the environment, but it could also harm humans. To aid in the prevention of these issues, it is recommended that the proper fire extinguishers are placed within an easy to reach area of the boat, and if hydraulic fluid or battery acid leaks into the water, the local fish and game authorities have to be contacted and made aware of the leakage

6 SYSTEM EVALUATION

6.1 TECHNICAL PERFORMANCE MEASURES

In Table 3.1, the Technical Performance Measures, which were set during the design phase of the project, were set as reference points to ensure the system operates at a sufficient level to create an improved, more efficient version of an existing scissor style blind through automations. The results for the test on the Technical Performance Measures are shown in Table 6.1.

6.2 TESTING RESULTS

Outlined below are the results of the testing phase based on the defined Technical Performance Measures.

Table 6.1: Results of Technical Performance Measures

Requirements	Specification	Result
Safety	System warns operator if obstructed and can be shut down if necessary	YES
Automated deploy and retraction	No human intervention required	YES
Controlled deploy and retraction	Range of 4-10 seconds	YES
Reliability	Must complete a minimum of 60 cycles	YES
Positioning ability	Must hold a specific position	YES
Strength	Must lift and hold a minimum of 100lbs	YES
Speed	Must not exceed 4in/s, with adjustability	YES
Weight	Bare blind must not exceed 100lbs	YES

The testing phase resulted in 100 percent efficiency based on the defined Technical Performance Measures.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 CURRENT PROGRESS

Throughout this project, there has been much trial and error, redesigning, reconstruction, and optimization of the automated duck blind. Fortunately, the automated duck blind has met the benchmarks set by the technical performance measures based on the 60 cycles run test, finite element analysis, safety testing, as well as strength and weight, thus the automatic duck blind can be deemed completed to specification.

7.2 FUTURE RECOMMENDATIONS

In the future, it is recommended that different materials be used for the frame of the duck blind. The material will need to keep the similar material properties of a good yield strength, light weight, and corrosion resistance, but needs to be more rigid than aluminum to ensure that there is not a natural bend to the crossbeams when no load is present. In addition, the stroke length of the cylinder needs to be more than eight inches to provide enough room for adjustability when there is a difference in height of hunters. The longer stoke length allows the blind to get higher when placed in a boat that has a shallower bottom.

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APPENDIX

Appendix A: Failure Mode and Effect Analysis

FAILURE MODE AND EFFECTS ANALYSIS

Item: TnR's Automated Duck Blind | Responsibility: Riley Harris and Tyler Spence | FMEA number: 1 of 1
Model: 1 Version 1 | Prepared by: Riley Harris | Page : 1 of 1
Core Team: Riley Harris and Tyler Spence | FMEA Date (Orig): | Rev: 1

Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Process Controls	Detec	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Action Results				
											Actions Taken	Sev	Occ	Det	RPN
Blind Frame	Shearing	User Harm	10	Weight	2	Statics/SoM	10	200	Rebuild	R and T/User	Repair	3	1	1	3
Pump Failure	Burnt Out	Function Loss	5	Overuse	1	You'll Smell it	10	50	Investigate	R and T/User	Replace/Repair	2	1	1	2
Cylinder Sticks	??	Function Loss	5	??	1	??	10	50	Invistigate	R and T/User	Replace/Repair	6	1	1	6
Hose line holes	Puncture	No fluid transfer	3	Sharp point	1	Fluid Leak	5	15	Find Hole	R and T/User	Replace	1	2	1	2
Fitting Break	Break/Shear	No fluid transfer	5	Outside Force	1	Disconnected Lines	5	25	Repair/Replace	R and T/User	Replace/Repair	1	1	1	1
Battery Dies	No Charge	No Power for System	5	Extended Use	1	Test Charge	2	10	Recharge/Replace	R and T/User	Charge/Replace	3	4	1	12
Electrical Short	Bad Connections	No Power/Human Harm	10	Loose Wiring	3	Test V+A Transfer	5	150	Check Wiring	R and T/User	Replace/Repair	7	6	1	42
Safety Sensors	No Communication	Human Harm	8	Off-Line	7	Test Sensor Alignment	1	56	Check Alignment	R and T/User	Realign	1	10	1	10
Emergency Stop	Disconnected	Human Harm	8	Loose Wiring	3	Test V+A Transfer	6	144	Check Wiring	R and T/User	Repair/Replace	9	2	1	18
								0							0
								0							0
								0							0
								0							0

Appendix B: Preliminary Project Schedule

Table B: Project Schedule

Task Mode	Task Name	Duration	Start	Finish	Predecessors
Auto Scheduled	**TnR's Automated Duck Blind**	**158 days**	**Wed 5/1/24**	**Fri 12/6/24**	
Auto Scheduled	**Finish ENGR 471**	**1 day**	**Wed 5/1/24**	**Wed 5/1/24**	
Auto Scheduled	Submit Final Report	1 day	Wed 5/1/24	Wed 5/1/24	
Auto Scheduled	Order Parts	1 day	Wed 5/1/24	Wed 5/1/24	
Auto Scheduled	**Summer 2024 Potential Work**	**71 days**	**Thu 5/2/24**	**Thu 8/8/24**	
Auto Scheduled	Receive Parts	2 wks	Thu 5/2/24	Wed 5/15/24	4
Auto Scheduled	Prepare Components for Assembly	10 days	Thu 5/16/24	Wed 5/29/24	6
Auto Scheduled	Begin Blind Frame Assembly	3 wks	Thu 5/30/24	Wed 6/19/24	7
Auto Scheduled	Finish Frame and Start Testing	4 days	Thu 6/20/24	Tue 6/25/24	8
Auto Scheduled	Assemble Hydraulic System	2 wks	Wed 6/26/24	Tue 7/9/24	9
Auto Scheduled	Test Hydraulic System	2 wks	Wed 7/10/24	Tue 7/23/24	10

Auto Scheduled	Wait until 491	12 days	Wed 7/24/24	Thu 8/8/24	11
Auto Scheduled	**ENGR 491**	**80 days**	**Mon 8/19/24**	**Fri 12/6/24**	
Auto Scheduled	Degree Works Page Review	1 wk	Mon 8/19/24	Fri 8/23/24	
Auto Scheduled	Integrate Blind and Hydraulic System	40 days	Mon 8/19/24	Fri 10/11/24	
Auto Scheduled	Life Long Learning Quiz	1 wk	Mon 9/30/24	Fri 10/4/24	14
Auto Scheduled	Mock Interview	1 wk	Mon 9/30/24	Fri 10/4/24	14
Auto Scheduled	Resume Interview	1 wk	Mon 9/30/24	Fri 10/4/24	14
Auto Scheduled	Test Blind for Full Operation	2 wks	Mon 10/14/24	Fri 10/25/24	15
Auto Scheduled	Attend All Lectures	1 wk	Mon 10/7/24	Fri 10/11/24	16,17,18
Auto Scheduled	Program Info to Shared Drive	1 wk	Mon 10/7/24	Fri 10/11/24	16,17,18
Auto Scheduled	Name, Email on Invite List in Drive	1 wk	Mon 10/7/24	Fri 10/11/24	16,17,18
Auto Scheduled	Begin Installation of Camo	3 days	Mon 10/28/24	Wed 10/30/24	19
Auto Scheduled	Test Full Operation w/Camo	5 days	Thu 10/31/24	Wed 11/6/24	23
Auto Scheduled	Design Presentation Review	1 wk	Mon 11/4/24	Fri 11/8/24	20,21,22
Auto Scheduled	Blind Complete	1 day	Thu 11/7/24	Thu 11/7/24	24
Auto Scheduled	Draft Report to Advisor	1 wk	Mon 11/11/24	Fri 11/15/24	25
Auto Scheduled	Project Poster to Shared Drive	1 wk	Mon 11/18/24	Fri 11/22/24	27
Auto Scheduled	Final Presentation Day	1 wk	Mon 11/25/24	Fri 11/29/24	28
Auto Scheduled	Complete CATME Survey	1 wk	Mon 12/2/24	Fri 12/6/24	29
Auto Scheduled	Complete Exit Survey and Interview	1 wk	Mon 12/2/24	Fri 12/6/24	29
Auto Scheduled	Poster and Session Attendance	1 wk	Mon 12/2/24	Fri 12/6/24	29
Auto Scheduled	Submit Final Report to Advisor	1 wk	Mon 12/2/24	Fri 12/6/24	29

Auto Scheduled	Submit Final Report to SOAR	1 wk	Mon 12/2/24	Fri 12/6/24	29	

Appendix C: Bill of Materials

Table C: Bill of Materials

	Item	Item Number	Cost	Quantity
1	Hydraulic Pump	SKU: HPU-BD-12VDC-DA	$349	1
2	2” Bore 8” Stroke Cylinder	SKU: WBC 2x8	$155	1
3	Aluminum Square Tubing	West Side Materials	$263	1
4	Pin Brackets	Amazon (ZJ05-32MM-T10)	$21.99	1
5	Safety Couple Pins	Amazon (25080)	$1.34 each	6
6	Hydraulic Hose and Fitting	Hydraulic Supply Company	$226.58	2
7	Hydraulic Fluid	ISO 40	$60	1 (2 pack)
8	Through Beam Sensors	LJ12A3-4-Z/AX	$11.99	1
9	Emergency Stop	LBT-FSA-1-S	$19.99	1
10	Red Light Alarm		$12.99	1
Total				16 Items

Appendix D: Budget

Table D: Project Budget

	Item	Cost
1	Hydraulic Pump	$186
2	Hydraulic Cylinder	$175
3	Hydraulic Fluid	$60
4	Aluminum Square Tubing	$263
5	Pin Brackets	$13.92 x 4
6	Safety Couple Pins (2 pack)	$11.99 x 2
7	Hydraulic Hose and Fittings	$226.58
8	Emergency Stop	$22.95
9	Red Light Alarm	$12.99
10	Through Beam Sensor	$19.99
Total		$1046.17

Appendix F: Design Considerations and Standards

Table F, Design Factors Considered

Design Factor	Page number, or reason not applicable
Public health safety, and welfare	Page 29
Global	N/A: Not intended to be distributed worldwide.
Cultural	N/A: Does not any reference point from a specific culture.
Social	N/A: Does not affect any specific social community.
Environmental	Page 29
Economic	N/A: Not intended for mass production.
Ethical & Professional	N/A: Does not have any reference point of ethical wellbeing or any professional involvement.
Reference for Standards	Occupational Safety and Health Administration, www.osha.gov/.