Targets and Metrics

Team 510

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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 C[JB1]. 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 1: 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. 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 with the maximum allowed surface area (30%).

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 C[JB2]. 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.

Table 2: 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	-

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