The Package Protector

John Mismash, *Student Member, IEEE,* Andrew Porter, Anthony Robinson, Lindsey Enders, Nathan Sartnurak
Computer Engineering Department, University of Utah

***Abstract*—With the rise of online orders and increased rates of package theft, the need for protecting delivered orders has become ever more important. The Package Protector is a novel device to prevent the theft of online orders after they are delivered. The Package Protector is an autonomous system that relies on sensors and micro-controllers to receive packages, hide them from public view, and protect them from tampering. This device will not only decrease package thefts nationwide, but it will also provide a more aesthetic and convenient service than devices already in practice.**

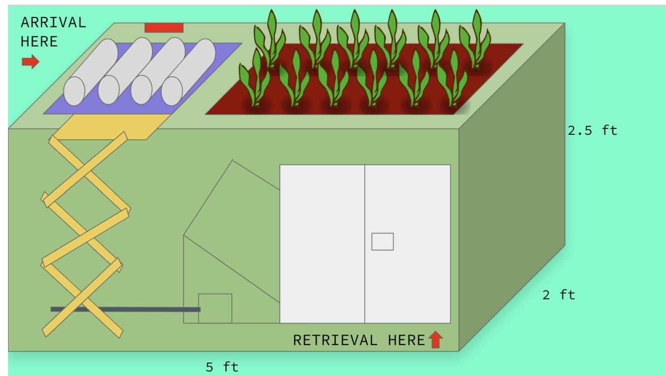


Fig. 1. General Sketch of the Package Protector with Dimensions

I. Introduction

PACKAGE theft is no joke. With the increase of online shopping during the Coronavirus pandemic, the number of package thefts increased significantly. In 2021, an estimated of 210 million packages were stolen, a 36% increase over the previous year. Even worse, more than half the people surveyed reported that they were the victim of multiple package thefts. This issue hits close to home, with Salt Lake City ranking as the third worst city for package thefts across the entire US [1]. Clearly, package theft is a growing problem, but solutions are few and far between. Products like Ring doorbells help identify package thieves, but cannot prevent theft. Mechanical lock boxes can add protection and potentially deter thieves, but the locking mechanisms can be overcome with some effort. In a recent study, 38% of porch pirate victims reported having a mechanical protection system in place [2]. In fact, research shows that supply chain crime is most prevalent at the final stages of delivery [3]. Thus, a more robust system is needed to prevent package theft.

Trends indicate that online shopping is not going away – in fact, it is growing considerably. E-commerce grew 44% in 2020, and many large retailers reported significant increases in online sales. Online shopping is also becoming increasingly accessible and convenient, with mobile shopping allowing shopping anywhere at any time, shoppers can now even buy products with a single button click, and buy now pay later plans extending online buying power [4], [5]. With e-commerce sales expected to grow over $5 trillion in 2022, which is a historical first, the number of packages will also increase, creating more opportunity for porch pirates [6].

The Package Protector was designed to address common issues found in current systems. It was also meant to not increase the workload of the delivery driver, be easy to use, effectively deter and prevent package theft, and provide additional features not seen in other package protection systems. The finished product is able to:

1) withstand unauthorized users from access
2) resist light rain and snow
3) keep the package intact and undamaged
4) indicate that there is a package inside ready to be retrieved
5) secure package in a reasonable amount of time
6) detect and deter tampering
7) support packages up to 15lbs
8) provide easy access to the packages for the user
9) add no extra work to the delivery driver
10) impart a modern, stylish appeal to the front porch

Deliverers may place their delivery on the receiving platform, which will trigger the package storage sequence. The platform, which sits on a scissor lift powered by a DC motor, will lower down into the inside of the box and slide the package into the protected storage compartment. After being secured, users may access their packages through RFID or mobile authentication. A motorized unlock system will respond to the user's request and open the spring-loaded doors. Security will be provided through the use of inertial measurement units that detect tampering and sound an alarm to deter thieves. Where other porch security systems only record theft or rely on clunky mechanical devices, the Package Protector will be an autonomous system that relies on sensors and micro-controllers to receive packages, hide them from public view, and protect them from tampering.

Package theft in the Unites States is one of the largest growing areas of concern for home owners, as one in three Americans report they have had a package stolen at least once. Moreover, online retail shopping has increased by over 30% since 2020 and has given rise to the importance of protecting delivered goods. This group initially designed this project with the goal of eliminating stolen deliveries, and each piece of hardware and software reflects the measures taken to ensure security and completeness of the product. Each section describes system components, testing methods, and overall team management through the course of this year.

II. Background

Several products that boast package protection benefits are already on the market. One group of these products focuses on video surveillance to provide real-time video of the porch area, aiming to deter potential thieves and keep the homeowner informed. Another classic product is the mechanical lock box, which use a standard lock and key mechanism to physically prevent the package from being stolen. Finally, a newer product is the smart mailbox, which improves upon the mechanical lock box by providing “smart” features such as mobile app support, motion sensing indicators with video surveillance, and tampering alarms to deter potential thieves. However, despite these existing market options, many of them suffer from pitfalls that make them less effective, or ineffective altogether.

A. Related Products

Different methods have been used previously to approach the problem of porch security. Fences protect homes, but are inconvenient for delivery drivers and easily overcome by thieves. Another more convenient system that has risen in popularity is the use of security cameras.

Security cameras provide residents an easy method of checking the perimeter of their home and porch. One specialized and easy-to-use camera that has risen in popularity is the wireless security camera embedded in doorbells. Amazon’s Blink, Google’s Nest, and Ring doorbells are some of the most recognizable doorbell security cameras in the industry. Phone applications tied to each of these doorbells allow customers to easily check their porch and be notified of movement wirelessly. Additionally, some of these doorbells provide two-way communication, permitting homeowners to interact with the porch whenever and wherever they choose. Notwithstanding the ease of use and interaction afforded by these devices, they are only able to deter a thief.

Unfortunately, the data also shows that Ring doorbells are ineffective at deterrence at all levels. For example, the police department of a suburb in Orlando, Florida partnered with Ring to obtain video footage of crimes-in-action around the town’s neighborhoods, including package thefts. Since 2018, when this program was deployed, no arrests have been facilitated by this footage. Additionally, after speaking with forty law enforcement agencies across eight states that have partnered with Ring, the results were the same: Ring cameras do not deter, prevent, or help reconcile crimes [9].

Fig. 2. Alternative Solutions: 1: Ring Doorbell adapted from [7] and 2: Package Delivery Box adapted from [8]

B. Direct Competitors

Many other systems have been put into place that resemble a similar structure to the Package Protector. Collectively, they are known as Porch Security Boxes and can be seen in Fig. 2, and range from traditional mechanical locking mechanisms to smart designs. According to one review published on ConsumerReports.com, the protection boxes that are currently on the market are neither intuitive for delivery people to use (hidden doors missed by delivery persons, knowledge of combination codes), nor are able to accurately determine if a package is placed within. This commercial design led the author to state, “In theory, package delivery boxes are a great solution to the porch pirate problem. But the reality is that delivery workers don’t use them enough to make the boxes practical” [10].

Additionally, smart porch security boxes fall victim to even more pitfalls, with many of the consumer reviews on popular products repeatedly complaining about the devices not living up to their ‘smart’ name. For example, one consumer reported, “frankly, it feels too complex for its own good” [10]. Other reviewers complained they could not get the smart features to work, noting the apps are difficult to use, setup is not straightforward, and built-in features, such as the security camera, are low quality and do not last [11]. After examining the pitfalls of the current market contenders, Package Protector was designed to address these issues. The final goal is to make deliveries easy, adding no extra work to delivery drivers, while also providing an intuitive user interface for the package owner that effectively deters and prevents package theft.

III. System Components

A. Interface

Each electrical or software system component was designed to interface with components to provide package arrival, mobile app integration, package retrieval, and alarm system capabilities. Each component was developed separately with incoming and outgoing signals established in the design phase so that during final assembly, parts would be able to plug into one another.

B. Lift Mechanism

The lift mechanism was the first component of the Package Protector to be designed and assembled. As an overview, the lift uses a scissor mechanism to lift and lower a platform that holds the online order. The lift is driven by a worm drive motor that turns a lead screw, which uses its linear motion to bring the legs of the scissor mechanism together or apart. The movement of the legs at the base either expands or contracts the whole mechanism.

Movement is controlled by two STM32F072 microcontrollers, although with the selection of a different microcontroller, functions might have been integrated into a single device. Two boards were used for separation of concerns and pin management. The “top” microcontroller is responsible for package detection via motion sensor, and determining the resting height of the lift when extended via limit switch. The "bottom" board is responsible for sending commands to the motor and determining the lower boundary of the lift as it descends. The two microcontrollers communicate through a direct wire UART connection. The allows the the "top" board to stop the motor via communication with the "bottom" board.

1) Lifting Motor: In order to choose the right motor for the project's needs, some specifications were defined so that torque and power needs could be determined. This included defining the maximum lift and lowering weight introduced by the package and the lift itself. Rough estimates were used, which assumed the lift would add about 10lbs to the overall weight in the worst case. The maximum package weight was set to 20 lbs. This meant the total weighted maximum for the motor was about 30 lbs. From this, Newton's laws were used to determine the forces generated during lifting and lowering motions.

In the case of lowering, gravity provides significant help and reduces the total work that the motor needs to do. When the lift raises, the package should no longer be on the lift, which means the motor only needs to lift the weight of the lift surface. In the worst case, the package is too large and does not enter the storage area, and is raised back to the top. This worst case was used to determine the force needs of the motor, given it would need to raise the lift and the package back to the starting position from a stop. The motor would need to generate enough force to overcome gravity without help.

Through these calculations, it was determined that a base requirement of 23 kg/cm of torque was required to control the lift. This was used as a rough starting point when looking at motor capabilities. To ensure there was little strain on the motor and to increase the longevity of the system, higher torque numbers were favored. After researching different types of motors, a fixed RPM worm drive motor was chosen. This motor includes a mechanical lock that prevents strain on the internal motor components when the motor is off, which means the lift requires no additional power to stay in a fixed position. This is ideal given the lift will spend most of its time at the top position waiting to receive a package.

The chosen motor has the following specs: 70 kg/cm torque, 12V power, 9 RPM, and max 1.6A current consumption. This provides more than enough power to properly control the lift with weight.

2) Motor Control Board: After selecting the motor, a motor control PCB was designed to allow directional control of the motor with an STM32F072 microcontroller. The motor controller board features an H-Bridge, which is a common component used for directional motor control.

Controlling the H-bridge requires three signals, Enable, Input 1 and Input 2. Enable turns the H-Bridge on and off, while Input 1 and Input 2 control the directions. With input 1 high and input 2 low, the motor spins one direction, when input 1 is low and input 2 is high, the motor spins the other direction. Both inputs should never be on, and this was accounted for in the controller code.

Power connections on the board include a barrel connector, which serves as the 12V motor power input. A screw terminal serves as the output connection to the motor. Finally, the H-bridge is powered through a 5V connection provided by the STM board. A picture of the motor board is included in Figure 3.

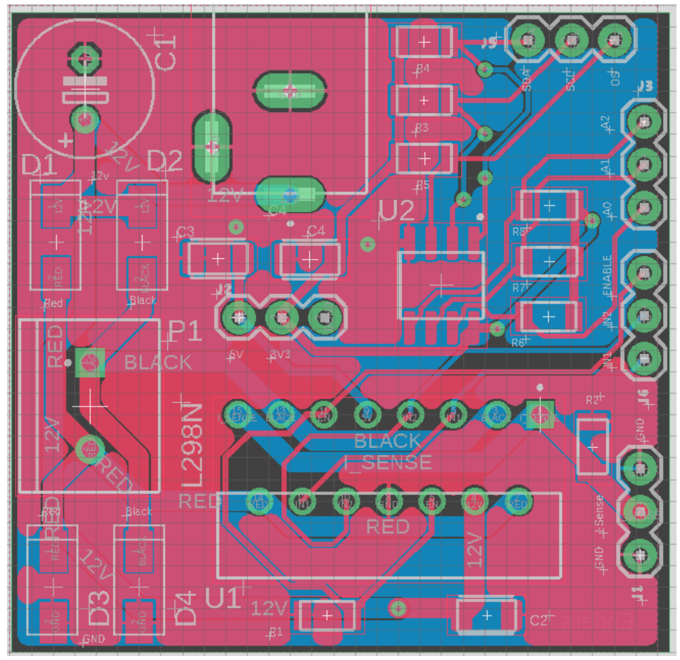


Fig. 3. CAD view of the motor control board

3) Limit Switches: In order to control the maximum and minimum heights of the lift, two limit switches were implemented. The limit switches are double pole double throw (DPDT) type switches, and only provide a high signal when they have been triggered. The limit switches were combined with the motor control code to determine the fully lowered and fully lifted positions of the lift within the box and control the motor direction accordingly.

4) Distance Sensor: To detect when a package has been placed on the lift, a distance sensor was employed. This was chosen over a break beam sensor since it only required one unit instead of two aligned units, which makes placement easier and provides flexibility when installing the sensor later. Once the distance sensor has detected a package within range for a long enough period of time, it triggers the lift sequence. The distance sensor value is read using an analog-to-digital converter (ADC), which is supported by the STM32F072.

5) General Code Flow: The lift system was implemented in Embedded C using both the STM32Cube and Keil uVision5 environment. To handle communication between the top and bottom boards, USART was implemented, as this is a common standard with clear implementation guidelines. It is also a function supported by the STM32F072 board. To handle all the hardware inputs and outputs for the lift, interrupts were used.

C. Housing

The housing structure (5ft Length, 2ft Width, 2.5ft Height) was built with modular parts and includes removable walls, lid, and floor attachments. The exterior was designed to mimic a planter box, and the added space on the top lid allows for plants and soil/mulch to be placed inside. The size of the Package Protector allowed enough space for all of the components including limit switches, PCB's, the scissor lift, and other sensors for this project. Moreover, the design of the exterior was purposeful. Thieves should not be able to readily identify the Package Protector as a target for their crimes.

D. Alarm System

To safely secure packages inside our package protector, an alarm system was implemented. To do this, a full alarm system needs a speaker, an alarm sensor for intrusion detection and tampering, and a device that can read the alarm sensor values and trigger a sound through the speaker. To accomplish this, an ISM330DHCX accelerometer fed acceleration values through an I2C protocol to the Raspberry Pi I2C bus. This communication then triggered the speakers to produce sounds. The accelerometer was placed on the interior ceiling of the Package Protector. This location was chosen because the accelerometer could record consistent values for various disturbances applied on different parts of the Package Protector.

1) ISM330DHCX Accelerometer : The 3-axis accelerometer reads acceleration values through the I2C protocol. To start reading the accelerometer values, the Raspberry Pi must use the I2C protocol to set the mode to high performance. If the Pi does not do this, the accelerometer will return invalid values. To debug these steps, the Pi runs the WhoAmI protocol to ensure communication has been made between the two systems. The last step was installing the accelerometer at the top of the box and threshold values were recorded when the box moved.

2) Speakers: The speakers also communicated with the raspberry pi through an auxiliary connection. The Pi uses Python's numpy library to play sounds in the background. This library was chosen because it is normally used to play background sounds in video games. The libraries also provide a way to play stop all sounds and play unique sounds based upon the *.wav* files. Therefore, there are two different sounds, an alarm sound that plays when the alarm is triggered, and an initialization beeping sound that tells the user alarm system is armed.

3) Raspberry Pi Integration : To fully integrate the speaker and accelerometer with the rest of the system, the program must be written in an asynchronous multithreaded fashion through the asyncio Python library. This is because the accelerometer must continuously read values and that process must happen in the background. Then the mobile app can continuously communicate with the Raspberry Pi. If the program was not written this way, then the program would stall on reading values from the accelerometer, and not be able to communicate with the mobile app. After startup, the program will automatically start and end the asynchronous multithreaded processes of reading values and produce sounds once the accelerometer values exceed a certain threshold.

E. Mobile App and AWS

The Package Protector employed an android mobile app to allow the user to receive notifications from the Package

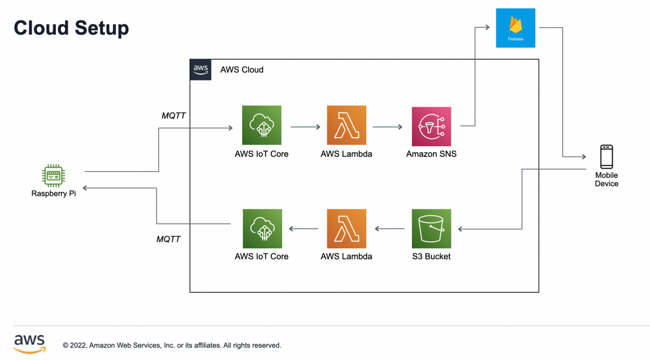


Fig. 4. Block Diagram of AWS Interface with Raspberry Pi

Protector, open the door, and turn off the alarm. To connect it to the Raspberry Pi inside of the Package Protector, Amazon Web Services (AWS) was used. A diagram of the AWS architecture is shown in figure 4:

When events trigger on the Raspberry Pi, a notification is sent to the phone. The events that trigger notifications are when there is a package arrival and when an attempted break-in occurs. The user can open the notifications and see information such as the total number of packages that have been delivered and whether or not a theft attempt has been made on the box.

The app can trigger events on the Raspberry Pi. The user can press the "Turn Off Alarm" button and the "Open Door" button. If the alarm is going off, the "Turn Off Alarm" button will silence it. The "Open Door" button will open the door for the user to retrieve their packages. This also disables the alarm so the user can jostle the box without setting the alarm off.

F. Lock Mechanism

The locking system was implemented using a servo connected to a sliding door latch. A servo is ideal for this task because its accurate positioning allows good control over locked and unlocked positions of the latch, and does not suffer from decreased accuracy over time like a standard DC motor. Additionally, only a fixed range of motion was needed for locking and unlocking.

1) Servo: The servo motor chosen was a Towerpro MG92B. This is a micro servo with high torque. The high torque is ideal in this case because the servo will be sliding a lock opened and closed. It requires 5V power and a 5V pulse width modulation signal to control. The pulse width modulation signal controls the position of the servo, so different duty cycles result in different positions. This servo can handle a full 180-degree range. For locking positions, 0 degrees is unlocked, and 180 degrees is locked. The servo is connected to the lock using a metal wire, which allows the lock to slide open and closed as the servo goes through its range of motion.

2) RFID Reader: An RFID Wiz Kit was used as the RFID reader in this system because it provided several convenient features. First, it supports training multiple RFID tags, and tags can be trained with the push of a button. This is convenient and allows the user to use any RFID chip they already have.

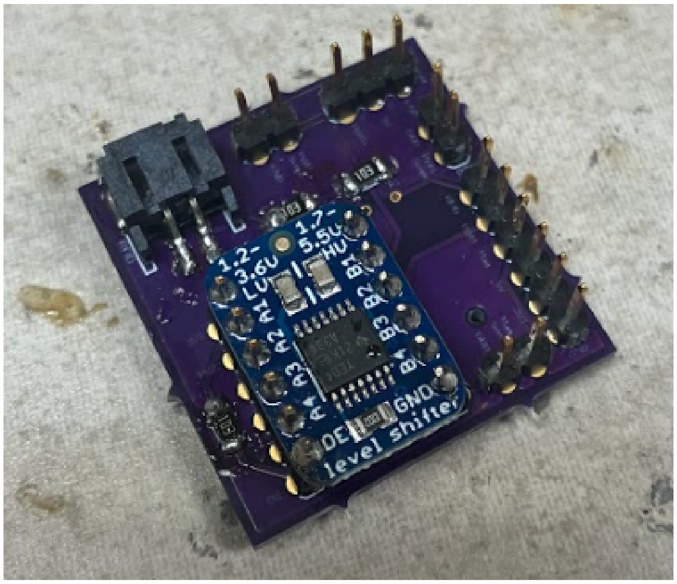


Fig. 5. PCB for the lock and door connections

Second, this particular kit was designed with a locking system in mind, so it provides a convenient interface to work with. Third, it comes with a separate RFID reader, which triggers the unlock mechanism when it reads a trained tag. Finally, it has options built in for trigger time to hold the unlock mechanism high, including instant and a five second hold. This provided flexibility when designing the code to control the locking mechanism and helped with testing.

3) Door Sensor: To support auto-locking, a reed switch sensor was used to determine when the door is open or closed. If the door is unlocked and has been opened, as indicated by this sensor, the lock will remain in the unlocked position. Once the door has been closed, after a short period of time, the system will automatically lock. If the door is never opened after the lock is unlocked, then the system will automatically re-lock.

4) Simplified Connection PCB: In order to minimize pins used on the Raspberry Pi, and prevent overlap with other components, a pass-through PCB board was designed specifically for the locking system. It includes connections for the Raspberry Pi board, RFID reader, door sensor, and servo motor. Additionally, to accommodate the 5V logic needs of the servo, a 3.3V to 5V logic level shifter is included on the board. Scope pins are also included for the RFID signal and the PWM signal to verify outputs and ensure the level shifter is operating correctly. The board is shown in figure 5

5) Raspberry Pi Integration: The Raspberry Pi controls the entire locking system. It is responsible for detecting when an OPEN signal has been received from the RFID or the app, sending pulse width modulation to the servo to define positions, monitoring the door sensor, and ensuring the system is re-locked. The default state of the box is locked.

G. Run On Startup

To turn our programs into a full-functioning system, the Raspberry Pi and STM boards run their respective programs on startup. The STM boards can be run on startup by providing it power. However, the Raspberry Pi can be run on startup only by changing the *.bashrc* file to compile and run our intended scripts. By doing this, all libraries and files must be given absolute file paths for the system to work. Since the communication protocol between the Raspberry Pi and the mobile app is through AWS, the start-up script must first check to see if there is an internet connection on the Raspberry Pi before running any program. By doing this, it can be ensured that the Raspberry Pi system runs properly and on startup.

IV. Testing

Our testing schema matched our modular building process. Each subsystem of the overall project was tested independently before being integrated with other systems.

- Lift: The lift mechanism was done with little knowledge of conventional mechanical engineering principles. As such, construction was ad hoc, and testing was thorough. Testing was primarily done to verify signals coming in and out of the microcontrollers. UART communication had to be verified between the boards, and the pin readings to start the motor. Mechanical aspects were planned out beforehand so that after construction, all pieces fit together. Given the unfamiliarity with distance sensors and limit switches, there were also many small tests to confirm how each device worked and understand how to use them in code before integrating them into the greater environment.
- Alarm System: After initial signals were verified, testing of the alarm system focused on setting appropriate thresholds for setting it off. An ISM330DHCX accelerometer was placed on a breakout board and strapped to the ceiling of the Package Protector. Various thresholds were set to determine the amount of disturbance the box should undergo before sounding the alarm. For the ISM330DHCX, the values 800-850 were a good middle-ground value between sensitivity and accuracy.
- Lock: All components of the lock system were tested individually, and then integrated together as an understanding of the system improved. The servo was tested first to determine which duty cycles corresponded to which servo arm positions. The RFID reader was tested next to understand its expected behavior when it encountered a trained tag. Finally, the function of the door sensor was explored to learn how it read in its opened versus closed positions. With this knowledge, the systems were put together to create the full locking system. The servo and the RFID were integrated first to ensure a proper control flow with opening and closing was designed. Then, the door sensor was added and started with a generic system that instantly locked when it was detected. Finally, the entire locking system was fine-tuned to allow the user a reasonable amount of time to open the door, re-lock after the door is closed, and auto-lock after a certain amount of time. The whole system was then installed in the housing and tested to ensure functionality was retained.
- Mobile App: To test the mobile app, integration with the alarm system was done first and then checked for edge

cases. This includes triggering the alarm and checking to see if the alarm system can be turned off through the mobile app. After that, the locking mechanism was integrated with the entire system and checked to see if the mobile app could unlock the door. Then the system was run against as many edge cases as possible. This includes opening the door with both the mobile app and RFID, trying to trigger the alarm, then closing the door and attempting to trigger the alarm again. If the door is open, the alarm should not be triggered, but if the door is closed, the alarm can be triggered. Another edge case was to unlock the door with the mobile app, but not physically open the door. For this edge case, the servo would force the door to go back to the locked state after a certain period of time.

V. Demonstration

A demonstration of the final product was given on December 9th, 2022. The demonstration of the product showed that the Package Protector worked as expected. The system could ran multiple times during the two-hour period. The Package Protector received packages from guests. Guests were able to then watch the scissor lift lower the package and move it into the area behind the retrieval door. The guests then retrieved the package using either the mobile app or the RFID tag. The mobile application worked as expected and no issue was present during the demonstration. The alarm system was also demonstrated by having guests shake the box, and then turn off the alarm using the app.

VI. Results

After completing thorough testing and demonstration of the project, the Package Protector was awarded Best Senior Project. It was well received by faculty and the public alike. Physical measurements showed that the Package Protector was able to receive one package per minute (assuming packages are not stacked). This is due to the low RPM of the high-torque motor chosen for this project. Another interesting consequence of the motor for this project was induced interference in our digital signals when all systems were integrated. This problem manifested itself the week prior to the demonstration. When the motor was disconnected from power, all systems worked seamlessly. However, as soon as the motor was powered, there were issues in separate systems. For example, as the lift begins to rise after dropping off a package, the servo motor will unlock the door without command. The Pi is able to auto-lock the door which mitigates the bug. When the Package Protector was moved to a carpeted room for demonstration, the problem was further mitigated. This points to EMF as the culprit. This issue was not discovered until the last moment and would be something to improve in future iterations.

VII. Team Management

This project has been a learning experience for all of us. From the start, the team has been dedicated to organization and communication. That has helped us navigate many design issues and fostered discussion about where we need to go. Generally speaking, each team member is invested in the project because we work towards unanimous decisions. We, like many teams, have had challenges also. One lesson that we had learned was the importance of setting deadlines to our goals. After we had built the initial lift, we falsely believed we were ahead of schedule. We were able to recover only because we set hard deadlines and distinct goals to accomplish. As we have ended our project, we are appreciative of the deadlines set that allowed us to finish on schedule with time left over for testing.

Another lesson we learned is how easy it is to over-engineer things. We have a tendency to want to solve problems using programmable devices and custom setups when sometimes, simplicity is the best answer. For example, we first believed we would be implementing a motorized roller system for the lid of the scissor jack to move packages off. After several renditions of how to do this, we realized we could accomplish the problem with no electrical parts. Rather, by using a fixed upright plank in the lift's path, a simple mechanical solution was found. This helped us realize the importance of soliciting feedback from people who have different backgrounds. It also is important to take a step back and see if the problem can be solved in a better way with a simpler, less engineering-intensive solutions.

VIII. Conclusion

This paper demonstrates a prototype solution to prevent the theft of online orders. While other products try to tackle this problem, they are inconsistent at both stopping thieves and ease of use for delivery drivers. The package protector is created to be discrete, and easy to use. Its dual purpose as both a security device and planter hide packages from potential burglars while delivery drivers can clearly see where to deposit the online order as they approach. Our innovative interior-locking system ensures that only the owner is able to retrieve the contents of the box. In the future, this product can be changed in order to accommodate different size porches (a big Package Protector versus a smaller version). Another area of future work is improvement of the lift design. Although the current design is compatible with the needs of the device, it requires a lot of torque and power. Future designs might leverage the mechanical advantages of pulleys or telescoping joints.

The approach taken in this paper will help lower crime rates. The Package Protector should be used as a baseline in the future of online order security for both aesthetics and utility. Without either, people will not use them. The Package Protector is here to help protect property, something that everyone can benefit from.

Appendix A
Links to Project Management Programs

- Trello Board
- GitHub Repository
- Google Drive

References

[1] B. Cost. (2021, Nov.) 210 million packages were stolen from Americans this year: survey. [Online]. Available: https://nypost.com/2021/11/29/210-million-packages-were-stolen-this-year-survey/

[2] J. Carlsen. (2021, Dec.) Worst Metro Cities for Package Theft for 2021. [Online]. Available: https://www.safewise.com/blog/metro-areas-porch-theft/

[3] T. Männistö, J. Hintsa, and L. Urciuoli, "Supply chain crime - taxonomy development and empirical validation," *Int. J. of Shipping and Transport Logistics*, vol. 6, pp. 238–256, 01 2014.

[4] M. University. Future of Online Shopping: Evolving E-Commerce Trends. [Online]. Available: https://online.maryville.edu/blog/future-of-online-shopping/

[5] K. A. Renzulli, "Deal or No Deal?" *Newsweek Global*, vol. 178, pp. 10–14, 2 2022.

[6] E. Cramer-Flood. (2021, Feb.) Global Ecommerce Forecast 2022. [Online]. Available: https://www.emarketer.com/content/global-ecommerce-forecast-2022

[7] Amazon. Ring Video Doorbell Pro 2 – Best-in-class with cutting-edge features (existing doorbell wiring required) – 2021 release. [Online]. Available: shorturl.at/kAMN9

[8] Porch-Box. Medium Porch Box. [Online]. Available: https://www.porch-box.com/quickshipbox/porch-box-lockable

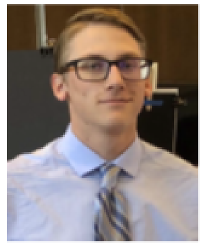
[9] C. Farivar. (2020, Feb.) Cute videos, but little evidence: Police say Amazon Ring isn't much of a crime fighter. [Online]. Available: https://www.nbcnews.com/news/all/cute-videos-little-evidence-police-say-amazon-ring-isn-t-n1136026

[10] D. Wroclawski. (2021, Nov.) At-Home Review: Package Delivery Boxes to Deter Porch Pirates. [Online]. Available: https://www.consumerreports.org/shipping-delivery/package-delivery-box-review-deter-package-theft-pirates-a8807161138/

[11] Amazon. Danby Parcel Guard - The Smart Mailbox - Wi-Fi Connected, Smart Phone Controlled, Stop Parcel Theft - DPG37G. [Online]. Available: https://www.amazon.com/Danby-Parcel-Guard-Connected-Controlled/dp/B07WRCP8PQ/?tag=dartcexhgpclo-20&linkCode=osi&th=1&psc=1

Anthony Robinson is an undergraduate student studying computer engineering at the University of Utah. His interests range from hardware implementation on FPGAs to designing large scale software systems. He has been successful in multiple internships, most notably researching optimized antennas for future 5G systems with the POWDER Wireless Group at the University of Utah and designing, testing, and implementing hardware for high performance signal processing at Raytheon Technologies. He is keen on collaborating in team settings with other highly motivated individuals to solve the problems of tomorrow.

Andrew Porter is a Computer Engineering Major at the University of Utah. He has consistently been on the Dean's List throughout his academic career. An active member of the Air Force ROTC, he currently serves as Deputy Mission Support Group Commander, overseeing material support for over 60 cadets. Andrew was recently one of ten cadets nationally selected by the Air Force to further their education after undergraduate studies and will begin his Masters degree in Robotics and Autonomy in 2023. Andrew is fluent in Spanish, and after living in four countries, has a deep appreciation for culture and diversity.



John 'Jack' Mismash was born in Omsk, Russia, and is a undergraduate student at the University of Utah studying Computer Engineering supplemented with a Certificate in Entrepreneurship. From Fall of 2018 to Spring of 2020, he was under scholarship to be a part of the Spread Spectrum Time Domain Reflectometry (SSTDR) research team within the Electrical and Computer Engineering Department in being able to detect, localize, and characterize faults within solar panel systems. He is currently pursuing a career as a software engineer and interested in machine learning and artificial intelligence, and has had experience in data analytics in this past year.

Nathan Sartnurak is an undergraduate student at the University of Utah studying Computer and Electrical Engineering, and a software intern at L3Harris. At L3Harris, he gained a 'Classified' security clearance in 2021 and works on programs such as Next Generation Jammer and Evolved Strategic Satellite Communications. He has also working on the Device Discovery on the Powder Network clinical project sponsored by Raytheon Technologies at the University of Utah

E. Lindsey Enders is a Computer Engineering student at the University of Utah and a Systems Engineering intern with L3Harris. At L3Harris, she provides software support to a fully remote, automated testing environment that allows automated design verification and integration testing for communication systems. As a student researcher, she has focused on IoT design, taking a project from concept to an implemented prototype. When she is not studying or working, she can be found climbing at the gym, training aerial silks, or hitting the slopes.