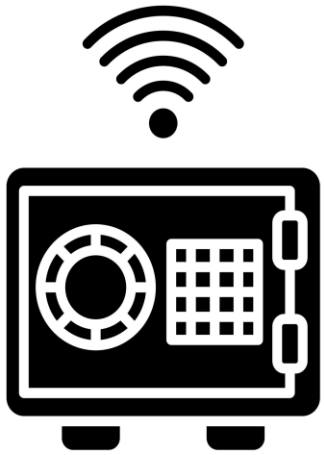
Senior Design 1

Project: Smart Safe



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2. Project Description

2.1 Project Motivation and Background

Our project is driven by the need for a highly secure storage solution for personal valuables. In today's world, people require a reliable means to safeguard important items such as passports, personal documents, jewelry, emergency cash, and firearms. Traditional safes offer physical security but may lack advanced protection features. To address this, we aim to develop a digital smart safe that enhances security through modern technology, making users feel more confident about the safety of their belongings [11].

Our smart safe eliminates the inconvenience of physical keys or cards by offering alternative access methods: a keypad and a fingerprint sensor. Registered users can receive real-time email notifications if any access attempts are made, enhancing their ability to monitor and respond to potential security breaches. Additionally, the integration of a motion sensor and timestamp functionality ensures users are aware of any activity around the safe. By combining these advanced features, our project aims to provide a comprehensive security solution with enhanced protection against theft and unauthorized access [11].

2.2 Project Goals and Objectives

The goal of this project is to design a smart safe equipped with advanced security features such as a 6-digit keypad code and fingerprint scanner, ensuring secure and convenient access. Additionally, we aim to develop a website where a registered user can input their email to receive notifications whenever the safe is accessed, allowing them to monitor for any unauthorized entry. The safe will also incorporate a motion sensor that detects nearby activity, and a timestamp will be provided to indicate the exact time the safe was accessed [11].

The keypad will require a 6-digit code, denying access if an incorrect code is entered. To enhance security, if the code is entered incorrectly three times, the safe will enter Lockdown Mode, where only the fingerprint of a registered user can disengage it and access the safe. Multiple users can register their fingerprints for authorized access. To further ensure protection, electromagnetic solenoid locks will secure the safe and prevent tampering or breakage. Our team aims to create a flexible and user-friendly system, so users can securely store their belongings with ease and confidence [11].

2.3 Project Features and Functionalities

Our smart safe is designed with a variety of features that provide both security and user convenience. These functionalities ensure that the safe offers multiple layers of protection, making it highly secure and easy to operate. Below are the key features of the safe and our goals [11]:

Basic Goals:

- **Keypad:** A 6-digit security code is required to access the safe. If the incorrect code is entered, access is denied, preventing unauthorized attempts [11].
- **LCD Screen:** Displays clear and readable user prompts during interactions with the safe [11].
- **Notifications:** Sends timely email alerts to the primary user when access attempts are made, including a timestamp of when the safe was accessed [11].
- **Solenoid Lock:** Unlocks the safe upon recognizing a registered fingerprint or correct passcode and remains locked if an unregistered fingerprint or incorrect passcode is entered [11].

Advanced Goals:

- **Fingerprint Scanner:** Accurately reads registered fingerprints and allows additional fingerprints to be added without issues, ensuring that access is limited to authorized users only [11].
- **Motion Sensor:** Detects individuals who are within proximity to interact with the safe, helping monitor attempts to access it [11].
- **Website:** Provides a web interface where registered users can input their email to receive notifications and manage safe settings [11].
- **Lockdown Mode:** Locks the safe after three consecutive incorrect passcode entries, requiring a registered fingerprint to disable the mode and regain access [11].
- **Buzzer Alert:** Provides audible signals—one buzzer sound indicates the safe is still unlocked, two sounds mean the safe is locked, and repeated buzzing signifies that Lockdown Mode is active after failed access attempts [11].
- **LED Status Light:** Visually indicates whether the safe is currently locked or unlocked [11].
- **Self-Locking Mechanism:** Automatically locks the safe after being unlocked for approximately 30 seconds if no further access is requested [11].
- **Battery Backup:** Keeps the safe operational during power outages or in case of a main power supply failure, ensuring that the system continues to function seamlessly [11].

Stretch Goals:

- **Camera Module**: Captures images of individuals attempting to access the safe for enhanced monitoring [11].
- **Motion Sensor Time Limit**: Sets a specific time window for motion detection [11].
- **Tamper Detection**: Alerts the user in case of any tampering or unauthorized attempts to breach the safe [11].
- **Temperature sensor**: Detects the temperature of the safe and alerts user if temperature is above or below predefined temperature range [11].
- **Password Reset**: The user will have the ability to reset their password via the website and use the updated password to access the safe [11].

2.4 Project Requirements and Specifications

Specifications	
*Fingerprint access accuracy	Unlocks safe 90% of the time (unless it's an unregistered fingerprint)
*Passcode access accuracy	Unlocks safe 90% of the time (unless it's the wrong code)
Status LED accuracy	Is correct 90% of the time
*Email notification duration	Received in under 2 minutes
Lockdown Mode activation	Activates after 3 passcode attempts
Self-Lock Time Limit	Locks after 30 seconds
Safe Size	6.7" x 6.7" x 9"

Table 1: Specifications Table

*The specifications highlighted in blue will be our 3 demonstratable specifications

2.5 Current/Existing Technologies

Ring Doorbell

The Ring Doorbell is a smart home device by Amazon that enhances the traditional doorbell with additional security features. It includes a motion detector that alerts the owner via any mobile device using the Ring App or any Amazon Alexa device when motion is detected at the front door [1]. The doorbell also allows users to see who is near it and speak to them through the mobile app [1]. Additionally, the app enables users to monitor the doorbell from anywhere and save camera footage for up to 180 days. It also allows for customization of alert settings to suit user preferences. The Ring Doorbell is part of a broader range of security products, including security cameras, alarms, and smart lighting [1]. The battery-operated Ring Doorbell features a built-in rechargeable battery or can be hardwired and includes functionalities such as video with night vision, two-way talk, motion detection and alerts, mobile app control, dual-band Wi-Fi, package alerts, and more [1] [11].

BILLCONCH Safe

The BILLCONCH Safe incorporates features like those planned for our smart safe, including a fingerprint sensor, keypad, and notification system for alerting the owner about safe access. However, the BILLCONCH Safe also includes a physical key for manual access and a mobile app for user information and notifications—features that we have not considered for our design [9].

Smart Lock Group 6 - Summer 2019 to Fall 2019
Group 6's Senior Design Project from Summer 2019 to Fall 2019 was a smart lock system with multiple access methods, including a keypad, RFID, fingerprint sensor, and facial recognition. Their project featured a touchscreen with a GUI interface, allowing homeowners to unlock the door using various methods such as a key fob, fingerprint sensor, or security code [5]. Additionally, their system included Bluetooth and mobile app capabilities [5]. We were inspired by this project's approach to integrating advanced access technologies and its focus on providing a secure and convenient solution for home entry.

Smart Cooler Group 23 - Spring 2022 to Summer 2022
The Smart Cooler project from Spring 2022 to Summer 2022 featured a cooler designed to retain cold air and incorporate smart glass to address issues like cold loss mitigation and privacy. The smart glass prevents cooling loss by allowing visibility without opening the cooler [6]. Additionally, the cooler includes USB ports for charging during outdoor activities, aiming to offer a low-cost and efficient solution with features beyond those of traditional coolers [6]. This project inspired us to enhance our safe with features like battery backup and a status light for improved user convenience.

2.6 Block Diagrams

Hardware Diagram:

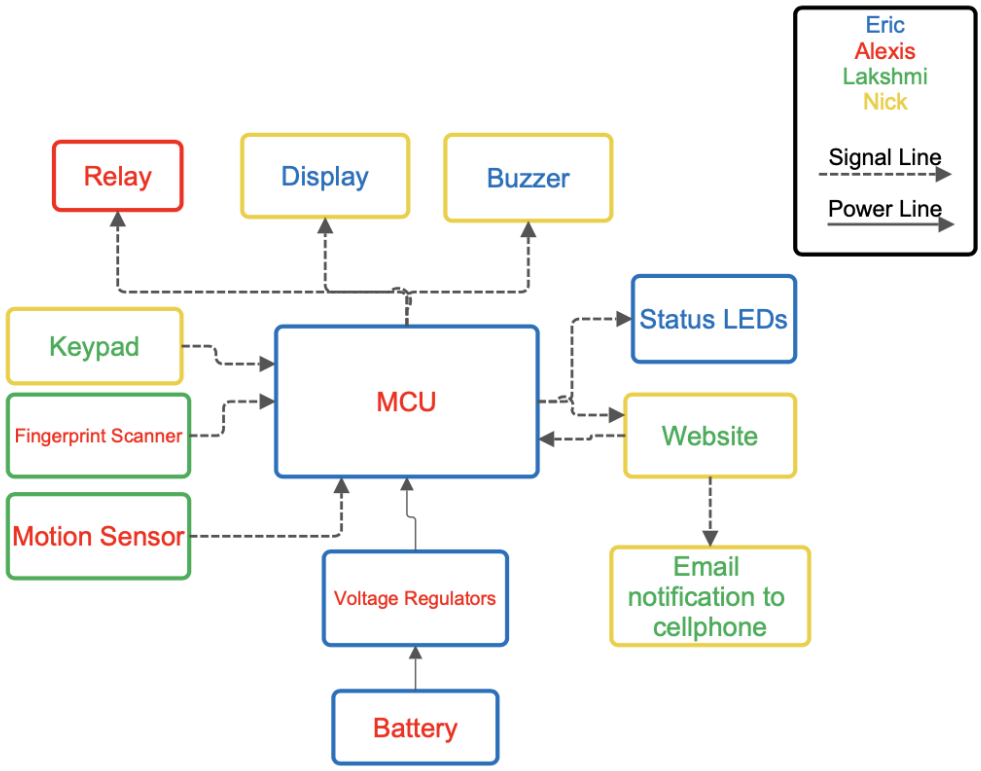

Figure 1: Hardware Block Diagram [3]

Work Division:

Eric & Alexis will handle all PCB work regarding the MCU and the battery while also integrating the status LEDs and the relay. Lakshmi & Nick are tasked with setting up the web server to be able to send email notifications that someone is accessing the safe. Furthermore, Alexis & Lakshmi are tasked with integrating the motion sensor and fingerprint scanner while Nick & Eric are tasked with integrating the Piezo Buzzer, LCD screen & 4x4 Keypad.

Software Diagram/Flowchart:

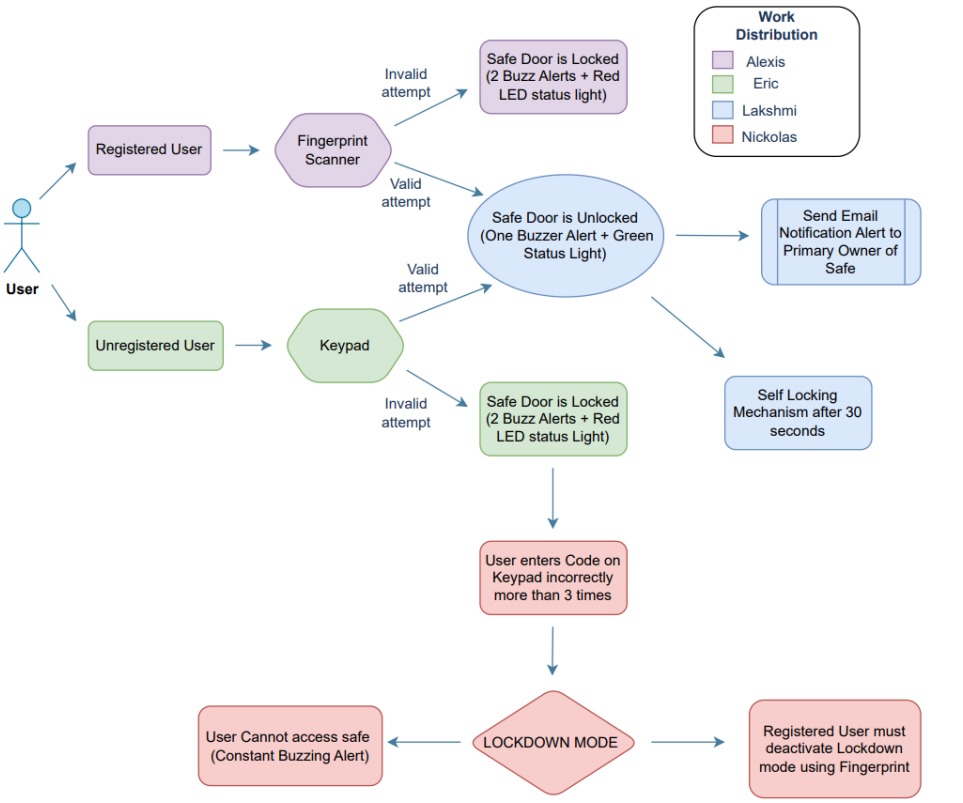

Figure 2: Software Block Diagram [2] [7]

Description of Software Diagram:

The software diagram above shows how the Smart Safe will work when a user interacts with it. First, the user must be identified as a registered user or an unregistered user. If the user is registered in the system, they may scan their fingerprint to unlock the safe. If the fingerprint is not recognized this is considered an invalid attempt and the safe door will stay locked. If the fingerprint is recognized this will be seen as a valid attempt and the safe door will be unlocked. If the user is unregistered, they will be required to use the keypad to enter a 6-digit security code to unlock the safe. If the code is entered incorrectly then the safe will remain locked. An extra condition is if the user enters the security code on the

keypad incorrectly more than 3 times the safe will enter Lockdown Mode. During Lockdown Mode, the digital safe prevents anyone from trying to access it. The only way to deactivate Lockdown Mode is for a registered user to use the fingerprint scanner. If the safe door is unlocked, the primary owner of the safe will receive an email notification stating their safe has been opened and to verify that this access was authorized. After the safe has been unlocked, the locks will be automatically locked after approximately 30 seconds using the self-locking mechanism. In addition, the safe will have a buzzer sound alert and LED status light. If the user has an invalid attempt the buzzer will make 2 alert noises, and the LED will be red. If the safe is unlocked, the buzzer will make one noise, and the LED will be green. If the safe enters lockdown mode it will make a constant buzzer alert.

For the work distribution, Alexis will be working on the parts highlighted in purple which consists of registered users, fingerprint scanner, and making sure the safe door is locked along with the buzzer noise and LED status. Eric will be working on the parts highlighted in blue which consist of unregistered users, keypad, and making sure the safe door is locked along with the buzzer noise and LED status. Lakshmi will oversee when the safe door is unlocked, sending email notifications, and the self-locking mechanism which are highlighted in blue. Nick oversees the self-locking mechanism which is highlighted in red. In conclusion, we will all be contributing to the overall tasks.

2.7 House of Quality

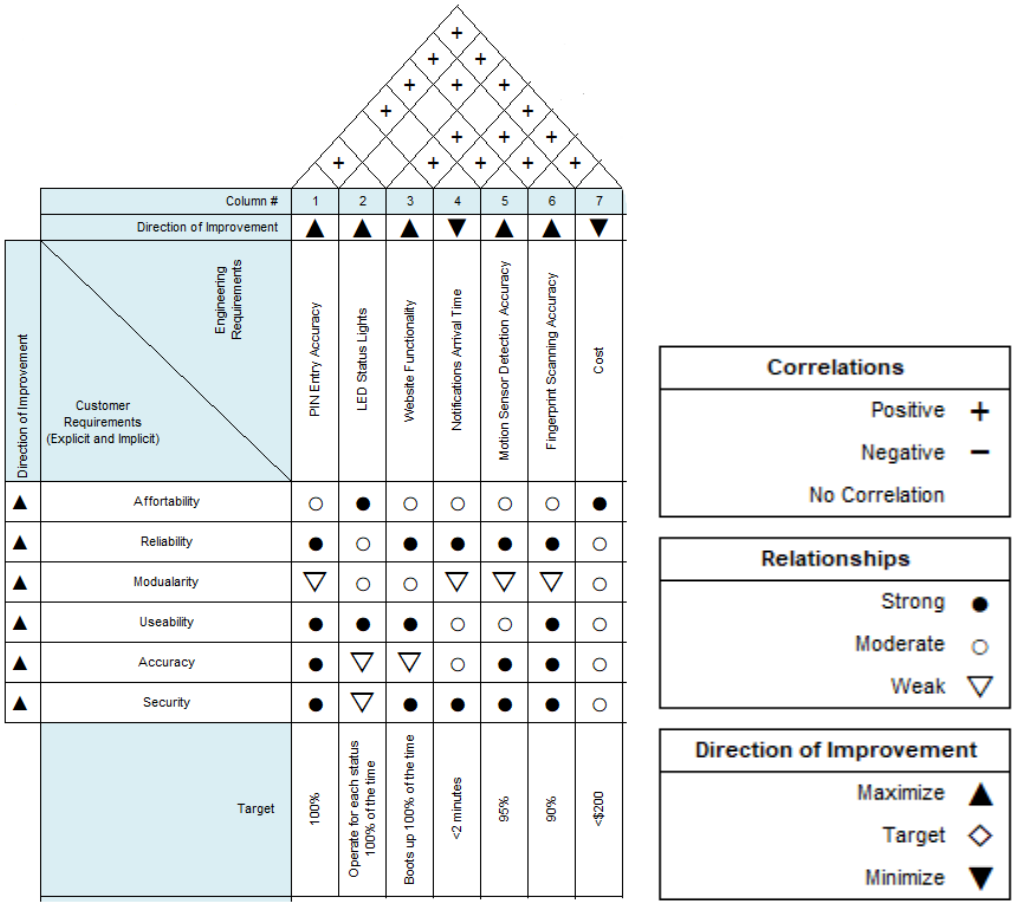

Figure 3: House of Quality

2.8 Prototype Illustration/Sketch

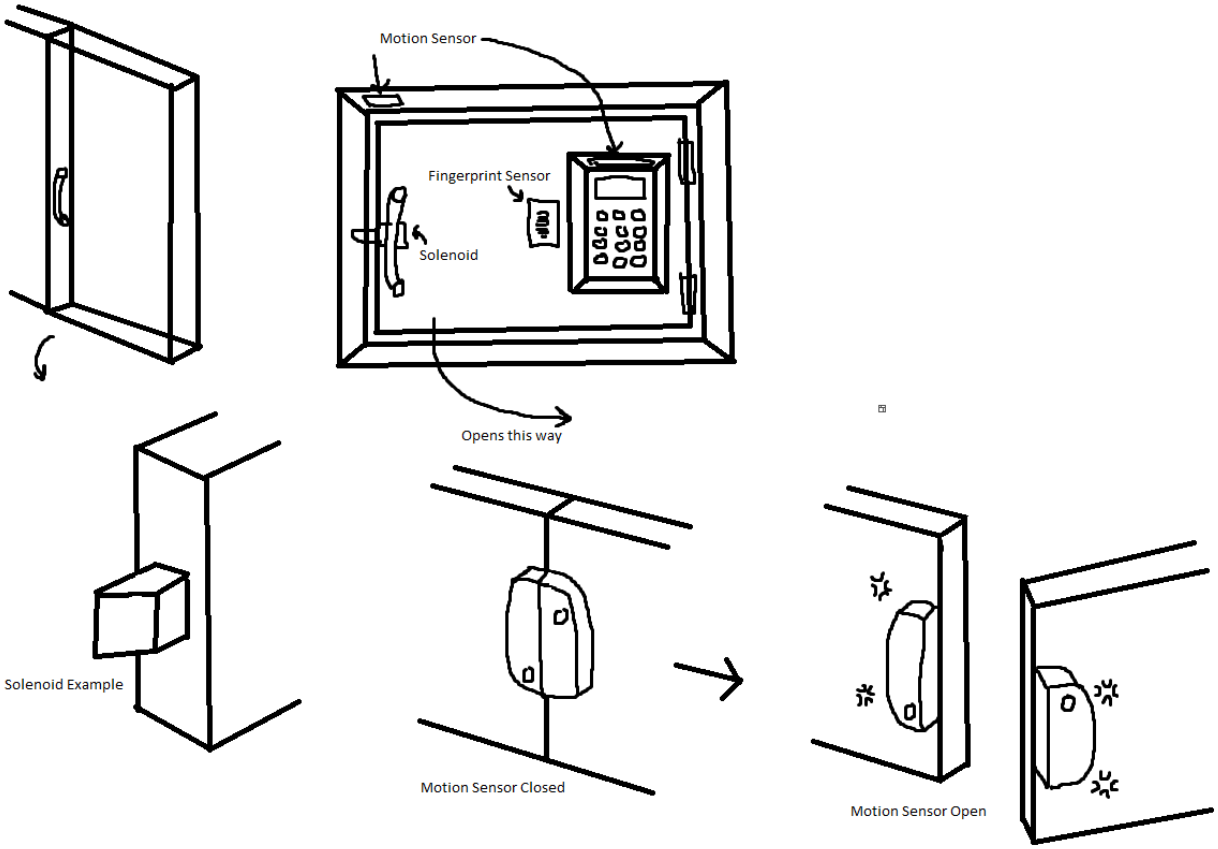

Figure 4: Sketch of the Prototype

10. Administrative Content

10.1 Project Budget

Item	Quantity	Cost	Total
MCU	1	$20	$20
Display	1	$18	$18
Keypad	1	$3	$3
Fingerprint Sensor	1	$20	$20
LEDs	2	$0.30	$0.60
Ultrasonic Sensor	1	$6	$6
Lock	1	$13	$13
Battery	1	$6	$6
Power Supply Adapter	1	$9	$9
Birch Plywood	6	$5	$30
PCB Board	5	$3	$3

IP Address	1	$1	$1
Website Domain	1	$14	$14
Total			$143.60

Table 2: Budget

Smart Safe operates with a flexible budget, being self-funded without external sponsorship. One of our main goals is to keep costs as minimal as possible for each group member, thereby making the project accessible and manageable for everyone involved.

Table 2 outlines the estimated costs for the key components essential to our project. These estimates are based on current prices and anticipated expenses, but it is important to note that they are subject to change. Variations in costs may arise due to several factors, including the size and specifications of the printed circuit board (PCB), which can significantly impact the overall material costs. Additionally, shipping expenses can fluctuate depending on the supplier and the shipping method chosen, further influencing the final budget.

As we move forward, these estimates will be refined and finalized in the bill of materials, which will provide a more accurate picture of the total cost. By carefully monitoring and managing these costs, we aim to achieve an efficient and cost-effective project outcome, while still delivering a high-quality Smart Safe.

10.2 Bill of Materials [10]

Item	Quantity	Cost	Total
MCU	1	$15.19	$15.19
Display	1	$23.03	$23.03
Keypad	1	$7.38	$7.38
Fingerprint Sensor	1	$23.99	$23.99
Ultrasonic Sensor	1	$6.99	$6.99
Lock	1	$6.99	$6.99
LED	2	$5.99	$5.99
Buzzer	1	$6.98	$6.98
Voltage Regulator	1	$6.99	$6.99
DC Power Connector	1	$6.99	$6.99
Power Supply Adapter	1	$8.98	$8.98
Battery	1	$9.49	$9.49

Battery Connector	1	$3.79	$3.79
Birch Plywood	6	$5.48	$32.88
Hinges	2	$5.99	$5.99
PCB Board (with shipping)	5	$2.00	$19.80
Total			$191.45

Table 3: Itemized Bill of Materials

Table 3 provides a comprehensive overview of the materials required for the construction of Smart Safe. The table details both the quantities of items needed and the actual prices of material. This includes considerations for items sold in multiple or bulk, which affects the overall cost.

To manage expenses and simplify the installation process, the safe will be constructed from birch plywood rather than metal. Plywood offers a cost-efficient and user-friendly alternative to metal, which can be more complex and expensive to work with. It's important to note that not all construction items are listed in the table; for instance, the handle is integrated into the plywood measurements for the safe. Additionally, items such as resistors are not included in the material list because they will be provided by the lab in UCF.

10.3 Project Timeline

Task	Start Date	Anticipated End Date	Duration
Group Recruitment	07/09/2024	08/18/2024	6 weeks
Project Idea Brainstorming	07/09/2024	08/16/2024	6 weeks
Project Scope Finalized	07/09/2024	08/18/2024	6 weeks
Individual Research	07/09/2024	09/05/2024	9 weeks
Divide and Conquer Report	08/25/2024	09/06/2024	2 weeks
Divide and Conquer Meeting	09/10/2024	09/10/2024	30 minutes
Divide and Conquer Revision	09/10/2024	09/27/2024	2 weeks
Upload DC Report on Website	09/10/2024	9/27/2024	2 weeks
Email DC Report to Committee	09/10/2024	9/27/2024	2 weeks
60 Page Milestone	09/27/2024	10/25/2024	4 weeks

60 Page Report Group Meeting	10/28-30/2024	10/28-30/2024	30 minutes
Upload Revised 60 Page Report	10/30/2024	11/08/2024	2 weeks
120 Page Milestone	10/25/2024	11/22/2024	5 weeks
Individual System Design	09/06/2024	10/03/2024	4 weeks
Individual System Testing	10/04/2024	10/29/2024	4 weeks
Breadboard Prototyping	10/30/2024	11/17/2024	4weeks
PCB Designing	11/24/2024	12/09/2024	3 weeks
Final Report	11/22/2024	11/26/2024	1 week
Upload Revised Final Report	11/26/2024	12/05/2024	1 week

Table 4: Senior Design 1 Project Milestones

Task	Start Date	Anticipated End Date	Duration
PCB Ordering	12/10/2024	01/06/2025	3 weeks
PCB Assembly	01/07/2025	01/21/2025	2 weeks
PCB Testing	01/22/2025	02/05/2025	2 weeks
System Integration/Testing	02/06/2025	03/06/2025	4 weeks
Practice Project Demo	03/10/2025	03/24/2025	2 weeks
Finalize Documentation	03/25/2025	04/08/205	2 weeks
Practice Final Presentation	04/10/2025	04/18/2025	1 week
Final Presentation	TBD	TBD	TBD

Table 5: Senior Design 2 Project Milestones

The team for Smart Safe was formed and began brainstorming ideas over the summer in preparation for Senior Design 1. During this period, we explored various concepts and solutions to build a solid foundation for our project.

Table 4 outlines the progress we've made so far and our plans for the remainder of the semester. Table 5 outlines our anticipated milestones and objectives for each month leading up to the end of Senior Design 2. Both tables offer a preliminary timeline and are subject to adjustment based on ongoing developments, although tasks with established deadlines will remain fixed.

Citations:

[1] “Video Doorbell Cameras | Wireless and Wired,” *Ring*. https://ring.com/video-doorbell-cameras

Used for Software Diagram:

[2] “Flowchart Maker & Online Diagram Software,” *Draw.io,* 2019. http://draw.io

Used for Hardware diagram:

[3] “SmartDraw - Create Flowcharts, Floor Plans, and Other Diagrams on Any Device,” *www.smartdraw.com*. http://smartdraw.com

Safe logo on Cover page:

[4] V. Icons, *Smart Safebox vector icon*. [Online]. Available: https://www.vecteezy.com/vector-art/21715408-smart-safebox-vector-icon

[5] “SD Group 6 Smart Lock,” *Ucf.edu*, 2024. https://www.ece.ucf.edu/seniordesign/su2019fa2019/g06/#Doc (accessed Sep. 06, 2024).

[6] “Smart Cooler,” *Ucf.edu*, 2024. https://www.ece.ucf.edu/seniordesign/sp2022su2022/g20/ (accessed Sep. 06, 2024).

[7] “Smart Door Security System,” *Ucf.edu*, 2021. https://www.ece.ucf.edu/seniordesign/sp2021su2021/g15/ (accessed Sep. 06, 2024).

[8] *Amazon.com*, 2024. https://www.amazon.com/b?ie=UTF8&node=13853235011#:~:text=Amazon%20Hub%20Locker%20is%20a (accessed Sep. 06, 2024).

[9] “Amazon.com,” *A.co*, 2014. https://a.co/d/b1kJqVp (accessed Sep. 06, 2024).

[10] “ESP32 Fingerprint Sensor Based Door Lock Security System,” How To Electronics, Feb. 06, 2020. https://how2electronics.com/esp32-fingerprint-sensor-security-system/

[11] ChatGPT, "Word Document Formatting Guide" OpenAI. Available: https://chatgpt.com/share/62588d64-90ce-4824-89d5-0ccb2fc2f64b. [Accessed: Sep. 19, 2024].