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University of Ottawa

GNG 1103 C04 – Engineering Design

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Project Deliverable D: Conceptual Design

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Abstract

This document will display team member concepts for three subsystems, generating three functional solutions. A decision matrix evaluates each, determining the most viable option with detailed explanations.

Table of Contents

Table of Contents 4
1 Introduction 6
2 Subsystems 6
2.1 Bat Box Structure 6
2.2 Tracking Device 6
2.3 Power and Coding Functionality 6
3 Engineers' Design and Description 6
3.1 Adam Sirota 7
3.1.1 Design 7
3.1.2 Description 7
3.2 Brayden Fitzgerald 9
3.2.1 Design 9
3.2.2 Description 9
3.3 Jordan Draper 10
3.3.1 Design 10
3.3.2 Description 10
3.4 Hala Aldahoun 12
3.4.1 Design 12
3.4.2 Description 13
3.5 Rami Mosleh 15
3.5.1 Design 15
3.5.2 Description 15
4 Final Global Concepts and Description 17
4.1 First Global Concept and Description 17
4.2 Second Global Concept and Description 18
4.3 Third Global Concept and Description 19
5 Best Global Concept 20
5.1 Comparison Analysis 20
5.2 Final Design Concept 20
6 Conclusion 20

1 Introduction

In this technical document, we will outline the concept designs generated by each of our team members for the 3 subsystems below, to build a bat box with a tracking device that helps at monitoring the number of bat visits to the bat box. At the end, we will design three functional solutions and choose the best one, using the decision matrix. Thus, with that approach, we will help bat conservationists in Canada to see the effectiveness of the bat boxes.

2 Subsystems

In this part, we are going to divide the bat box design into three subsystems, which are the bat box structure, the tracking/storing device, and the power and coding functionality. From these subsystems, our design will track bat visits to that box and will help bat conservationists to see the efficacity of that box.

2.1 Bat Box Structure

This subsystem, bat box structure, needs to be designed to give those bats a home that considers their safety, comfort, and health and withstands any change in weather.

2.2 Tracking Device

This subsystem, the tracking device, needs to be designed to count the number of bats using this bat box. These data can be stored in a device or transferred to a device that this user always use.

2.3 Power and Coding Functionality

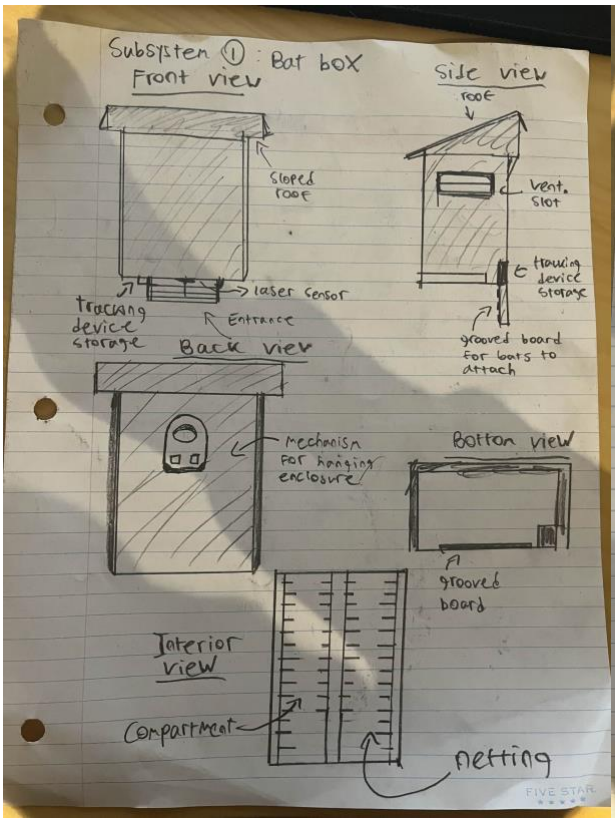
The last subsystem, power and coding functionality, ensures that our tracking device has electricity to function and works autonomously without relying on a computer.

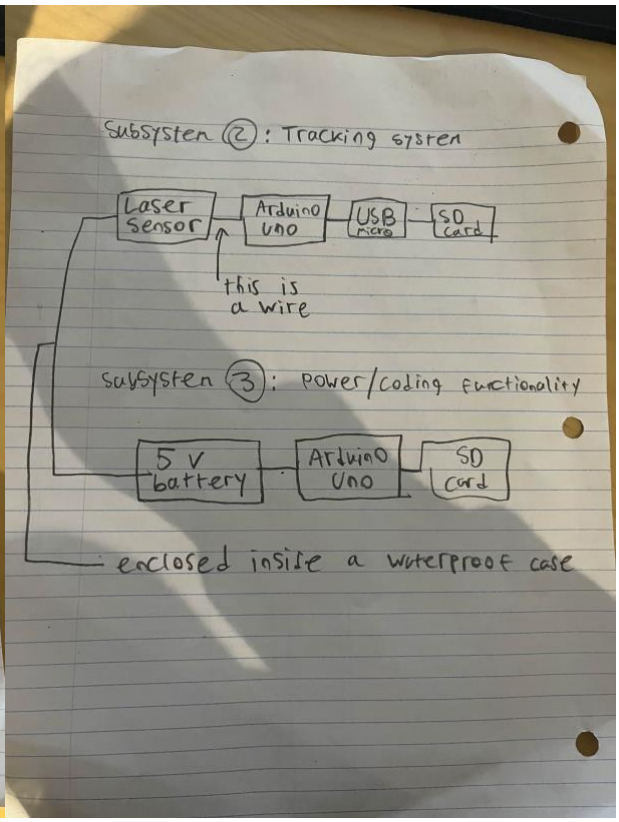
3 Engineers' Design and Description

This section will show the designs of each of our team members and the explanation, they provided, related to its functionality.

3.1 Adam Sirota

3.1.1 Design





3.1.2 Description

Subsystem 1: Bat Box Structure

The above designs illustrate multiple views for the dark wooden bat box, each portraying an important part of the structure and its functionality. Starting from the front view, the grooved board by which bats will attach to and enter the enclosure is displayed, as well as the laser sensor and the approximate location of the waterproof case in which the tracking and power system will be stored. The side view displayed the ventilation slots, one on each side, which provide proper air flow and circulation in a low-cost fashion. The sloped roof is also shown here, with the goal of preventing water damage or weight damage due to precipitation. The back view shows the hanging mechanism which will be used to attach the box to any structure. This mechanism can be removed or interchanged with custom hanging mechanism to fit any purpose. The interior view shows the inside of the enclosure. As can be seen, ample room has been provided, as well as separate compartments to ensure the bats can roost comfortably. Bet netting is also shown; an important part of a bat habitat.

Subsystem 2: Tracking System Device

As mentioned before, the tracking system will be enclosed in a waterproof case and attached to the bat enclosure. The Laser sensor, which will detect when a bat has landed on the board by detecting when the laser has been interrupted, will connect via wire to the Arduino uno microcontroller. The Arduino will connect to the power source via a micro-USB connection. An SD card module is attached to store all the bat entry data and inputs.

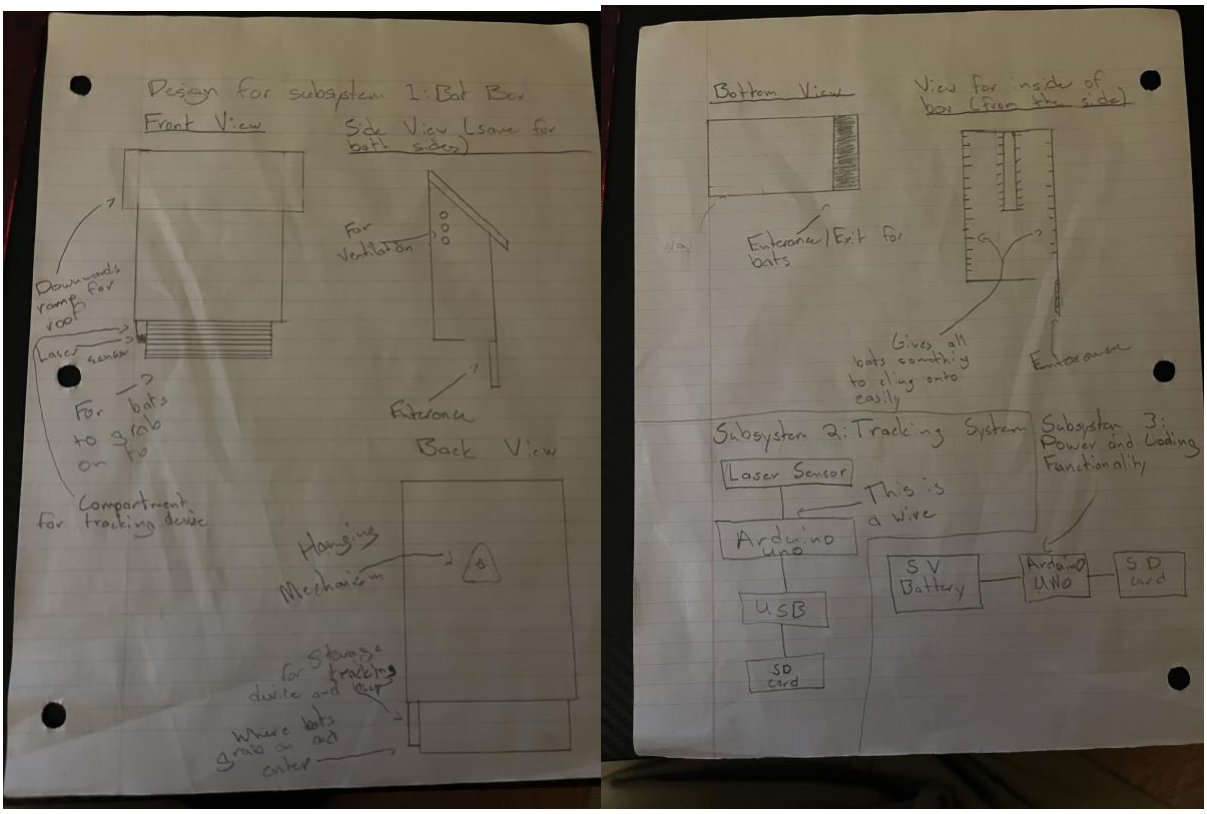
Subsystem 3: Power and Coding Functionality

Due to the power/voltage specifications of the Arduino uno, a 5-volt rechargeable lithium-ion battery will be used. This battery is also very reliable and requires little to no maintenance while providing steady power to the system. The battery can be recharged without being removed from the system via another micro-USB connection.

In terms of coding functionality, the Arduino IDE, which employs a simplified version of C++, will be used to write and maintain programs. These programs will ensure the Arduino functions as needed.

3.2 Brayden Fitzgerald

3.2.1 Design



3.2.2 Description

Subsystem 1: Bat Box Structure

The design above for subsystem one includes a front view, side view, back view, bottom view, and a view of the inside of the bat box from the side. Starting with the front view, you can see that the roof is tilted on an angle, so that precipitation does not build up on the roof of the bat box. You can also see the slots at the bottom of the box, which allow easy access for bats to grapple onto and enter the box. Right where the slots are, the laser is located just to the left, along with the other components that help track the amount of bat visits. These components including the laser will be in a waterproof case, that has a very tiny slit in it to let the laser track movement across the slots. Now, for the side view, which is the same for both sides, you can see that there isn't a ton to it other than the fact that there are ventilation points, which helps a lot with temperature regulation and humidity control. From the back, you can see there is a hanging mechanism, which allows for easy mounting onto any type of object, although most likely a tree. From the bottom, you can see how much space there is for the bats to enter and exit the box. For the view of the inside of the box from the side, you can see that there is bat netting. This allows for many bats to easily cling onto the netting and provides them with a roosting site.

Subsystem 2: Tracking System Device

As you can see in the rough diagram, the way the amount of bat visits will be tracked starts from the laser sensor, which then is connected straight to the Arduino Uno which processes the signals from the laser

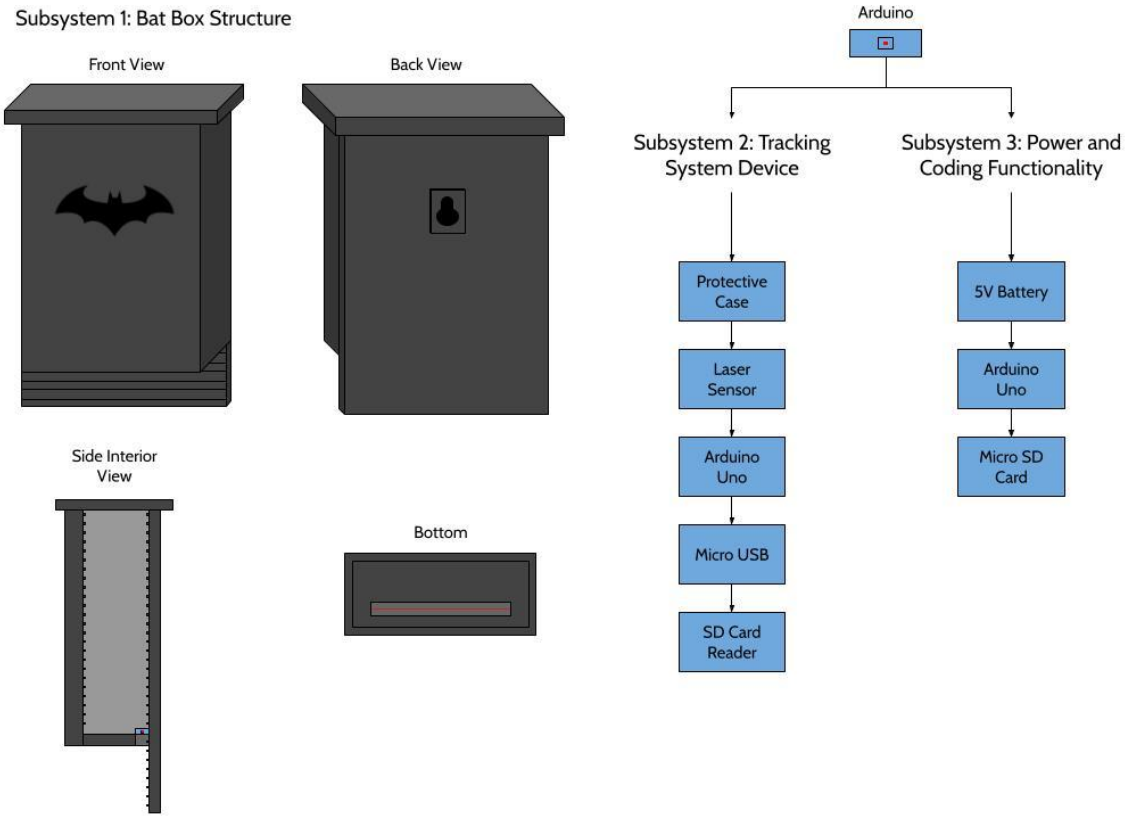
sensor. There is also a USB, which is connected to the Arduino Uno, which allows for the programming for the Arduino. Then lastly, the SD card is used to grab all of the information so that the person who wants to know the statistics on how many bat visits there are, can easily access the information through the SD card.

Subsystem 3: Power and Coding Functionality

As you can observe from the diagram under subsystem 3, a 5 volt battery will be powering the Arduino Uno which is capable of tracking and storing all data through coding that doesn't need any maintenance and can all be done if there is a power source which is the batter hooked up to it. Attached to the Arduino Uno, there is an SD card, which will track all the coding in the Arduino Uno, so that the person who is looking for the information on the bats can have easy access to it. This setup is very trustworthy, and requires very little maintenance, although the changing of batteries, and updates you may need to make within the code will have to be done manually. It also isn't an expensive setup, which can help out with funding other parts of the bat box that may need it.

3.3 Jordan Draper

3.3.1 Design



3.3.2 Description

Subsystem 1: Bat Box Structure

The bat box design showcases its structure and functionality through multiple views. The front view includes a grooved entry board for bats, a laser sensor for tracking visits, and a waterproof case for the tracking system. The back view features a hanging mechanism for easy attachment to trees or other structures. Inside, ample space and bat netting create a comfortable resting environment, while a tracking device box detects bat entries and exits through strategically placed openings, ensuring efficient traffic management and blocking access to other animals. Overall, the design balances practicality and cost-effectiveness to provide a safe habitat for bats.

Subsystem 2: Tracking Device

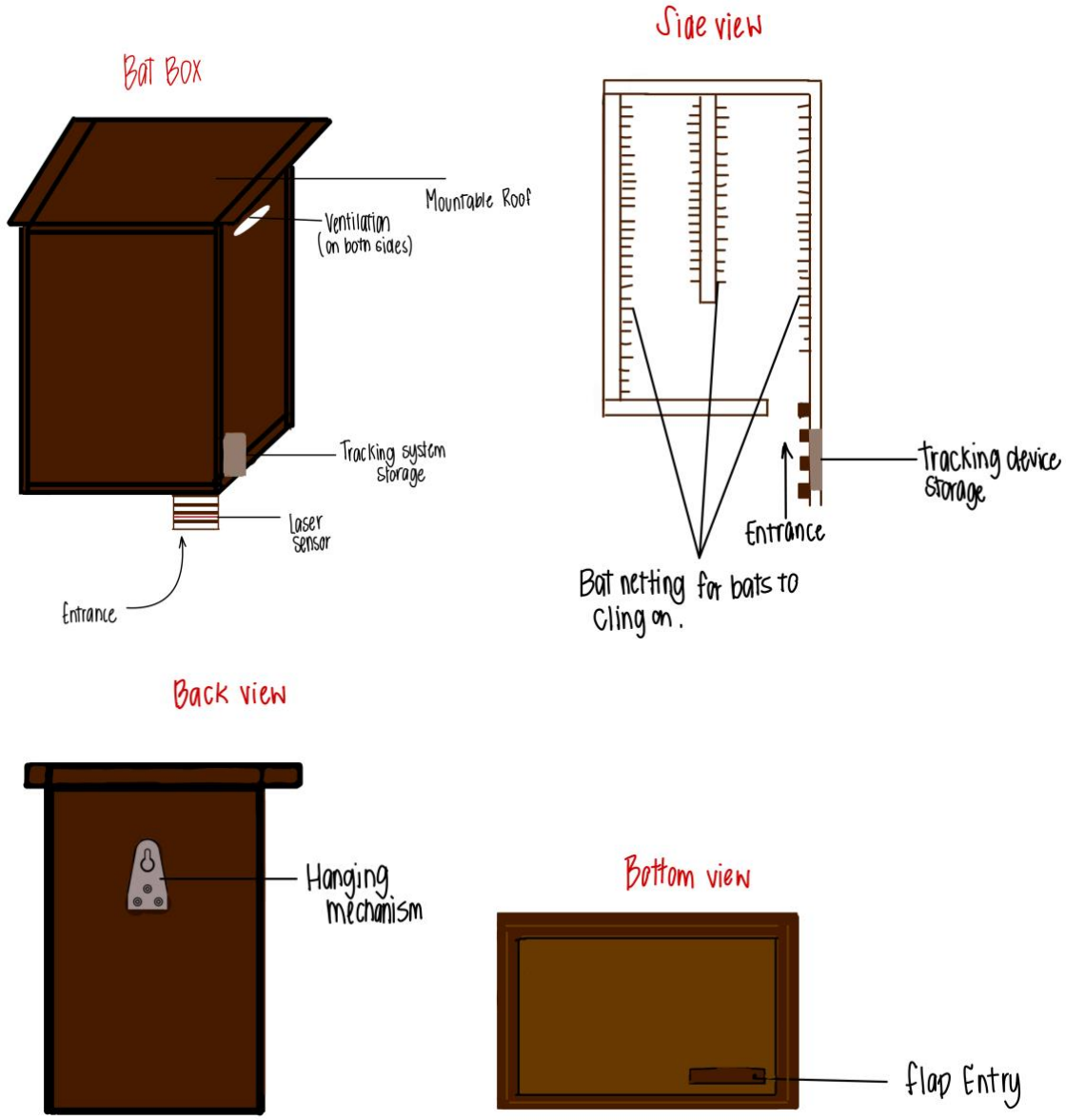
The tracking system is housed in a waterproof case, featuring a laser sensor that detects when bats land by interrupting the beam. This sensor connects to an Arduino Uno, which processes the signals and records data on an SD card. Powered by a rechargeable battery pack, the system includes a voltage regulator to maintain optimal power levels. An LED indicator provides real-time visual feedback on bat activity. This setup operates independently of the internet, making it ideal for remote locations and ensuring reliable data collection for monitoring bat populations.

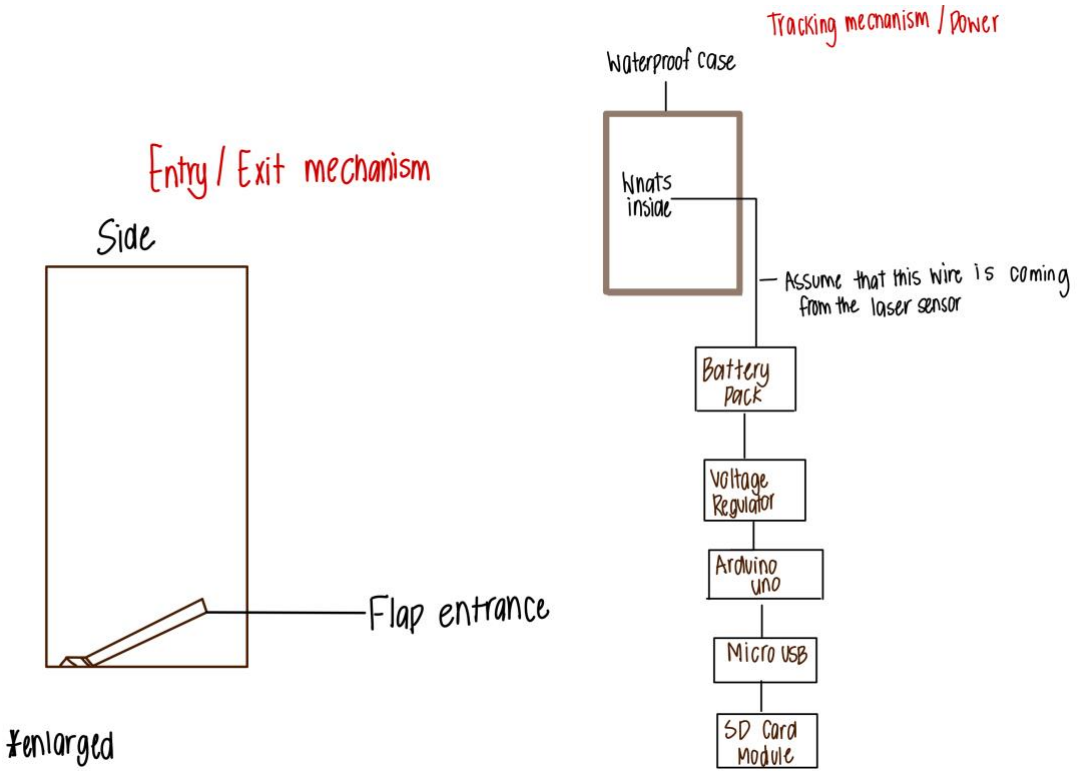
Subsystem 3: Power and Coding Functionality

The bat box system uses a 5-volt rechargeable lithium-ion battery to power the Arduino Uno, ensuring reliable and maintenance-free operation. The battery can be recharged via a micro-USB connection, allowing for easy access without removal. The Arduino Uno can be programmed using C++ in the Arduino IDE and control the bat tracking system, manage sensors, and log bat visits. This requires minimal setup and maintenance with occasional battery changes, providing a steady power supply for long-term monitoring.

3.4 Hala Aldahoun

3.4.1 Design





3.4.2 Description

Subsystem 1: Bat Box Structure

The natural wooden bat box design features multiple views to showcase its functionality and components. The back view includes a hanger, allowing the box to be easily mounted on a tree or other structures. This hanger can be designed using CAD software and 3D printed, ensuring a precise fit for secure attachment. The side view provides insight into the interior layout, featuring bat netting to create a comfortable roosting area. Ample space has been allocated to accommodate multiple bats. The bottom view highlights the entry/exit mechanism, which plays a crucial role in managing bat traffic. I designed a small opening to prevent overcrowding, ensuring that the sensor can accurately track bat entries and exits. Finally, the general view of the bat box encompasses all these features, including ventilation openings on both sides for proper airflow which is very low- cost. A Waterproof designated area for the tracking system is included on the side, providing a secure location for essential components. The roof design is mountable, offering flexibility for installation, whether hung or placed on a flat surface.

Subsystem 2: Tracking System Device

The tracking system comprises several key components that work together to monitor bat visits effectively. The battery pack serves as a rechargeable power source for the Arduino and other components, ensuring continuous operation. If necessary, a voltage regulator is included to convert the battery voltage to the appropriate level for the Arduino and sensors. The Arduino Uno acts as the main controller, processing signals and managing the overall system. A Micro USB connection allows for easy charging of the battery pack and programming of the Arduino. The laser sensor detects bat entries by interrupting the laser beam, providing real-time data on bat visits. If used, an SD card module is

incorporated for logging bat visit data, allowing for thorough analysis. Lastly, an LED indicator provides visual feedback for bat entries, enhancing the overall functionality of the tracking system.

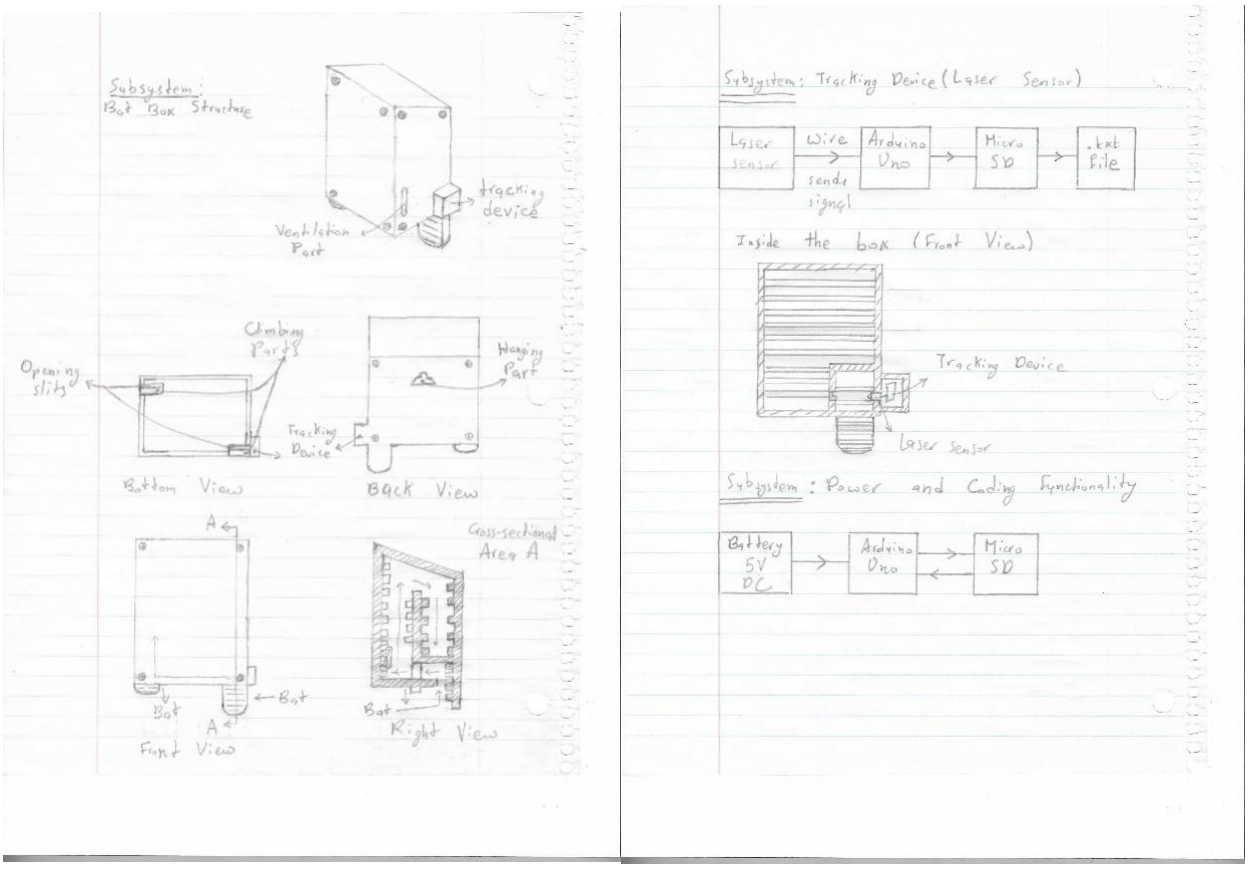
Subsystem 3: Power and Coding Functionality

The power and coding functionality of the bat box plays a crucial role in ensuring the system operates efficiently and records data accurately. Coding will be essential in controlling the bat tracking system, managing the sensors, and logging bat visits. The best programming language for this type of project is C++, which is commonly used with Arduino systems due to its compatibility and efficiency in handling hardware interactions. Arduino IDE uses a simplified version of C++, making it ideal for writing code to manage tasks like reading sensor input, counting bat entries, and controlling the power system.

In terms of power, a rechargeable lithium-ion battery is a good choice. These batteries are compact, provide sufficient power for long durations, and are rechargeable, making them cost-effective in the long term. Additionally, a voltage regulator can be used if necessary to ensure the power supplied to the Arduino and sensors is at the correct level, which is typically 5V for the Arduino Uno. The battery can be charged via a micro-USB connection, allowing for easy recharging without the need to remove the battery from the system. This combination of coding and a reliable power source ensures that the bat box system can operate autonomously, with minimal user intervention.

3.5 Rami Mosleh

3.5.1 Design



3.5.2 Description

Subsystem 1: Bat Box Structure

The natural wooden bat box structure is a unique design that provides a comfortable and safe environment for bats, promoting ease of movement and accessibility. At the front view, the structure features a single wall inside the bat box with a right-down corner opening, allowing bats to pass through and move between different sections of the box. AT the right view, the ceiling is slightly lower upon entry, encouraging natural movement behavior and healthy roosting patterns.

The design also includes an area where bats can either cross the wall or remain in place if they prefer to stay in their current location. The roof design is slightly sloped from right to left, creating a higher point on the left and a lower point on the right, preventing water accumulation and maintaining a dry environment inside.

The bat box structure also includes a tracking device box on the right side, which houses a laser sensor that detects when a bat's claws enter the notch, sending a signal to the tracking system. It has two openings: one at the right-back corner (designed for bats to enter) and another at the left-front corner (designed for bats to exit). To facilitate bat entry, the box has a large climbing structure at the right-back

corner and a smaller one at the front-left for the exit. In addition, the openings are too short in width, so that it prohibits any other animal or insect to enter.

Outside, there are removable walls, secured with screws for easy removal and adjustment. Ventilation slots on both sides ensure adequate airflow and temperature regulation.

Subsystem 2: Tracking Device

The tracking device uses a laser sensor to detect bat activity, sending a signal to the Arduino Uno when a bat touches a notch or entrance area. The data is then sent to a Micro SD card, where it is recorded as a.txt file. This system provides reliable data about bat populations. It works without internet, making it suitable for remote locations. Thus, the combination of the Arduino Uno and a Micro SD card is an affordable and efficient way to implement tracking without expensive equipment.

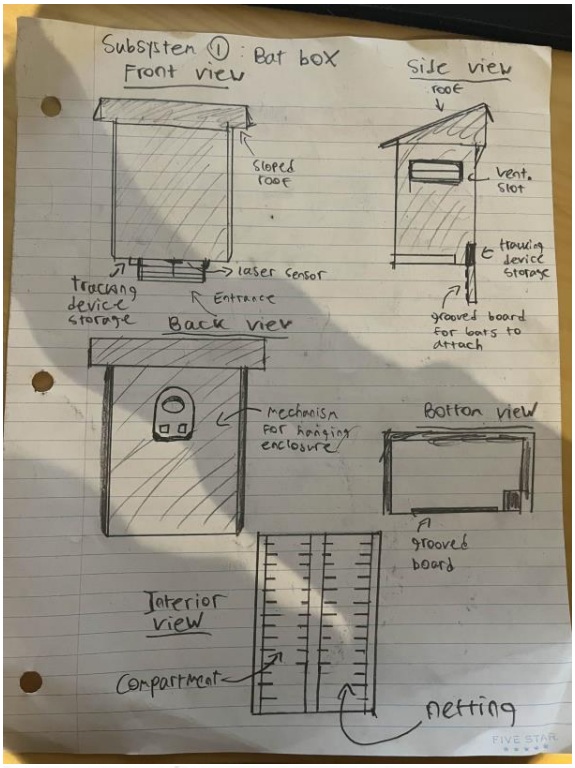
Subsystem 3: Power and Coding Functionality

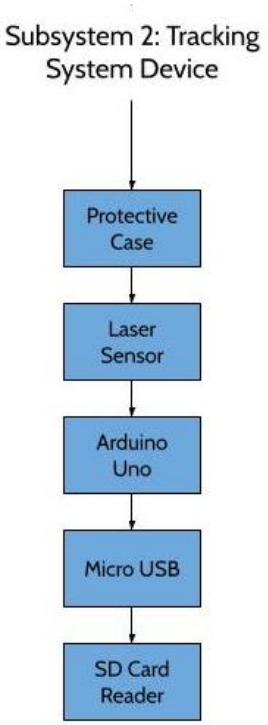
The Arduino Uno, a power and coding functionality subsystem, is designed for use in remote areas without electricity or internet. It operates autonomously, powered by a 5V DC battery, and uses a Micro SD card to store Arduino's code. This system eliminates the need for a computer to program or run Arduino. It is cost-effective, providing a reliable power source and data storage medium. The Arduino Uno can perform tracking and data storage functions autonomously, ensuring long-term monitoring with minimal maintenance. In addition, a reset button can be added to the system, if needed.

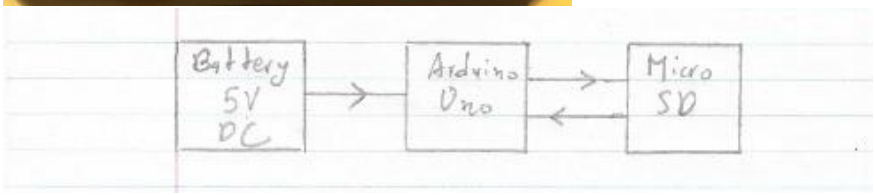
4 Final Global Concepts and Description

In this section, we will take 3 ideas from each of the three subsystems and combine between these 3 subsystems to build 3 final functional solutions.

4.1 First Global Concept and Description







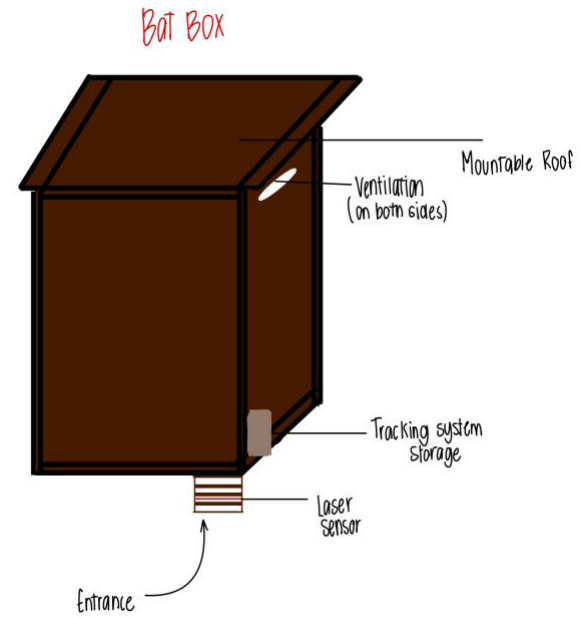
Pros

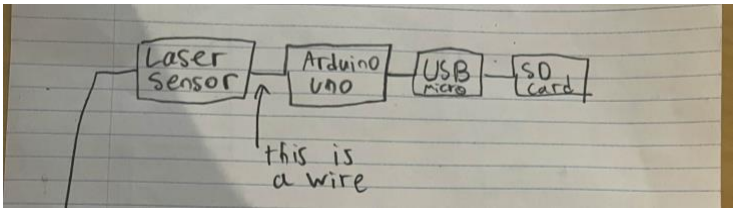
- Ventilation
- Climbing grooves
- Hanging mechanism
- Sloped roof
- Multiple compartments
- Interior device storage
- Protective casing

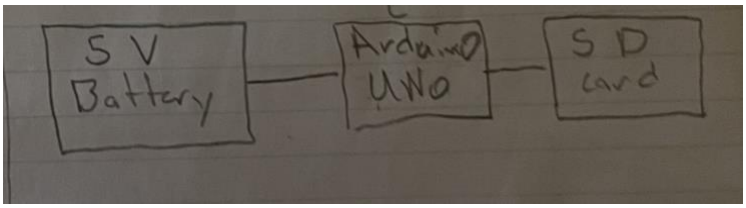
Cons

- Possible conflicting media types
- Poor interior accessibility
- No disassembly

4.2 Second Global Concept and Description







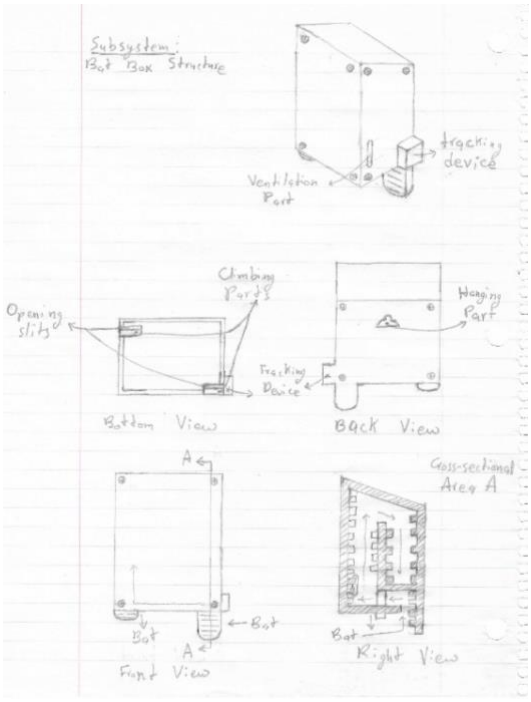
Pros

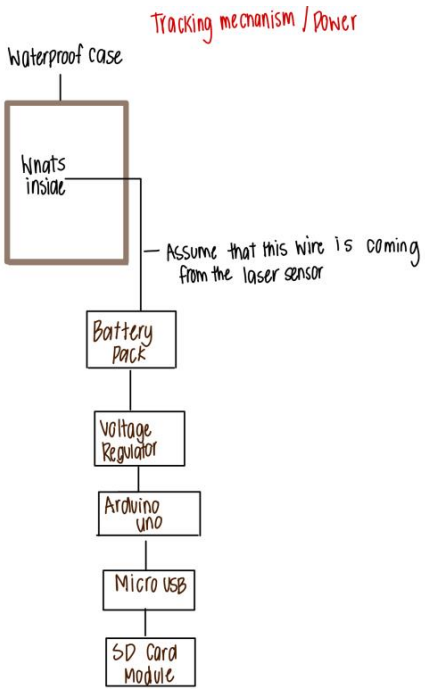
- Ventilation
- Climbing grooves
- Hanging mechanism
- Multiple compartments
- Flap entrance
- Accessible device storage

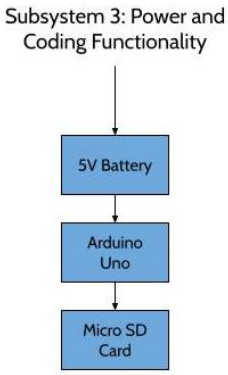
Cons

- Flat roof
- Poor interior accessibility
- No disassembly

4.3 Third Global Concept and Description







Pros

- Ventilation
- Climbing grooves
- Hanging mechanism
- Accessible device storage
- Waterproof casing

Cons

- No disassembly

5 Best Global Concept

From the three final global concepts, we will choose what is considered as the best global concept, using selection matrix. Once selected, we will end our report with a conclusion.

5.1 Comparison Analysis

Specifications	Importance	First Global Concept	Second Global Concept	Third Global Concept
Cost	3	3	2	1
Weight	3	2	3	1
Bat Box Material	3	3	3	3
Bat Box Shape	2	3	2	1
Bat Box Size	2	1	3	2
Box's Face Thickness	3	3	3	3
Bat Box Color	1	3	2	2
Temperature	4	1	2	3
Notch Shape	3	3	3	3
Ventilation System	4	1	3	2
Humidity	4	1	3	2
Predator Guard	5	1	2	3
Removable Panels	4	1	3	2
Tracking Sensor	5	3	3	3
Data Storage Media	3	3	3	3
Power Source	5	3	3	3
Built-in code	4	3	3	3
Total		125	159	143

5.2 Final Design Concept

We, as a team, have chosen the second global concept as our final design due to its balance of functionality and simplicity. Since it features a compact structure with well-thought-out compartments and a well-integrated tracking system, it marked out as our final design. Although all general concepts have the same tracking system, the first global concept was less safe for bats against predators and less warm for bats to roost, and the third global concept, due its multiple components, could complicate the user experience and potentially affect bat life.

6 Conclusion

The goal of this deliverable was to design a practical bat box with a tracking system for monitoring bat activity. After designing three subsystems, building three general concepts and then comparing using the selection matrix, we chose the second global concept as our final design. Although other concepts had appealing features, they were complex and posed some challenges. Thus, as we said, the second global concept provided a straightforward solution for bat accommodation and data collection.