1/9/2025

EML4551-2

Team 510: Swing Gate Lock Improvement

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Abstract

The abstract is a concise statement of the significant contents of your project. The abstract should be one paragraph of between 150 and 500 words. The abstract is not indents.

Keywords: list 3 to 5 keywords that describe your project.

Acknowledgement

These remarks thanks those that helped you complete your senior design project. Especially those who have sponsored the project, provided mentorship advice, and materials. 4

- Paragraph 1 thank sponsor!
- Paragraph 2 thank advisors.
- Paragraph 3 thank those that provided you materials and resources.
- Paragraph 4 thank anyone else who helped you.

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Notation

Abbreviation   *Meaning*

Chapter One: EML 4551C

1.1 Project Scope

Project Description

The objective of this project is to design an innovative gate latch receiver mechanism that effectively addresses current customer acclaimed issues with misalignment and improper latching Ghost Control's current system. Our goal is to develop a solution that ensures reliable engagement, enhanced durability, and ease of installation. As gates age, they may begin to sag due to repeated impact during closing, along with various external factors. This occurs from a lack of support opposite of the hinges, putting the entire gates weight on the hinges and supporting posts. Weather events such as heavy rain, wind, extreme temperatures can cause soil to shift. This leads to movement in support posts, resulting in misalignment over time (Fence Finders, 2024). Bouncing is an accepted part of having a swinging gate, however, it deteriorates the gates' ability to close. Sagging can be addressed externally by adjusting the gate closure itself. To effectively prepare for sagging, a new method of gate latching must be considered that not only accounts for the factors that cause it but actively anticipates it.

Key Goals

This project aims to create a new receiving mechanism that accommodates extensive sagging in swing gates, using the current "ZombieLock" design sold by Ghost Controls as a reference. Sagging on the end opposite of the hinges causes alignment issues between the current lock and receiver system offered by Ghost Controls. The product will be designed to be commercially produced and sold on a large, profitable scale. It must also be universal to many gate configurations, easy to install, and function regardless of relatively poor installation, as this product is aimed at do-it-yourselfers (DIYers). There must also be a mechanical method of locking and unlocking the latch in the event of a loss of power due to a dead battery, broken wire, etc. The latch will be resilient to adverse environmental conditions, tamper resistant for increased safety, and contain a passive method of releasing in the event of a loss of power.

Markets

Primary Markets

Primary markets include homeowners, farmworkers, and other property owners who feel a need for added security. This also includes large corporations, such as U-Haul, lumber companies, or potential agricultural businesses; any company needing locks for their storage facilities would benefit from this product.

Secondary Markets

Secondary markets include businesses specializing in gate installations or fence contractors. Clients may specifically ask for Ghost Control locks, or Ghost Controls may be recommended to them by installers. Another secondary market would be retailers distributing Ghost Controls at their stores, such as Tractor Supply Co., Home Depot, Lowes, or other agricultural stores selling them

Assumptions

Assumptions can be made about the project regarding power supply, installation, and design. The power supply is assumed to be a 12V DC battery; the gate does not require power when stationary and will not receive continuous power. When installation occurs, the installer will have proper tools and instructions appropriate for a DIY install. A limited number of tools are required, a small hand tool set including a ratchet, and sockets will be sufficient. The gate will not use wheels and will swing freely throughout the entire range of motion. The gate post will be securely set in concrete or some other anchoring medium to maximize rigidity. A reasonable adult will be able to operate the gate opening and latching systems using remote control. The gate the Ghost Controls opens will not exceed 20ft, nor will it go on any contact gates for properties or fencing. It will also not be used for animal containment. The existing “ZombieLock” may be used as a reference for potential redesigns. The system will be used in all climates.

Stakeholders

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Consumers/Customers of Ghost Controls | https://www.amazon.com/stores/GhostControls

UL Standards (Code and Safety Compliance) | https://www.shopulstandards.com/

The opportunity for this project is offered by the FAMU-FSU College of Engineering. Dr. McConomy and Dr. Hruda will be the majority advisors on this project. Darryl Beadle and Mickey Nguyen are Head Engineers at Ghost Controls and have granted us access to their local facilities in Tallahassee, FL. The future consumers of ghost control will benefit greatly from a successful design that accounts for misalignments with their gates.

1.2 Customer Needs

To determine the needs for our design, Team 510 developed a set of questions to interview the project's sponsors, Darryl Beadle and Mickey Nguyen. The team presented these questions in a face-to-face meeting at the Ghost Controls Facility. These questions were developed with an understanding of the Ghost Controls consumer demographic and the challenges they face with their current systems. A common issue for these consumers is their gate sagging and gradually becoming misaligned over time. Table 1 below shows the questions asked to the advisors, their answers and interpreted needs to better inform our design process.

Table 1: Customer Needs Q&A

Customer Needs Q&A			
	Question	**Customer Statement**	**Needs Interpretation**
1	What is the maximum gate size/weight we need to account for?	"The maximum gate length recommended for the gate opener is 20 feet. The arm for the opener weighs roughly 54 pounds."	Mechanism works for gate lengths up to 20 feet.
2	Is the desired product a latch or a lock?	"It does not matter. A latch and lock are the same except for the security aspect. It is up to the team to choose, but if a lock design is chosen, it must be secure and resist 50 pounds of force."	Gate lock design can resist 50 lbs. of force at the lock.
3	How often is the gate opener used?	"The gate is stationary way more than in motion."	Gate can stay locked in the closed position after opener is used.
4	What are the biggest complaints about the current ZombieLock product?	"Check amazon reviews for specifics, but mostly the sagging of the gate over time results in the lock not properly latching."	The gates tendency to sag is the root of the main issue with the current product.
5	What kind of	"They are marketed as no	Product is marketed for no

	environment do you market your gates for?	contact gates for properties and fencing. They are not for animal containment."	contact gates such as a residential property.
6	Are there any specific types of lock options you would like us to focus on?	"No, anything you want to try is acceptable. Recall, the lock needs to be mechanical, and electronics can only be used for the release of the lock. A magnetic lock is not possible due to lack of energy."	The type of lock is at the team's discretion if it is mechanical.
7	Are there any environmental factors you would like us to consider?	"The product needs to be universal and work in various weather conditions: high winds in the north, earthquakes in the west, etc. Note the gate can vary by length and material."	The gate performs in rugged environments, as well as perfect conditions.
8	How do you currently account for the sagging in the gate?	"Adjust the latch/lock or realign the post to account for the sag rather than fixing it."	Gate adjusts system to account for the sag.
9	What is the desired budget?	"The current product is the ZombieLock and sells for $199. Under $99 would be preferred, to appear more affordable to customers."	Improvements made to the lock will cost less than the current market system.
10	How is power provided to the gate and lock?	"There is a 12V battery or solar panel to power the gate. The lock only receives power to unlatch and relatch."	Lock is mechanical and draws power to lock and unlock the gate.
11	What occurs in the event of a loss of power?	"The mechanism must also have a mechanical, passive release method if power is lost or not available"	Product contains a fail-safe method of unlocking

As the needs were interpreted, a new locking mechanism that accounts for the inevitable misalignment due to sagging and other factors is desired. An emphasis was placed on the importance of ensuring the gate is secure when stationery. Various extreme environmental factors are accounted for when designing and selecting material. It is important for the product to maintain the current budget. The product only has access to power when unlatching and relatching provided by the battery. The product is universal for various gate sizes up to 20 feet that are used in residential areas.

1.3 Functional Decomposition

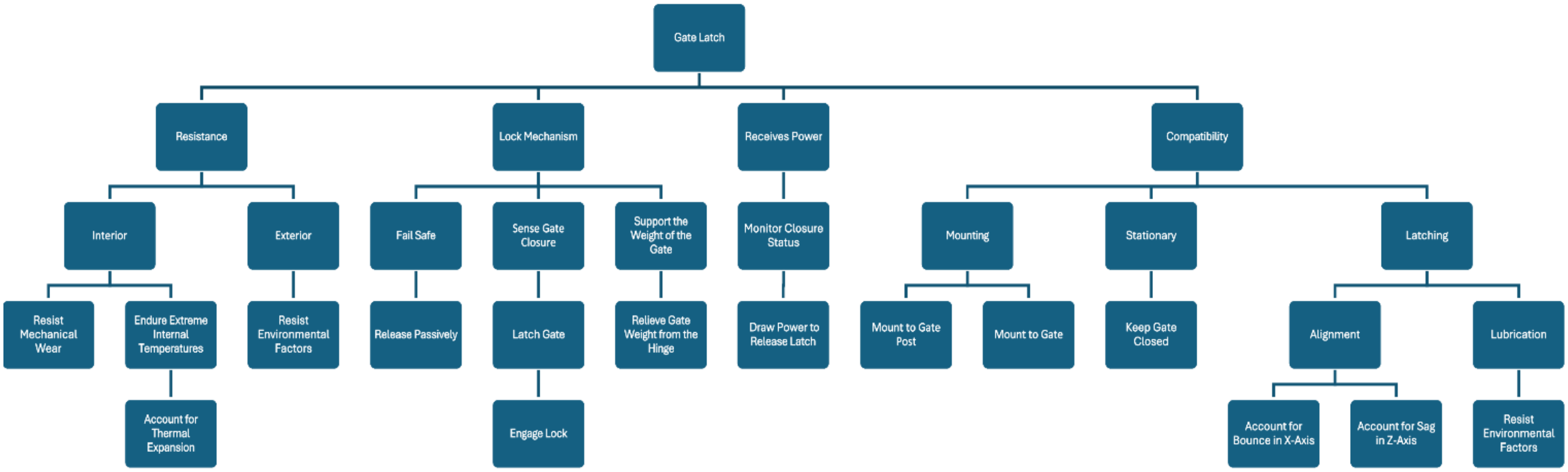
Introduction

The Ghost Controls lock system needs to be analyzed and divided into basic systems. This is done to uncover functions within each system that are necessary components and utilized to lay out the goals of the project. These functions are broken down into a complex process that outlines the small tasks and their outcomes. This process is presented as a functional decomposition.

Function Generation

The functions shown in Figure 1 are placed under their respective systems. The function delineations were based on discussions with the customer and assumptions based on the scope of the project. The manner in which the components interact was established upon the analysis of current systems in place and future design details. Major functions of the system were identified and placed at the top of the chart. Cascading down from the major functions are minor functions meant to produce a functional and reliable gate lock system.

Figure 1: Hierarchy Chart



Hierarchy Chart Reasoning

The hierarchy chart demonstrates four systems to represent the main functions of the design: Resistance, Lock Mechanism, Power, and Compatibility. These systems were further divided into minor functions, with the objective being to design a solution that ensures reliable engagement, enhanced durability, and ease of installation within an innovative gate latch mechanism that effectively addresses current issues with misalignment and improper latching.

Resistance

The resistance system is divided into two subsystems: interior and exterior. Internal components must be resilient against mechanical wear and extreme internal temperatures to account for thermal expansion. Exterior elements must be able to withstand outside environmental factors, such as wind, significant precipitation, and extreme external temperatures.

Lock Mechanism

The lock mechanism system is divided into three subsystems: fail-safe, gate sensing, and gate weight support. A fail-safe ensures that the gate can be released passively in the event of a power failure. Sensing the gate's closure ensures that when the gate is latched, the lock is engaged. The weight of the gate must also be supported to relieve weight from the hinges.

Receives Power

The power system only has one subsystem which is to monitor the closure status of the gate, since the mechanism can only draw power to release the latch. The mechanism must receive power and direct it to the latch to allow movement of the gate.

Compatibility

The compatibility system is divided into three subsystems: mounting, latching, and stationary. It is crucial to the structure of the system that the mechanism is mounted to the gate and gate post securely at a level height. When the gate shuts, the lock must remain closed, so the gate remains stationary. The latching of the gate needs to account for bouncing and sagging, in the x and y directions respectively, so that the latches remain aligned.

Cross Reference Table

A functional decomposition cross reference table is used to establish the relative importance of the major functions, or systems, of the hierarchy chart. The importance of the major functions will be dependent upon the number of minor functions that interact with them. To develop the cross-reference table below, Team 510 reviewed the hierarchy chart. The four systems were considered the major functions, while the corresponding functions were considered the minor functions. The two types of functions were each put on an axis of the cross-reference table. Beginning with the first minor function, each box in that row is to be marked if the major function corresponding with that column is dependent upon that minor function.

Table 2: Functional Decomposition Cross Reference Table

	Systems			
Minor Functions	**Resistance**	**Lock Mechanism**	**Receives Power**	**Compatibility**
Resist Mechanical Wear	**X**	**X**		
Account for Thermal Expansion	**X**	**X**		
Resist Environmental Factors	**X**			**X**
Release Passively		**X**		
Engage Lock	**X**	**X**	**X**	
Relieve Gate Weight from the Hinge		**X**		**X**
Draw Power to Release Latch	**X**		**X**	

Mount to Gate Post	**X**			**X**
Keep Gate Closed		**X**		**X**
Account for Bounce in X-Axis		**X**		**X**
Account for Sag in Z-Axis		**X**		**X**
Function Ranking	**3**	**1**	**4**	**2**

Smart Integration

By calculating the amount of "x" in Table 1, the primary system highlighted within the functional decomposition is the lock mechanism. This system has eight out of eleven minor functions connected to it. Most of the minor functions directly impact the locking function and can be managed through design control, while the remaining functions cannot but must be accommodated instead. The compatibility and resistance systems are matched in importance for the functional decomposition. Since Team 510 is designing a universal product, it is taken into consideration that not every consumer will have the same factors, i.e. gate type, gate post type, environment, or installation. Different scenarios are considered. Coming from the customer needs, the project should not rely too much on power. Thus, the last ranking system receives power. It has two minor functions: engaging and releasing the latch.

Action and Outcome

The main purpose of this mechanism, based on the previously explained function, is to close and lock a swinging gate. The overall outcome of this is to create a gate lock mechanism that accounts for misalignment caused by sag, which can be achieved by redesigning the gate latch itself. For this to occur, the mechanism must engage the lock, as this minor function affects the most major functions.

Functional Resolution

The product should ideally utilize power to unlock the latch, allowing the gate to be opened by the gate opener arm, while accommodating potential misalignment from vertical sag and horizontal bounce, and ensuring the gate is securely closed, all while being compatible with various swing gate designs.

1.4 Target Summary

Target Derivation and Validation

Targets serve as quantifiable objectives to measure and verify the proper functionality of a project. They can be used as parameters or limitations for a design to ensure the project is not subject to scope creep. Targets specify the constraints that need to be met for the product to be deemed successful within the means of the individual project. Functions were generated in necessity of addressing the functionality requirements of the project. These requirements, and their individual targets, were determined through research, reviewing customer feedback on the current product, and speaking with the chief engineers at Ghost Controls. The lowest-level functions on the functional decomposition hierarchy chart, as well as a few other functionless goals, were assigned targets to quantify the achievement of these requirements. The project metrics are the means to verify these targets are being met. Targets can then be deemed achieved via calculating, adjusting, and prototyping. An absolute list of these targets can be found in Appendix B. The targets that were found to be the most important to the satisfaction of the customers are labeled as the critical functions. These critical functions, along with their respective targets, are in Table 1 below.

Table 3: Critical functions, Targets, and Metrics

System	***Function***	***Target***	***Metric***
Lock Mechanism	**Engage Lock**	**≤ 5 [Seconds]**	**Time**
Compatibility	**Mount to Gate Post**	**0.31 ± 0.05 [Inches]**	**Tolerance**
Compatibility	**Mount to Gate**	**M8, 0.25 Depth [Inches]**	**Thread Size**
Compatibility	**Account for Bounce in Vertical Axis**	**1 – 3 [Inches]**	**Distance**

These critical functions were found to be the most important to the overall success of Team 510's project. As determined via the functional decomposition cross reference table, the two highest priority subsystems were determined to be "Lock Mechanism" and "Compatibility". These were deemed appropriate by the team, as the two largest goals for this project are to create a locking/latching device and that it can be universal for a variety of swing gates to encourage Do-It-Yourselfers (DIYers) to purchase and install this product. The teams lowest-level functions that were considered critical were "Engage lock", "Mount to gate post", "Mount to gate", and "Account for bounce in the vertical axis". These are each discussed in more detail in their individual subsystems below.

Resistance Targets and Metrics

To ensure the product is determined to be resistant, the functions under this subsystem must have quantifiable targets that will need to be achieved. Humidity, precipitation, and wind are the metrics to define the ability of the system to operate in all environments and resist appropriate environmental factors. The target for humidity is for the product to withstand up to 100% humidity. This accounts for the dryest of environments, as well as the humidity during precipitation. To validate this target, materials that have undergone corrosion and tolerance testing must be selected to ensure the product does not rust or become damaged because of environmental factors. The target for precipitation is up to 50 inches within a 24-hour period. This is to ensure the device functions regardless of the amount of rain. To get this metric, the United States 24-hour precipitation record was used to establish an extreme circumstance (Masters, 2018). To validate this target, the materials selected for the device must undergo water testing to ensure corrosion is not a concern. As standard with other products offered by Ghost Controls, the product designed will be tested while underwater to ensure moisture or water intrusion is not an issue. The target for wind is for the product to withstand up to 50 pounds of force caused by the force of wind on the gate. This is the maximum force the gate should be able to withstand according to Ghost Controls. To test this metric, force analysis should occur on a gate of the maximum size, 20 foot, with the maximum allowed surface area (30%). Additionally, in order to test the 50 pounds of force target, a scale will be attached to the end of the gate with the lock mechanism on it and a pulling force, such as a winch, will be attached at the other end of the scale. A force greater than 50 pounds prior to breaking will be proof of successfully reaching this target.

Temperature is the metric used to define the ability of the internal system to operate at extreme temperatures. The target is for the device to function from -5 to 160 °F. This was received from Ghost Control's website, as the linear actuators in the gate opener arms have that range as their recommended operating temperature (Ghost Controls). To validate, material testing and tolerancing must be prepared to ensure that clearance will not be an issue for the product.

Lock Mechanism Targets and Metrics

The lock mechanism system needs to enhance security and functionality while meeting specific targets and metrics to guide its performance. The metric for the system function of being able to open anytime is time. Five seconds is the maximum response time the system should experience before the latch is released. This ensures a quick response time, satisfying quick access for the user. This rapid engagement is very important for user convenience and emergencies. This can be tested by timing the reaction time of the latch via a stopwatch. The next function is one of the critical functions of the project, “Engage Lock”. The lock is programmed to engage when the latch is detached. The metric for this function is time. Similarly to the previous function, the time tolerated for the engagement of the gate lock is five seconds and can be tested by using a stopwatch to record the time it takes for the product to successfully lock the gate. Five seconds was deemed appropriate due to the current product offered by Ghost Controls, the ZombieLock, being able to accomplish an unlocking time of “a few seconds”.

One of the primary complaints regarding the current lock design, ZombieLock, is misalignment (Amazon). The issue partly roots from sagging in the gate itself over time. Reducing the force exerted on the gate at the hinges will decrease the sag that occurs in a given time; therefore, the metric is force. Relieving at least 5 force pounds of weight at the hinges will decrease the rate at the gate sags significantly improving the lifespan of the product. This can be quantified with a force analysis of the system and can be observed over an extended period.

Power Targets and Metrics

The gate lock system will require a 12V power supply, which aligns with the existing voltage in the gate's system. Electric potential is the metric used for the "Draw power to release latch" function. The target for this metric is between 12 and 12.9 Volts. This voltage range is the standard operating voltage for a sealed 12-volt lead acid battery, just like the one sold by Ghost Controls (ShopSolar, 2023). The voltage will come from the solar-charged DC battery that powers the gate's actuating arm by releasing the gate latch on the zombie lock. Using a higher voltage would add unnecessary costs, this voltage will be more than adequate to power and operate the lock system. This target can be easily quantified using a multimeter to measure the voltage from the battery.

Compatibility Targets and Metrics

As the highest priority subsystem, compatibility is an important aspect of the project and will largely reflect the success of the final product. Ghost Controls boasts their easy-to-install, universal product line, so a product that can fit a variety of gates in of high importance. The gate lock/latch mechanism must be universal to different types of swing gates and gate posts. The first critical function in this section is "Mount to Gate Post". The metric for this function is tolerance of the mounting holes in the latch. The target is to have a hole between 0.26 and 0.36 inches, with a nominal diameter of 0.31 inches. This is inspired by the current product, which has mounting holes of 0.31-inch diameter. This has been found to be appropriate for the existing product. This product is designed to be directly mounted to any gate post, whether it be wood and mounted with lag bolts, or a round post mounted with bolts and nuts. For this reason, it is appropriate for the new latch/lock mechanism to simply have mounting holes, offering many configuration options for the installer. The next critical function in the compatibility subsystem is

“Mount to Gate”. Similarly to the previous function, the metric for this function is the dimensions of the mounting holes in the product. The target, however, is to have a threaded hole with M8 threads drilled at a depth of 1/4 inch. This is based on the current ZombieLock design, which utilizes this thread size and depth. This will allow for the product to be compatible with the “Universal Tube Bracket Kit – AXTB” product that Ghost Controls currently offers to ensure the product can be mounted to tube gates of diameters ranging from 1-5/8 – 2 inches. This will serve a large majority of the customer base and will not restrict the usability of the product further than it currently is. The next lowest level function in the compatibility subsystem is “Keep Gate Closed”. Force is the metric used for this function, while the target is to withstand up to 50 pounds of force before failing and allowing the gate to be opened. This target came from the chief engineers at Ghost Controls as a specific and measurable goal of the product to provide sufficient protection of the customers’ property. Achievement of this target can be measured using a force scale attached to both a pulling force and the end gate where the lock is attached. The two remaining functions in this subsystem include “Account for bounce in horizontal axis” and “Account for bounce in vertical axis”. Both functions have a target of distance and a metric of 1-3 inches. The purpose of these targets are to limit the oscillations and inconsistencies felt by the gate when closing. To ensure these targets are being met, a ruler or tape measure may be held near the gate while it is being closed to determine whether the bounce in either direction is acceptable for the latch/lock product to accommodate for.

Targets Outside of Functions

In conjunction with the other very important systems sourced from the functional decomposition, supplementary functions were also generated from and based upon the customers' needs and the key goals of the design. These supplementary functions help to give the group sound boundaries to build upon when the team enters the design and physical ideation part of the design process.

The first function within the supplementary function tree is meant to assist in creating boundaries to make the design profitable to produce. When discussing the customer needs generated from the first meeting, it was imperative that the design be marketable and profitable. The idea of designing something to be profitable is no stranger to anyone who comprehends standard economics and helps the team to narrow down complexities and material choices when ideas near the bounds of being unrealistic. The most comparable product on the market hovers around the $150 price point (Ghost Controls) and nets a profit margin well over the targeted 50% due to being manufactured in bulk quantities. By aiming to develop a product to be sold with that margin, we should be able to design a profitable product within the realm of reasonability.

Continuing the idea of profitability, assuming a design that will be under a nominal weight will alleviate distribution costs. Size and weight are the two main factors taken into consideration when determining shipping costs (Georgiev, 2024). For clarification, the product and everything it ships with should be under ten pounds. Not only does this lower the distribution costs associated with the product, but it also helps to lighten the workload of the installer. A lighter product will also help to lessen the effects of sag seen on longer gates, contributing to the main objective of the design.

Compliance with industry standards is arguably just as important as making the device function on its own. There are many regulatory bodies that develop standards for workplace practices, machine operation, safety codes, and much more. By understanding these guidelines and their effects, the team will be able to design a product that can be safely manufactured without harm to workers. Abiding by further guidelines concerning installation and maintenance once it gets to the customer will ensure the customer's safety and assist in avoiding liability concerns when product issues arise.

Summary and Catalog

A complete list of the targets and metrics for the group's project can be found in Appendix B. These targets and metrics were paired with the lowest-level functions from the functional decomposition hierarchy chart, as well as a few supplementary functions. Team 510's interpretation of the customer needs was also considered when producing the targets and metrics. To achieve successful development, implementation, and operation of the product, the targets shown in the table must be met. Some of the targets mentioned are out of the control of Team 510, however, we are required to conform to these. For example, standard DC batteries such as those used for the Ghost Controls system are typically limited to a standard power range of 12 to 12.9 volts. For this reason, we must use this range as the operating voltage range of the product.

As the project progresses, the targets may change as real-world application and testing make them less feasible.

1.5 Concept Generation

Concept Generation

Concept generation is used to inspire innovative solutions for a problem which is a crucial phase in the design process. Systematic processes such as brainstorming and ideating promote creativity and collaborative thinking allowing ideas to build on one another. A list of one hundred designs concepts were created, each representing a potential way to achieve the projects' goal. By embracing a variety of generation tool guides for the project, unconventional solutions were created and encouraged. The concepts created will be analyzed and divided into different concept fidelity levels: low, medium, and high. The feasibility of the concept will be determined by the team based on prior knowledge, existing technology, and engineering intuition.

Concept Generation Techniques

Morphological Chart

A morphological chart is a technique that aids in generating a large number of concepts quickly. It lists the critical functions of the design, along with numerous independent solutions that carry out each function, putting them all into one matrix. Combining different solutions allowed for logical changes in concept design, all while ensuring that the design still performs each critical function. This can be found in Appendix B.

SCAMPER

SCAMPER, which stands for substitute, combine, adapt, modify, put to another use, eliminate, and reverse, is a technique that allows for modification of the pre-existing ZombieLock to fit the new design parameters and goals. The ideas yielded by this technique keep the parts of the ZombieLock that accomplished critical functions while improving or changing parts that were subpar for the new design goals.

Concept Fidelity

Low fidelity concepts are concepts that are not feasible. This could be due to time, budget costs, technological constraints, or inability to do a key function. All low fidelity concepts can be found in the complete concept generation list in Appendix C. Medium fidelity concepts are concepts that are plausible, capable of successfully completing all targets and metrics, but may be unattainable. These concepts could still be pursued if any of the high-fidelity concepts prove unworthy but should not be given a large amount of effort until then. The medium fidelity concepts are displayed in Table 1.3.1. For high fidelity concepts, they meet all design function requirements and have the highest potential success. These concepts are shown in Table 1.3.2.

Table 4: Medium Fidelity Concepts

Concept Number	Description	Reasoning
15	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.--	Matches all customer needs and accomplishes all functions from the hierarchy chart. Weight may be an issue due to the use of stainless steel. Deadbolt lock will also increase weight.
30	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using oil and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using springs. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with physical chains.	Matches all customer needs and accomplishes all functions from the hierarchy chart. The internal battery may be problematic in extreme weather and will add unnecessary weight to the end of the gate. Oil could cause build up in the lock inhibiting proper function of the lock mechanism. External release arm sacrifices security for customer convenience. Physical chains are not practical as they add weight and are inconvenient for the customer.

33	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using a universal tube bracket kit. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a spring-loaded latch.	Matches all customer needs and accomplishes all functions from the hierarchy chart. Internal battery and external release arm will add weight to the end of the gate. Grease is known to trap dirt and dust which could lead to problems with the lock mechanism properly latching.
87	An adaptation of the current zombie lock mechanism made of aluminum. The receiver and lock are swapped, but the receiver has two rotating “latch” members like French doors.	Matches all customer needs and accomplishes all functions from the hierarchy chart. Lock mechanism will have more moving parts requiring more weight, more power and larger housing.
98	An adaptation to the current receiver design of the ZombieLock. Swap the receiver and latch functions. Create a sliding cylindrical bolt that triggers top-down once the gate is within range. The receiver on the gate is now a circular opening bound of the receiver. The design is similar to a pool gate.	Matches all customer needs and accomplishes all functions from the hierarchy chart. Moving the receiver to the gate post will require the wiring to be exposed or buried underground. This may inconvenience the user.

Table 5: High Fidelity Concepts

Concept Number	**Description**	**Reasoning**
53	A latch mechanism that uses the pre-existing ZombieLock gate attachment but adds a cylindrical rotating member attached to the gate with a plate upon which the underside of the housing will be welded. The rotating member will “wobble” in a way that, when	Matches all customer needs and accomplishes all functions from the hierarchy chart. The arm can account for sag by matching the expected

	counter-balanced, will adjust the angle of alignment from the latch to the receiver, compensating for angle misalignments within the system.	angle due to sag. The arm will add more weight but will be accounted for when calculating the angle for the arm.
67	Keeping the pre-existing ZombieLock design but adding a small ramp attached to the receiver at the end to guide the gate to a closed position.	Matches all customer needs and accomplishes all functions from the hierarchy chart. The ramp will be attached to the receiver and will therefore not add weight to the gate. It will not keep the gate from sagging but will lift the gate into position as it reaches the catch. Need to check power of arm to ensure arm is able to follow the ramp.
71	Making a modified version of ZombieLock that has a series of magnets on both the gate and gate post. When at rest, the magnets on the gate side will be aligned with the magnets on the gate post side, causing them to be magnetically attracted to one another. When unlocking, an electric DC motor will be used to misalign the magnets, voiding the magnetic attractive force.	Matches all customer needs and accomplishes all functions from the hierarchy chart. The magnets will be on both the receiver and the gate attachment. It allows the magnets to guide to each other using magnetic attraction, and will hold force. Have to check the weight of electromagnets to see if they will cause sag. Check power of motor to see if it can accommodate moving strong magnets.

1.6 Concept Selection

Concept Selection Process

From concept generation, a mix of 8 high fidelity and medium fidelity concepts were selected from the 100 concepts the team created. The first three concepts in Table 6.0.1 are the high-fidelity concepts and the remaining are medium fidelity. To select the final concept, the team conducted several concept selection analyses including binary pairwise comparison, house of quality, Pugh charts, and the analytical hierarchy process. After completing the concept selection process, the team agreed with the results and chose 67, as the final concept.

Table 6: Selected Concepts for Concept Selection

Concept #	Description
Pivoting ZombieLock	A latch mechanism that uses the pre-existing ZombieLock gate attachment but adds an angle adjusting arm that the user can adjust when needed.
Receiver Ramp Modification	Keeping the pre-existing ZombieLock design but adding a small ramp attached to the receiver at the end to guide the gate to a closed position.
Magnet System	Making a modified version of ZombieLock that has a series of magnets on both the gate and gate post. When at rest, the magnets on the gate side will be aligned with the magnets on the gate post side, causing them to be magnetically attracted to one another. When unlocking, an electric DC motor will be used to misalign the magnets, voiding the magnetic attractive force.
Shocks	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the receiver picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
Chains	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using oil and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using springs.

	Additionally, weight will be relieved from the hinges by the receiver picking the gate up as it is being latched. Once latched, the gate will be kept closed with physical chains.
Spring	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using a universal tube bracket kit. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the receiver picking the gate up as it is being latched. Once latched, the gate will be kept closed with a spring-loaded latch.
French Doors	An adaptation of the current zombie lock mechanism made of aluminum. The receiver and lock are swapped, but the receiver has two rotating “latch” members like French doors.
Pool Lock	An adaptation to the current receiver design of the ZombieLock. Swap the receiver and latch functions. Create a sliding cylindrical bolt that triggers top-down once the gate is within range. The receiver on the gate is now a circular opening bound of the receiver. The design is similar to a pool gate.

Binary Pairwise Comparison

The Binary Pairwise Comparison chart shows the customer needs, which were determined earlier, and sets them against one another. In doing so, their order of importance is established. Going through the chart, if the customer need in the row is considered more important than customer need in the column, it receives a “1”. On the other hand, if it is deemed less important, it receives a “0”. Summing the rows of this matrix resulted in the importance weight factor matrix of our customer needs. This factor is used as a metric in the following table, the House of Quality, and will be discussed in further detail later. For Team 510, the binary pairwise comparison, shown below in Table 6.1.1, resulted in the customer needs “Gate can stay locked in the closed position" and "Product must be mechanical in nature but use power to unlock" to receive the greatest importance weight factors, 7. Inversely, the customer needs "Product is intended for no contact gates" and "Improvement to lock costs less than the current market competitors" received the lowest importance weight factors, 1.

Table 7: *Binary Pairwise Comparison*

Binary Pairwise Comparison										
Customer Needs	1	2	3	4	5	6	7	8	9	**Total**
1. Mechanism works for lengths up to 20 feet	-	1	0	1	0	0	0	1	0	3
2. Gate lock design can resist 50 lbs. of force	0	-	0	1	0	0	0	1	0	2
3. Gate can stay locked in the closed position	1	1	-	1	0	1	1	1	1	7
4. Product is intended for no contact gates	0	0	0	-	0	0	0	1	0	1
5. Product must be mechanical in nature, but uses power to unlock	1	1	1	1	-	1	1	0	1	7
6. The gate performs in rugged environments	1	1	0	1	0	-	0	1	0	4
7. Gate adjusts system to account for the sag	1	1	0	1	0	1	-	1	1	6
8. Improvement to lock costs less than the current market competitors	0	0	0	0	1	0	0	-	0	1
9. Product contains a fail-safe method of unlocking	1	1	0	1	0	1	0	1	-	5
	5	6	1	7	1	4	2	7	3	n-1 = 8

House of Quality

Following the binary pairwise comparison, the house of quality was created next. On the leftmost axis, the customer requirements were listed, while the engineering characteristics were listed on the top axis. Going through the chart, each engineering characteristic was ranked depending on its level of contribution to fulfilling the customer requirement. The engineering characteristic relationship was measured as weakly, moderately, or strongly related to the customer requirement. The corresponding values were 1, 3, and 9, respectively. Using the importance weight factor matrix, along with the values now assigned to the chart, each engineering characteristic was given a ranking of importance. The most important characteristic for our product was determined to be the engagement of the lock, while the least important was relieving gate weight from the hinge.

The purpose of ranking our project's engineering characteristics is to eliminate the less important ones, helping to simplify our concept selection process. We decided to eliminate some of these based on their relative weight percentages. If any of the characteristics had a lower relative weight percentage than the threshold, it was eliminated from our process. The threshold was decided by considering the average of the relative weights, as well as the median since it is a small sample size. To aid in making a reasonable threshold, the average of these two values were used. This left 7 remaining engineering characteristics to be used in the creation of the Pugh charts. The house of quality is shown below in Table 6.2.1.

Table 8: *House of Quality*

House of Quality															
		Engineering Characteristics													
Improvement Direction		↑	-	↑	-	-	↑	-	-	↓	-	↑	↑	↑	↑
Units		n/a	K	n/a	n/a	n/a	kg	n/a	n/a	V	n/a	in	in	in^3	$
Customer Requirements	**Importance Weight Factor**	**Resist Mechanical Wear**	**Account for Thermal Expansion**	**Resist Environmental Factors**	**Release Passively**	**Engage Lock**	**Relieve Gate Weight From Hinge**	**Mount to Gate Post**	**Mount to Gate**	**Draw Power to Release Latch**	**Keep Gate Closed**	**Account for Bounce in Horizontal Axis**	**Account for Bounce in Vertical Axis**	**Volume**	**Cost**
1. Mechanism works for lengths up to 20 feet	**3**		3			9		3	3			9	9	1	1
2. Gate lock design can resist 50 lbs. of force	**2**			3		3		9	9		9	3	3		
3. Gate can stay locked in the closed position after opener is used	**7**	1	3	1		9		3	3		9			3	3
4. Product is intended for no contact gates	**1**			3	3			9	9	9		3	3		9
5. Product must be mechanical in nature, but uses power to unlock	**7**	1	1	1	9	9				9	3			3	3
6. The gate performs in rugged environments	4	9	9	9	3	3		1	1		1			1	
7. Gate adjusts system to account for the sag	**6**	1	1				9					9	9		3
8. Improvement to lock costs less than the current market competitors	**1**														9
9. Product contains a fail-safe method of unlocking	**5**	1	1		9	1				3				9	3
Raw score	**1242**	61	84	59	123	176	54	61	61	87	106	90	90	94	96
Relative Weight %		4.9	6.8	4.8	9.9	14.2	4.3	4.9	4.9	7.0	8.5	7.2	7.2	7.6	7.7
Rank Order		10	9	13	2	1	14	10	10	8	3	6	6	5	4

Pugh Chart

Team 510 used the Pugh charts to whittle down the number of concepts. These decisions were made based on the important engineering characteristics determined in the House of Quality. The Pugh charts are used to compare the selected concepts to a datum. The chart uses (+), (-), or (S) to dictate if a concept is better, worse, or satisfactory when it is compared to the datum. The chart uses a (+) symbol to dictate if an engineering characteristic has a more positive effect on the product when compared to the datum. The (-) symbol determines if the concept characteristic is worse than the respective datum. The (S) symbol, satisfactory, is used to represent that the concept is equivalent in function of the engineering characteristic when compared to the datum. Each of these symbols represents +2, 1, and -2 points, respectively. The total scores are used to quantify the concepts viability.

The datum selected for the first iteration Pugh chart is the current lock product offered by Ghost Controls, the ZombieLock. The two concepts that proved to have the lowest total, shown in red in Table 6.3.1, were then excluded from the concept selection process. The remaining six concepts moved onto the second iteration of the Pugh chart. The pool lock concept made for a good datum for iteration two because it received a score of -3 in the first iteration of the Pugh chart. This was the median of the results, so it offered room for improvement when compared to the other concepts.

Table 9: *Pugh Chart: Iteration 1*

Pugh Chart: Iteration 1									
Engineering Characteristic	ZOMBIELOCK	**Concepts**							
		15	53	33	87	67	30	71	98
Engage Lock	Datum	-	S	-	+	+	-	S	-
Release Passively		-	S	-	S	S	-	-	+
Draw Power to Release Latch		S	S	S	S	S	S	-	-
Keep Gate Closed		S	S	S	-	S	-	S	S
Accounts for Misalignments		+	+	+	+	+	S	S	+
Volume		-	-	-	-	S	-	-	-
Cost		-	-	S	-	-	S	-	-
Plus (+)		1	1	1	2	2	0	0	2
Satisfactory (S)		2	4	3	2	4	3	3	1
Minus (-)		4	2	3	3	1	4	4	4
		-4	2	-1	0	6	-5	-5	-3

The 2nd iteration of the Pugh Chart can be seen below. For this iteration, the chain and magnet concepts were removed as they scored the lowest in the previous Pugh Chart iteration. Once the chart was completed, the ramp concept scored significantly higher than the other concepts analyzed as noted in green. The lowest concept ratings were marked red and similarly the neutral marked yellow.

Table 10: *Pugh Chart: Iteration 2*

Pugh Chart: Iteration 2						
Engineering Characteristic	**CONCEPT 98**	**Concepts**				
		15	53	33	87	67
Engage Lock	Datum	-	-	S	S	S
Release Passively		-	S	-	-	+
Draw Power to Release Latch		+	-	S	-	+
Keep Gate Closed		S	-	S	S	S
Accounts for Misalignments		-	+	-	S	S
Volume		-	+	+	+	+
Costs		-	+	+	+	+
Plus (+)		1	3	2	2	4
Satisfactory (S)		1	1	3	3	3
Minus (-)		5	3	2	2	0
		-7	1	3	3	11

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process is applied to identify what engineering characteristics are deemed most significant for the project. From the House of Quality, the 7 top characteristics were selected for evaluation. The characteristics were compared against each other to establish relative importance. Each cell in the matrix has a reciprocal value to maintain balance and cells compared to themselves are assigned a 1.

Table 10: *Criteria Comparison Matrix*

Development of Candidate Set of Criteria Weights {W}							
Criteria Comparison [C]							
	1	2	3	4	5	6	7
1 Engage Lock	1.00	7.00	5.00	7.00	5.00	9.00	9.00
2 Release Passively	0.14	1.00	1.00	0.20	7.00	9.00	5.00
3 Draw Power to Release Latch	0.20	1.00	1.00	0.20	0.33	9.00	3.00
4 Keep Gate Closed	0.14	5.00	5.00	1.00	5.00	7.00	7.00
5 Accounts for Misalignments	0.20	0.14	3.00	0.20	1.00	5.00	7.00
6 Volume	0.11	0.11	0.11	0.14	0.20	1.00	3.00
7 Cost	0.11	0.20	0.33	0.14	0.14	0.33	1.00
Sum	1.91	14.45	15.44	8.89	18.68	40.33	35.00

The rankings in the columns were summed vertically and then normalized by diving each value by its respective column sum. A consistency check was also performed to assess any bias, adjusting rankings if the ratio exceeded 0.1. These tables can be seen in Appendix E.

Final Selection Matrix

The final rating matrix below shows that ramp concept slightly outperformed the rotating ZombieLock concept. These ratings were based off the three most important criteria found using the AHP charts. The rotating ZombieLock and ramp concepts performed similarly in the ‘reducing sag’ and ‘misalignment with the gate’ categories. However, based on the performance analytics deduced in the chart below, the ramp concept will be selected as the final design.

Table 11: Final Rating Matrix

Final Rating Matrix		
Criteria	Concept	
	53	67
Engage Lock	0.5	0.8
Keep Gate Closed	0.25	0.5
Release Passively	0.25	0.25
Total	1	1.55

Final Selection

Our team has selected the ramp concept as the best design for this project. This concept involves creating a ramp that will be attached to the receiver at the end of the gate to guide it into the closed position. This concept will ultimately address the primary criteria of correcting gate misalignment through the guided ramp, allowing the lock to engage properly. This selection was made using the pairwise comparison table, house of quality, and analytical hierarchy process. Overall, the ramp concept outperformed all design concepts making it the best choice to fulfill our project's performance requirements.

1.7 Spring Project Plan

Objectives			Milestone	Target Dates
	x		Communicate with Machine Shop	10-Jan-25
	x		Research Cost and Materials for Parts	10-Jan-25
	x		Order Parts	17-Jan-25

	x		Confirm Necessary Parts	17-Jan-25
	x		Finish 2nd Prototype	22-Jan-25
	x		Attach 2nd Prototype	22-Jan-25
		x	Show Ghost Controls Prototype 2	24-Jan-25
	x		Force/Material Testing	4-Feb-25
x			Spring Break Begins	10-Mar-25
x			Spring Break Ends	14-Mar-25
		x	Complete Senior Design Day Poster	26-Mar-25
x			Update Website	26-Mar-25
		x	Complete Final Prototype	26-Mar-25
	x		Final Testing	27-Mar-25
		x	Senior Design Day	1-Apr-25
x			Finals Week	28-Apr-25
x			Graduation	3-May-25
Academic	Testing	Presentation		

Chapter Two: EML 4552C

2.1 Spring Plan

Project Plan.

Build Plan.

Appendices

Appendix A: Code of Conduct

I. Mission Statement

Team 510 is dedicated to creating a positive and supportive work environment that emphasizes professionalism, respect, creativity, and responsibility. We will uphold these values both within our team and in all our communications with our advisors and clients. Every member of our team will give their best effort to develop a project that meets all requirements and exceeds the expectations of our sponsors.

II. Outside Obligations

We will respect and accommodate each team members outside obligations, if they do not interfere with the timely completion of project tasks, attendance at team meetings, or fair contribution to the team. This senior design team is expected to meet at least two times a week based on when everyone is free. If any new commitments arise that may impact project tasks or meetings, members should inform the team as soon as possible so adjustments can be made. Team members are expected to attend every team meeting to minimize schedule changes. At least two team members are required to attend a meeting with capstone advisor weekly.

- Kayla Boudreaux: Fixed ROTC schedule.
- Jacob Brock: Schedule is flexible. No outside obligations other than the senior design class.
- Ernest Patton: Works 10-15 hours a week on nights or weekends, FSU Student
- Dior Reece: Works during the week and on the weekends, obligations to NSBE. Schedule is flexible outside of work and class schedule.
- Olivia Walton: Works a fixed 10 hours a week as a Learning Assistant.
- Bradley Wiles: Schedule is flexible. No outside obligations other than class schedule.

III. Team Roles

Individual Engineering Responsibilities

- Kayla Boudreaux: Project Manager
  - Responsible for design processes
  - Identify and manage risks
- Jacob Brock: Design Lead
  - Responsible for creating CAD solid models and drawings
  - Assemble prototypes and final product for design reviews
- Ernest Patton: Quality Engineer
  - Responsible for creating targets for material and physical tests
  - Feasibility studies for material and production costs
  - Review industry standards to ensure compliance

- Dior Reece: Test Engineer
  - Responsible for design inspections
  - Design testing methods to verify targets are met
  - Execute tests that ensure the customer needs are being met
- Olivia Walton: Manufacturing Engineer
  - Machine shop liaison
  - Create drawings for CAD
- Bradley Wiles: Materials Engineer
  - Responsible for material selection and strength of materials
  - Responsible for ordering/managing parts

Other Expected Responsibilities

Team members will delineate the tasks in a just and fair manner so that everyone must contribute, considering current and assumed responsibilities. This includes, but is not limited to being responsible for:

- Communications with sponsors, advisers, clients, etc.
- Financial matters.
- Presentation creation.
- Traveling for any purpose.
- Report writing and editing.
- Website management.
- Reviewing articles before submission.
- Collaborating at all necessary meetings and adhering to the attendance policy. *Ref Section VI.
- Being prepared at meetings with all assigned work completed.
- Being attentive and mindful of the project timeline.
- Being willing to volunteer when others cannot complete their designated tasks due to extenuating circumstances.

It is important to note that some responsibilities are shared between all team members and are expected, as well as required. These shared responsibilities are not considered sufficient as a member's sole contribution for any assignment or task. These include, but are not limited:

- Attendance to all design reviews.
- Attendance to any and all meetings.
- Editing and reviewing documents.
- Taking meeting minutes/notes.

IV. Communication

- The primary method of communication between the team members will be via text messages in the team group chat.
- When sponsors, advisers, and other professionals are contacted, it will be done via email. *Ref Section VII.
- Team members are expected to act civilly and cordially in all meetings, and amongst each other through all kinds of communication. They are expected to follow the NSPE Code of Ethics for Engineers.

V. Dress Code

Team Meetings (Casual Attire):

For internal team meetings, members are expected to dress in casual attire. This includes comfortable, everyday clothing appropriate for a professional setting (e.g., jeans, T-shirts, sneakers).

Sponsor Meetings (Casual Attire):

When meeting with sponsors or external stakeholders, members are required to dress in smart casual attire. This includes comfortable, everyday clothing appropriate for a professional setting (e.g., jeans, T-shirts, sneakers).

Team Presentations (Business Casual/Business Professional):

For formal team presentations, members will aim for similar attire, maintaining a consistent and unified appearance. Business professional or Ghost Controls shirts are acceptable. Business professional consists of blazers, dress pants, dress shirts, and dress shoes, The Ghost Control shirts will be paired with pants of a similar color decided upon before the presentation. All members will coordinate to ensure a cohesive look.

VI. Attendance Policy

Attendance will be recorded by the team at the start of each meeting. Absences and tardiness will be tracked and reviewed periodically. If a team member is absent from a scheduled meeting without a valid excuse, they must provide snacks at the next meeting. Snacks will be chosen by popular vote of the other team members. If class ends early, all team members are expected to stay afterwards to meet and attend work sessions, unless the meeting is decided unnecessary by majority.

1. Team members must attend all scheduled meetings, work sessions, and checkpoints.
2. Members should inform the team at least 4 hours in advance if they cannot attend a scheduled meeting, providing a reason for their absence.
3. Members should arrive on time and be prepared for meetings, having completed any assigned tasks or required materials in advance.

Team Voting for Instructor Involvement:

If a member's attendance becomes a recurring issue and affects the team's progress, the team has the right to vote on whether to escalate the issue to the project instructor. A discussion will be held where team members present their concerns and vote on whether the absentee member's behavior warrants a meeting with the instructor. If a majority votes in favor, the team will collectively approach the instructor to discuss the attendance problem and seek guidance on the next steps.

Peer Review and Evaluation:

Poor attendance will be reflected in peer evaluations, potentially affecting any final assessments or outcomes tied to the project.

VII. Notifying/Responding

When a message needing action is received from a sponsor, adviser, client, Dr. McConomy, or any other professional that applies, a response will be administered within a 24-hour period. Exceptions apply if messaged on a Friday, over the weekend, or during an FSU or FAMU (Florida A&M University) observed holiday. When applicable, the sender will receive a response the next business day.

VIII. Instructor Interference

In the event of issues arising within the team, no matter the severity, the team will first attempt to mediate the issue(s) via an in-house intervention. If the issue resides between two different team members, the other members will mediate the conflict. If the conflict concerns the majority versus a minority of the group, the resolution will appease the majority. If a satisfactory conclusion cannot be reached, a vote will be taken to determine if the matter necessitates mediation from a third party. A winning vote consists of 3/6 team members in favor of escalation. Issues regarding the scope of the project will be mediated by the assigned advisor, Dr. Hruda. All other issues regarding a specific individual, partisanship, delegation, and team structure will be mediated by the instructor, Dr. McConomy and/or his Teaching Assistant(s).

IX. Amendment Procedure

The code of conduct can be amended at any time with a formal team vote. A unanimous decision must be made between the team members for the amendment to take effect. If an amendment is made, the specified changes will be made to the document within 24 hours. All members will then be notified via text message of the change.

X. Assignment Regulations

Deliverable Deadlines

All deliverables with a Friday deadline must be completed by Thursday night at 11:59 PM. The entire day on Friday will be dedicated to review and quality control, ensuring all work is thoroughly checked before submission.**Early Progress**

If the team completes all tasks ahead of schedule, work due in the following week will begin immediately. This proactive approach ensures we stay ahead of deadlines and have sufficient time for unexpected issues.

XI. Statement of Understanding

By signing below, I confirm that I have read and agree to abide by the code of conduct. I understand the importance of fulfilling my assigned responsibilities and commit to doing so with integrity and diligence. Furthermore, I pledge to be a team player, working collaboratively with others for the success and betterment of the team.

All Team Members Must Print and Sign Below:

I, Kayla Boudreaux, understand the above statement.

X ________ **Date:** 9 Jan 25

I, Jacob Brock, understand the above statement.

X ________ **Date:** 1/9/25

I, Ernest Patton, understand the above statement.

X ________ **Date:** 01/09/2025

I, Dior Reece, understand the above statement.

X ________ **Date:** 1/9/25

I, Olivia Walton, understand the above statement.

X ________ **Date:** 1/9/25

I, Bradley Wiles, understand the above statement.

X ________ **Date:** 1/9/25

Appendix B: Target Catalog

System	***Function***	***Target***	***Metric***
Resistance	Resist Environmental Factors	≤ 100[Percent] ≤ 50 [Inches]	Humidity Precipitation
Resistance	Endure Extreme Temperatures	-5 – 160 [Degrees Fahrenheit]	Temperature
Lock Mechanism	Release Passively	≤ 5 [Seconds]	Time
Lock Mechanism	**Engage Lock**	**≤ 5 [Seconds]**	**Time**
Lock Mechanism	Relieve Gate Weight from the Hinge	≥ 5 [Pounds-Force]	Force
Power	Draw Power to Release latch	12 – 12.9 [Volts]	Electric Potential
Compatibility	**Mount to Gate Post**	**0.31 ± 0.05 [Inches]**	**Tolerance**
Compatibility	**Mount to Gate**	**M8, 0.25 Depth [Inches]**	**Thread Size**
Compatibility	Keep Gate Closed	≤ 50 [Pounds-Force]	Force
Compatibility	Account for Bounce in Horizontal Axis	1 – 3 [Inches]	Distance

Compatibility	**Account for Bounce in Vertical Axis**	**1 – 3 [Inches]**	**Distance**
Supplementary	Maintain Profitability	≥ 50 [Percent]	Profit Margin
Supplementary	Be Light Weight	≤10 [Pounds-Force]	Weight
Supplementary	Comply with industry standards	Compliant	-

Appendix C: Morphological Chart

Functions	Solution 1	Solution 2	Solution 3	Solution 4	Solution 5	Solution 6
Resist Mechanical Wear	Grease	Graphite	Oil	Use a Teflon coating	Electroplatin g	Nitriding
Account for Thermal Expansion	Flexible items (i.e. springs)	Use stainless steel	Use brass	Use Teflon	Use an aluminum alloy	Use a ceramic material
Resist Environmental Factors	Waterproof seals and gaskets	Corrosion Resistant Coating	Paint	Use UV resistant materials	Drains	Non-Metallic Materials
Release Passively	Spring loaded release	Physical key	Thermal release	Use exterior magnets	Release button	Removable pin
Engage Lock	Spring loaded hinge	Electric motor	Insertable pin	Physical key	Use exterior magnets	Sliding Bolt
Relieve Gate Weight from the Hinge	Lift the gate end up while latching	Lift the gate end up after latching using electric motor	Attach a jack to the gate	Use shock absorbers to lift the gate end up	Physically lift the gate into a high latch	Tensioned guy wire from lock to post
Draw Power to Release Latch	Use an internal battery with electric motor	Wire into the existing 12-volt battery with electric motor	Use an internal battery with electric solenoid	Wire into the existing 12-volt battery with electric solenoid	Electromagn etic release	Pneumatic lock release
Mount to Gate Post	Directly bolt/screw to post	Weld to post	Use cable ties	Adhesive	Universal tube bracket kit	Mounting plate
Mount to Gate	Directly bolt/screw to gate	Weld to gate	Use cable ties	Adhesive	Universal tube bracket kit	Mounting plate
Keep Gate Closed	Deadbolt	Physical Chains	Strong electromagne	Spring loaded latch	Insertable pin	Pneumatic lock

Functions	Solution 1	Solution 2	Solution 3	Solution 4	Solution 5	Solution 6
			ts			
Account for Bounce in Horizontal Axis	Shock absorbers	Springs	Padding	Cross braces stiffen to stiffen gate	Guy wire attachment	
Account for Sag in Vertical Axis	Shock absorbers	Springs	Padding	Lift the gate end up while latching	Lift the gate end up after latching using electric motor	Add cross braces to stiffen the gate

Appendix D: 100 Concepts

Concept Number	Concept Description
1	A corrosion resistant coated lock mechanism made of stainless steel utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
2	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
3	A lock mechanism made of stainless steel and UV resistant materials utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
4	A lock mechanism made of stainless steel and featuring drain holes to prevent moisture retention utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
5	A sealed lock mechanism made of stainless steel utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for

	using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
6	A sealed lock mechanism made of brass utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
7	A sealed lock mechanism made of Teflon utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
8	A sealed lock mechanism made of an aluminum alloy utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
9	A sealed lock mechanism made of a ceramic material utilizes an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
10	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
11	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using graphite and can be

	passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
12	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using oil and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
13	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using Teflon coatings and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
14	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
15	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
16	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by removing a pin. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.

17	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by removing an exterior magnet. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
18	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by pressing a release button. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
19	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. The lock will be mounted to the gate via direct mounting using bolts or screws, while the catch will be mounted to the gate post using universal tube brackets. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
20	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. The lock will be mounted to the gate via direct mounting using bolts or screws, while the catch will be mounted to the gate post using cable ties. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
21	A sealed lock mechanism made of brass uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using graphite and can be released passively by holding a lighter or match close to the mechanism, as the latch is engaged by a thermal release. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for by using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is in the process of being latched. Once latched, the gate will be kept closed with an insertable pin.
22	A sealed lock mechanism made of brass uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using oil and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing,

	bounce in the horizontal axis and sag in the vertical axis will be accounted for using springs. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with strong electromagnets.
23	A sealed lock mechanism made of brass uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using Teflon coating and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via welding to the posts. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with physical chains.
24	A sealed lock mechanism made of Teflon uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using oil and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with strong electromagnets.
25	A sealed lock mechanism made of Teflon uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using cable ties. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using padding. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with an insertable pin.
26	A sealed lock mechanism made of Teflon uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using graphite and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using adhesive with the gate post. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a spring-loaded latch.
27	A sealed lock mechanism made of a ceramic material uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using oil and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with strong electromagnets.
28	A sealed lock mechanism made of a ceramic material uses an electric motor powered by an internal

	battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using padding. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a spring-loaded latch.
29	A sealed lock mechanism made of a ceramic material uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using Teflon coating and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using cable ties. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with an insertable pin.
30	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using oil and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using springs. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with physical chains.
31	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via welding directly to the post. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using padding. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with strong electromagnets.
32	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using graphite and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with an insertable pin.
33	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using a universal tube bracket kit. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the

	catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a spring-loaded latch.
34	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using Teflon coating and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using adhesive to the post. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using springs. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
35	A sealed lock mechanism made of brass uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using padding. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with spring loaded latch.
36	A painted lock mechanism made of brass uses an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. The lock will be mounted to the gate via direct mounting using bolts or screws, while the catch will be mounted to the gate post using cable ties. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
37	A painted lock mechanism made of brass uses an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. The lock will be mounted to the gate via direct mounting using bolts or screws, while the catch will be mounted to the gate post using cable ties. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using padding. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
38	A painted lock mechanism made of ceramic material uses an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using Teflon coating and can be passively released by a physical key. The lock will be mounted to the gate via direct mounting using bolts or screws, while the catch will be mounted to the gate post using cable ties. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using springs. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
39	A painted lock mechanism made of ceramic material uses an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using graphite and can be

	passively released by a physical key. The lock will be mounted to the gate via direct mounting using bolts or screws, while the catch will be mounted to the gate post using universal tube bracket kit. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
40	A painted lock mechanism made of ceramic material uses an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. The lock will be mounted to the gate via direct mounting using adhesive to post, while the catch will be mounted to the gate post using cable ties. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using padding. Additionally, weight will be relieved from the hinges by the catch picking the gate up as it is being latched. Once latched, the gate will be kept closed with physical chains.
41	A UV resistant lock mechanism that features graphite lubrication. A spring-loaded hinge gate engages the latch and passively released using a thermal mechanism. The lock and catch are both mounted to the gate and post respectively using a mounting plate. Horizontal bounce is countered using a cross brace, and vertical sag is handled by lifting the gate after latching. Physical chains will hold the gate closed.
42	A brass-coated lock mechanism uses a spring-loaded hinge to engage and a removable pin for passive release. The system is powered by an internal battery with an electric solenoid. The lock is mounted to the gate using adhesive, and the catch is bolted to the post. Padding is used to account for horizontal bounce, and vertical sag is controlled by physically lifting the gate into a high latch. The gate remains closed using a deadbolt.
43	A waterproof lock mechanism with graphite lubrication engages with a pneumatic release, powered by an internal battery. Passive release is achieved using exterior magnets. The lock is mounted with cable ties, and the catch is bolted to the post. Horizontal bounce is managed with cross-braces, and vertical sag is controlled by shock absorbers. A strong electromagnet will secure the gate.
44	A stainless-steel lock coated in graphite uses an electromagnetic release and is passively disengaged by a removable pin. The lock is mounted to the gate using a mounting plate, and the catch is attached with adhesive. Horizontal bounce is reduced with padding, and vertical sag is handled by physically lifting the gate into a high latch. A deadbolt will keep the gate closed.
45	A stainless-steel lock coated in graphite uses an electromagnetic release and is passively disengaged by a removable pin. The lock is mounted to the gate using a mounting plate, and the catch is attached with adhesive. Horizontal bounce is reduced with padding, and vertical sag is handled by physically lifting the gate into a high latch. Physical chains will hold the gate closed.
46	A UV-resistant lock with oil lubrication uses a sliding bolt to engage the latch. Passive release is achieved by a physical key, and the system is powered by an internal battery. The lock and catch are mounted with universal tube brackets. Padding is used to reduce bounce, while sag is controlled by lifting the gate during latching. Physical chains will hold the gate closed.

47	A ceramic lock mechanism uses a physical key for passive release and a sliding bolt for engagement. The system is powered by a pneumatic release. The lock and catch are mounted to the gate using cable ties. Horizontal bounce is managed with shock absorbers, and vertical sag is controlled by adding cross braces to the gate. Once latched, the gate is held closed with physical chains.
48	A ceramic lock mechanism uses a physical key for passive release and a sliding bolt for engagement. The system is powered by a pneumatic release. The lock and catch are mounted to the gate using cable ties. Horizontal bounce is managed with shock absorbers, and vertical sag is controlled by adding cross braces to the gate. Once latched, a deadbolt will keep the gate closed.
49	A corrosion-resistant lock mechanism featuring an oil-lubricated system uses an electric solenoid powered by an internal battery for latching. Passive release is achieved using a physical key. The mechanism will be mounted to the gate with adhesive, and the catch will be bolted to the post. Horizontal bounce is reduced using padding, while vertical sag is controlled by lifting the gate during latching. The gate remains closed with physical chains.
50	A corrosion-resistant lock mechanism featuring an oil-lubricated system uses an electric solenoid powered by an internal battery for latching. Passive release is achieved using a physical key. The mechanism will be mounted to the gate with adhesive, and the catch will be bolted to the post. Horizontal bounce is reduced using padding, while vertical sag is controlled by lifting the gate during latching. A strong electromagnet will keep the gate closed.
51	A latch mechanism that uses the pre-existing ZombieLock gate attachment and materials, but instead uses a gravity latch to close.
52	A latch mechanism that uses the pre-existing ZombieLock gate attachment but adds cushioned impact absorbers.
53	A latch mechanism that uses the pre-existing ZombieLock gate attachment but adds an angle adjusting arm that the user can adjust when needed.
54	A latch mechanism that uses the pre-existing ZombieLock gate attachment but adds a guided catch into the latch to funnel it in.
55	Keeping the pre-existing ZombieLock design but adding support wheels onto the bottom of the gate to prevent sagging.
56	Adding a robotic arm onto the pre-existing ZombieLock design to stop the gate.
57	A latch mechanism that uses the pre-existing ZombieLock gate attachment but uses a threaded rod that spins to lift gate into place.
58	Keeping the pre-existing ZombieLock design but adding magnets on a track below the gate that repel the gate upward to prevent sag.
59	Keeping the pre-existing ZombieLock design but adding bungee cord tension along the height of the

	gate, preventing sag.
60	Keeping the pre-existing ZombieLock design but adding tension rods to the latch/lock that come out when the gate is meant to be locked.
61	Keeping the pre-existing ZombieLock design but training Olivia Walton’s dog to push the latch shut.
62	Keeping the pre-existing ZombieLock design but adding a sliding receiver to lead it in.
63	Keeping the pre-existing ZombieLock design but adding a large bubble around it to prevent wind/environmental factors from causing sag.
64	Keeping the pre-existing ZombieLock design but adding a pulley system atop each mechanism to weigh them upwards.
65	A latch mechanism that uses the pre-existing ZombieLock gate attachment but instead uses a cam-shaped motion to hook gate closed.
66	Keeping the pre-existing ZombieLock design but adding a soft close mechanism similar to a drawer to prevent bounce.
67	Keeping the pre-existing ZombieLock design but adding a small ramp attached to the receiver at the end to guide the gate to a closed position.
68	Keeping the pre-existing ZombieLock design but hiring Dr. McConomy’s children to close the gate (paid under the table).
69	Chage the pre-existing ZombieLock receiver to accommodate the sag of the gate by angling the catch with a 3inch diameter to accommodate different gate lengths.
70	Making a modified version of the ZombieLock that includes a magnet on the top of the latch and the inside of receiver box.
71	Making a modified version of ZombieLock that has a series of magnets on both the gate and gate post. When at rest, the magnets on the gate side will be aligned with the magnets on the gate post side, causing them to be magnetically attracted to one another. When unlocking, an electric DC motor will be used to misalign the magnets, voiding the magnetic attractive force.
72	A latch mechanism similar to a push pad lock, but electromechanical. When activated a pin comes out of the lock and when the gate is closing, as it reaches the receiver a button will be pushed inside. The pin is released back into the lock.
73	A latch mechanism that, when released, a latch will pop up allowing for the gate to swing freely. When the gate needs to be closed, there will be a release mechanism that will be activated when enough weight is pressed against a button and the latch will drop down.
74	Using the existing design, modify the placement of the lock to the bottom of the gate. The receiver

	will be modified with a guide that slopes to will help align the latch into the right place.
75	Using a similar mechanism to a mechanical gravity lock, the moment the gate closes, the weight the gate will activate a latch that will fall down covering the latch and securely lock the gate.
76	Create a locking mechanism similar to a deadbolt. The moment the gate closes, the deadbolt is released into the receiver. This will be done after enough weight of the gate is pushing a button to engage the deadbolt.
77	Created a modified version of the ZombieLock that doubles the latch mechanism. One latch in the upper middle of the gate with the second one near the ground. This concept combines Concept 74 with the original ZombieLock. This concept will implement something similar to a gear train to keep the locks in both latches on the same turn-path.
78	Latching mechanism that is design to be lock a vise grip. The moment the gate closes and the latch is pushed against a button, clamping jaws come down and securely lock the gate.
79	Using a similar design to a multi-pin bolt locking mechanism, there will be three to four bolts that locks the gate at multiple points. This concept will use a weight button to activate and deactivate the bolts.
80	Keeping the pre-existing ZombieLock materials but creating a latch/mechanism that is lies horizontal instead of vertical and allows a guide to lead it in.
81	An adaptation of the current zombie lock mechanism made of aluminum. Instead of a sharp, blocky latch end, the edges are rounded to allow for a slight bit of extra travel along the vertical axis.
82	An adaptation of the current zombie lock mechanism made of aluminum. Instead of the traditional latch, a sliding bolt with a receiver that is simply a slot. The sliding bolt can move up and down a lot more than the current design.
83	An adaptation of the current zombie lock mechanism made of aluminum. The receiving end of the latch is double the height, allowing for more travel in the y-direction.
84	An adaptation of the current zombie lock mechanism made of aluminum. The receiver of the latch lies horizontally and feeds into the lock upon closure.
85	An adaptation of the current zombie lock mechanism made of aluminum. The receiver of the latch lies horizontally, and the lock rotates down onto the receiver to close.
86	An adaptation of the current zombie lock mechanism made of aluminum. The receiver and lock are swapped, the mechanical lock is mounted to the gate and the dumb receiver is mounted to the gate.
87	An adaptation of the current zombie lock mechanism made of aluminum. The receiver and lock are swapped, but the receiver has two rotating “latch” members like French doors.
88	An adaptation of the current zombie lock mechanism made of aluminum. The lock has two of the

	shaped “latch” members like French doors. Allows for more travel in the x-axis.
89	The receiver is a large opening, and the latch is a large, cubic sliding bolt.
90	A much larger alternative to the current ZombieLock mechanism. The receiver is simply a metal holed slot protruding from the post. The latch mechanism releases a cylindrical bolt into the hole and a magnet or motor will retract the bolt as necessary.
91	Simply, make the receiver slightly bigger vertically, and make the latch component smaller.
92	An adaptation to the current receiver design of the ZombieLock, spring load the bar that lock mechanism latches on to. This would allow for the receiver to play in the x direction.
93	An adaptation to the current receiver design of the ZombieLock, flare the edges of the mount to form a V-shape that will, in effect, move the latch into place.
94	An adaptation of the current zombie lock mechanism made of aluminum. Mounting the mechanism on a hinge at the rear or in the center would allow it to “wobble” a few degrees giving the system a bigger range
95	An adaptation of the current zombie lock mechanism made of aluminum. Allow the locking pin to pivot slightly on its base so that it can adjust to the position of the gate frame as it closes.
96	An adaptation to the current receiver design of the ZombieLock, flare the edges of the mount to be conical to guide the mechanism into the locking position
97	An adaptation to the current receiver design of the ZombieLock. Swap the receiver and latch functions by creating a sliding cylindrical bolt that triggers once the gate is within the, now wider, bounds of the receiver.
98	An adaptation to the current receiver design of the ZombieLock. Swap the receiver and latch functions. Create a sliding cylindrical bolt that triggers top-down once the gate is within range. The receiver on the gate is now a circular opening bounds of the receiver. The design is similar to a pool gate.
99	Mount the entire receiver on a plate full of springs that sag and guide the receiver up into a satisfactory lock position.
100	Rubberize receiver or latch so that the materials allow for more play.

Appendix E: Concept Selection

Table E-1: Characteristics

Concept #	Description
53	A latch mechanism that uses the pre-existing ZombieLock gate attachment but adds an angle adjusting arm that the user can adjust when needed.
67	Keeping the pre-existing ZombieLock design but adding a small ramp attached to the receiver at the end to guide the gate to a closed position.
71	Making a modified version of ZombieLock that has a series of magnets on both the gate and gate post. When at rest, the magnets on the gate side will be aligned with the magnets on the gate post side, causing them to be magnetically attracted to one another. When unlocking, an electric DC motor will be used to misalign the magnets, voiding the magnetic attractive force.
15	A painted lock mechanism made of stainless steel utilizes an electric motor powered by an external battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by a physical key. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the reciever picking the gate up as it is being latched. Once latched, the gate will be kept closed with a deadbolt lock.
30	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using oil and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using bolts or screws. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using springs. Additionally, weight will be relieved from the hinges by the reciever picking the gate up as it is being latched. Once latched, the gate will be kept closed with physical chains.

33	A sealed lock mechanism made of an aluminum alloy uses an electric motor powered by an internal battery to release the latch. The mechanism resists mechanical wear using grease and can be passively released by an external release arm, as the latch is engaged by a spring. Both the lock and catch will be mounted to the gate and gate post, respectively, via direct mounting using a universal tube bracket kit. While closing, bounce in the horizontal axis and sag in the vertical axis will be accounted for using shock absorbers. Additionally, weight will be relieved from the hinges by the receiver picking the gate up as it is being latched. Once latched, the gate will be kept closed with a spring-loaded latch.
87	An adaptation of the current zombie lock mechanism made of aluminum. The receiver and lock are swapped, but the receiver has two rotating "latch" members like French doors.
98	An adaptation to the current receiver design of the ZombieLock. Swap the receiver and latch functions. Create a sliding cylindrical bolt that triggers top-down once the gate is within range. The receiver on the gate is now a circular opening bound of the receiver. The design is similar to a pool gate.

Table E-2: Binary Pairwise

Binary Pairwise Comparison										
Customer Needs	1	2	3	4	5	6	7	8	9	Total
1. Mechanism works for lengths up to 20 feet	-	1	0	1	0	0	0	1	0	3
2. Gate lock design can resist 50 lbs. of force	0	-	0	1	0	0	0	1	0	2
3. Gate can stay locked in the closed position	1	1	-	1	0	1	1	1	1	7
4. Product is intended for no contact gates	0	0	0	-	0	0	0	1	0	1
5. Product must be mechanical in nature, but uses power to unlock	1	1	1	1	-	1	1	0	1	7
6. The gate performs in rugged environments	1	1	0	1	0	-	0	1	0	4
7. Gate adjusts system to account for the sag	1	1	0	1	0	1	-	1	1	6
8. Improvement to lock costs less than the current market competitors	0	0	0	0	1	0	0	-	0	1
9. Product contains a fail-safe method of unlocking	1	1	0	1	0	1	0	1	-	5
	5	6	1	7	1	4	2	7	3	n-1 = 8

Table E-3: House of Quality

House of Quality															
		Engineering Characteristics													
Improvement Direction		↑	-	↑	-	-	↑	-	-	↓	-	↑	↑	↑	↑
Units		n/a	K	n/a	n/a	n/a	kg	n/a	n/a	V	n/a	in	in	in^3	$
Customer Requirements	Importance Weight Factor	Resist Mechanical Wear	Account for Thermal Expansion	Resist Environmental Factors	Release Passively	Engage Lock	Relieve Gate Weight From Hinge	Mount to Gate Post	Mount to Gate	Draw Power to Release Latch	Keep Gate Closed	Account for Bounce in Horizontal Axis	Account for Bounce in Vertical Axis	Volume	Cost
1. Mechanism works for lengths up to 20 feet	3		3			9		3	3			9	9	1	1
2. Gate lock design can resist 50 lbs. of force	2			3		3		9	9		9	3	3		
3. Gate can stay locked in the closed position after opener is used	7	1	3	1		9		3	3		9			3	3
4. Product is intended for no contact gates	1			3	3			9	9	9		3	3		9
5. Product must be mechanical in nature, but uses power to unlock	7	1	1	1	9	9				9	3			3	3
6. The gate performs in rugged environments	4	9	9	9	3	3		1	1		1			1	
7. Gate adjusts system to account for the sag	6	1	1				9					9	9		3
8. Improvement to lock costs less than the current market competitors	1														9
9. Product contains a fail-safe method of unlocking	5	1	1		9	1				3				9	3
Raw score	1242	61	84	59	123	176	54	61	61	87	106	90	90	94	96
Relative Weight %		4.9	6.8	4.8	9.9	14.2	4.3	4.9	4.9	7.0	8.5	7.2	7.2	7.6	7.7
Rank Order		10	9	13	2	1	14	10	10	8	3	6	6	5	4

Table E-4: Pugh Chart Iteration

Pugh Chart: Iteration 1									
Engineering Characteristic	ZOMBIELOCK	Concepts							
		15	53	33	87	67	30	71	98
Engage Lock	Datum	-	S	-	+	+	-	S	-
Release Passively		-	S	-	S	S	-	-	+
Draw Power to Release Latch		S	S	S	S	S	S	-	-
Keep Gate Closed		S	S	S	-	S	-	S	S
Accounts for Misalignments		+	+	+	+	+	S	S	+
Volume		-	-	-	-	S	-	-	-
Cost		-	-	S	-	-	S	-	-
Plus (+)		1	1	1	2	2	0	0	2
Satisfactory (S)		2	4	3	2	4	3	3	1
Minus (-)		4	2	3	3	1	4	4	4
		-4	2	-1	0	6	-5	-5	-3

Table E-5: Pugh Chart Iteration 2

Pugh Chart: Iteration 2						
Engineering Characteristic	CONCEPT 98	Concepts				
		15	53	33	87	67
Engage Lock	Datum	-	-	S	S	S
Release Passively		-	S	-	-	+
Draw Power to Release Latch		+	-	S	-	+
Keep Gate Closed		S	-	S	S	S
Accounts for Misalignments		-	+	-	S	S
Volume		-	+	+	+	+
Costs		-	+	+	+	+
Plus (+)		1	3	2	2	4
Satisfactory (S)		1	1	3	3	3
Minus (-)		5	3	2	2	0
		-7	1	3	3	11

Table E-6: Characteristics Comparison Matrix

Development of Candidate Set of Criteria Weights {W}							
Criteria Comparison [C]							
	1	2	3	4	5	6	7
1 Engage Lock	1.00	7.00	5.00	7.00	5.00	9.00	9.00
2 Release Passively	0.14	1.00	1.00	0.20	7.00	9.00	5.00
3 Draw Power to Release Latch	0.20	1.00	1.00	0.20	0.33	9.00	3.00
4 Keep Gate Closed	0.14	5.00	5.00	1.00	5.00	7.00	7.00
5 Accounts for Misalignments	0.20	0.14	3.00	0.20	1.00	5.00	7.00
6 Volume	0.11	0.11	0.11	0.14	0.20	1.00	3.00
7 Cost	0.11	0.20	0.33	0.14	0.14	0.33	1.00
Sum	1.91	14.45	15.44	8.89	18.68	40.33	35.00

Table E-7: Normalized Characteristic Comparison Matrix

Normalized Criteria Comparison Matrix [NormC]							
	1	2	3	4	5	6	Criteria Weights {W}
1 Engage Lock	0.524	0.484	0.324	0.788	0.268	0.223	0.435
2 Release Passively	0.075	0.069	0.065	0.023	0.375	0.223	0.138
3 Draw Power to Release Latch	0.105	0.069	0.065	0.023	0.018	0.223	0.084
4 Keep Gate Closed	0.075	0.346	0.324	0.113	0.268	0.174	0.216
5 Accounts for Misalignments	0.105	0.010	0.194	0.023	0.054	0.124	0.085
6 Volume	0.058	0.008	0.007	0.016	0.011	0.025	0.021
7 Cost	0.058	0.014	0.022	0.016	0.008	0.008	0.021
Sum	1.000	1.000	1.000	1.000	1.000	1.000	0.979059

Table E-8: Consistency Vector

Weighted Sum Vector {Ws}=[C]{W}	Criteria Weights {W}	Consistency Vector {Cons}={Ws}./{W}
4.136	0.435	9.50
1.213	0.138	8.78
0.630	0.084	7.53
2.104	0.216	9.72
0.737	0.085	8.68
0.204	0.021	9.84
0.175	0.021	8.35

Table E-7: Consistency Ratio

Average Consistency	Consistency Index	Consistency Ratio
8.91	0.319	0.236

Table E-8: Final Rating Matrix

Final Rating Matrix		
Criteria	Concept	
	53	67
Engage Lock	0.5	0.8
Keep Gate Closed	0.25	0.5
Release Passively	0.25	0.25
Total	1	1.55

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