Deliverable D

Conceptual Design

GNG 1103C

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Group 15

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Abstract

This deliverable is meant to display Group 15's conceptual designs. The main purpose is to show the team's process of evaluating its current designs. Through the analysis of the team's designs, a decision was made on which designs the team will continue developing.

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1. Introduction

Group 15 has been assigned the project of developing a sensor used to track the roosting habits of bats in Ontario. To proceed, each member of the team has drafted rudimentary designs for the various subsystems that will be involved.

Below, in the Subsystems chapter, various subsystems have been defined. These subsystems require clear boundaries, which allows each design to be interchangeable in any drafts of a functional solution. Also in this chapter, the various subsystem designs that the team has assembled will be described. Rough sketches will be shown, and the benefits and drawbacks of these designs will be explained.

These concepts have been analyzed against the specific design criteria that the team defined in Deliverable C [1]. In the Functional Solutions section, analysis was done to compare concepts which combine subsystem designs, focusing on their benefits and feasibility. Finally, through analysis and evaluation a best final solution has been determined, which the team will proceed with.

2. Subsystems

The team has decided on a total of 4 subsystems related to the development of the bat box and the tracking of its data. As the scope of this project is more centred around the deployment of a data-collection device to add onto pre-existing bat boxes, the sensors, power, and data storage were the team's primary focus. Based off the design criteria, it was decided that the objective of this project is to devise a device that has a variety of data inputs, requires minimal power and maintenance, has a storage system that is easily accessible, and can be mounted onto existing bat box designs without interference to bat roosting. Thus, the 4 subsystems revolve around this and their respective design criteria ensuring that the needs of the users and customers are accommodated for.

The first subsystem the team defined was the Sensors and Data Collection. It will be impossible to collect data about the bat's activities and conditions without an accurate and reliable sensor setup. This subsystem includes the sensors that could be used, how they are setup/placed and how data will be collected and transferred to the microcontroller.

The second subsystem is Power Generation and Storage. This subsystem is also extremely important as it allows the team to further define a constraint that affects the project as a whole: power. Any sensor and data storage needs to be able to fit within a strict power supply budget. These designs for power generation and storage determine which other subsystem designs are viable.

The next subsystem the team designed for is Data Storage and Communication. This subsystem will store and allow for the transfer of the collected data while also considering storage backups and the output interface. This subsystem has the largest variety of possible designs, as there are numerous ways to send and save the simple data the sensor will be producing.

Finally changes to bat box designs were thoroughly considered. As a result of there being bat boxes currently in place, this subsystem looks at ways in which sensors can be integrated into existing designs. It includes modifications that can be implemented on to any bat box to accommodate and house the electronics. These concepts are evaluated based off the difficulty of installation, ability to adapt to different designs, interference with bat roosting or structural stability of bat house and can survive the conditions of being near bats and in Southern Ontario. This subsystem was modified to focus on the integration of the sensors and the device on to existing bat boxes rather than coming up with a new design because of the team's consensus to leave design changes to the researchers yet provide them with a device and a way of mounting it to aid them in tracking the results of their changes.

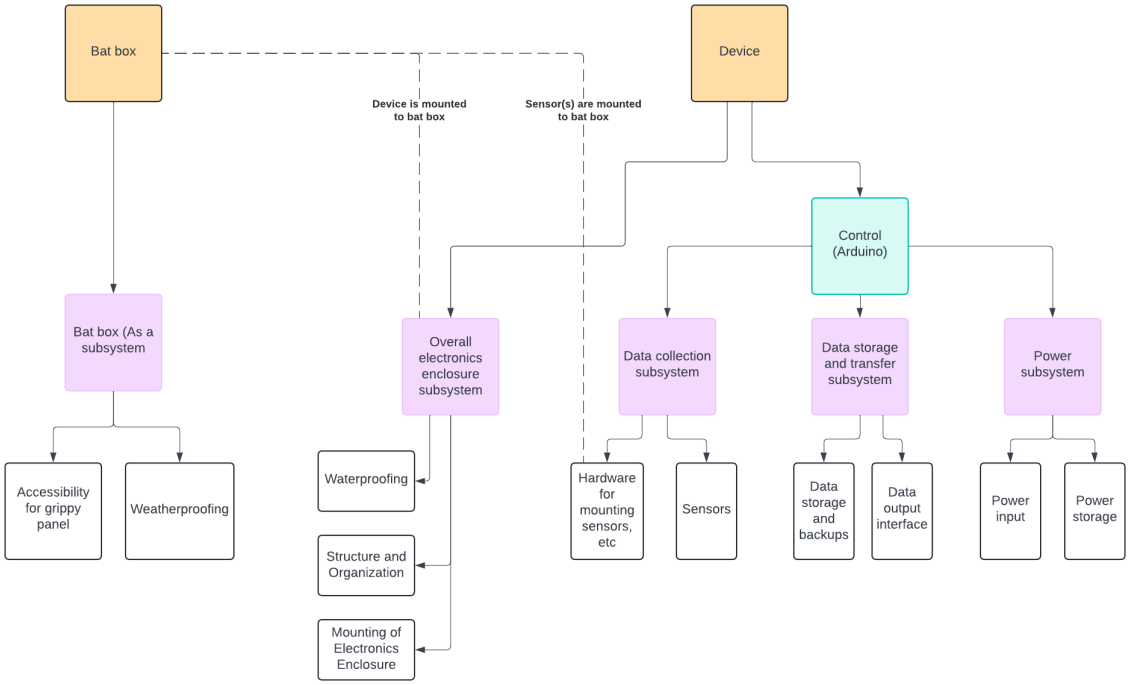

Figure 1: Chart describing each of the subsystems, what they consist of and how they are related to each other. A major change was made to the Bat Box and Overall Electronics Enclosure Subsystems in which they were both combined. This way, the subsystem focuses on modifications made to the bat box to accommodate the sensors, while still taking into consideration bat accessibility and weatherproofing. Furthermore, the Data collection and Sensor subsystem was changed to not include hardware for mounting sensors yet will still reflect on placement of sensors.

2.1. Sensors and Data Collection

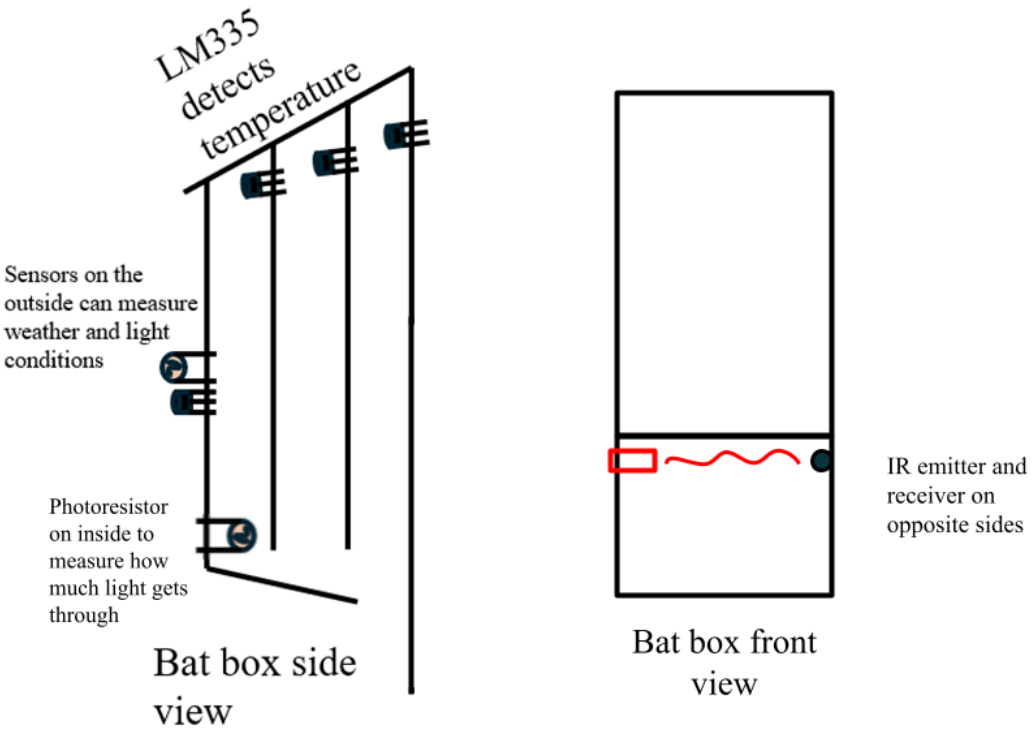

Figure 2: This design uses an outside photoresistor to measure the light outside, and a photoresistor on the inside to measure how much light gets through. Outside and inside temperature is also gathered using LM335 modules to analyze the insulative capabilities of the bat box. Detection of bat entrance and exits is done using an IR sensor whereby the receiver is on the opposite side *[2]*. Although through-beam sensors are reliable, accurate installation of both emitter and receiver can be difficult and costly. There is also a large consumption of power due to the number of sensors.

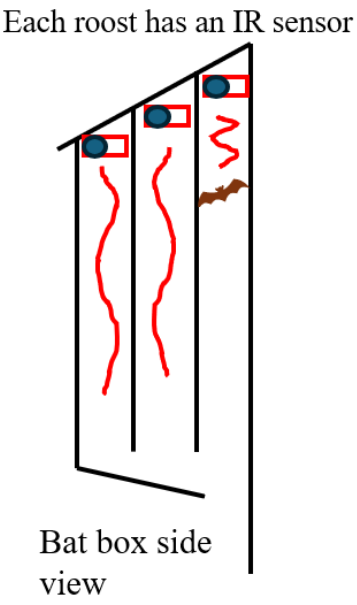

Figure 3: Using 3 IR sensors, this design could actively monitor the occupancy of each slot. This could track which roosts were being used and for how long. This design would also have the least amount of error but use the most amount of power.

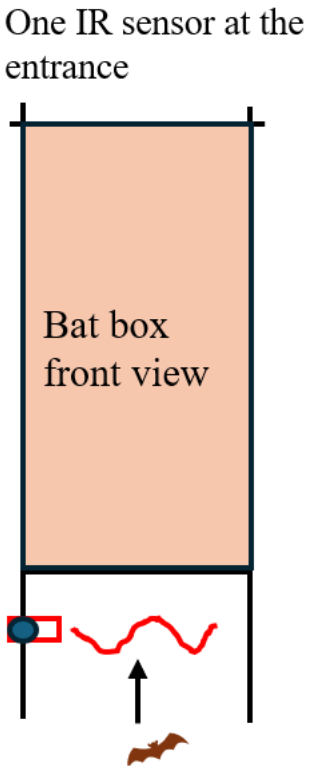

Figure 4: Single IR sensor at the entrance. This will only be able to count the number of times a bat enters or exits the bat box. If coded right, it will be able to tell the group how many bats enter the box, but with a small amount of error. This design is estimated to use the least amount of power.

2.2. Power Generation and Storage

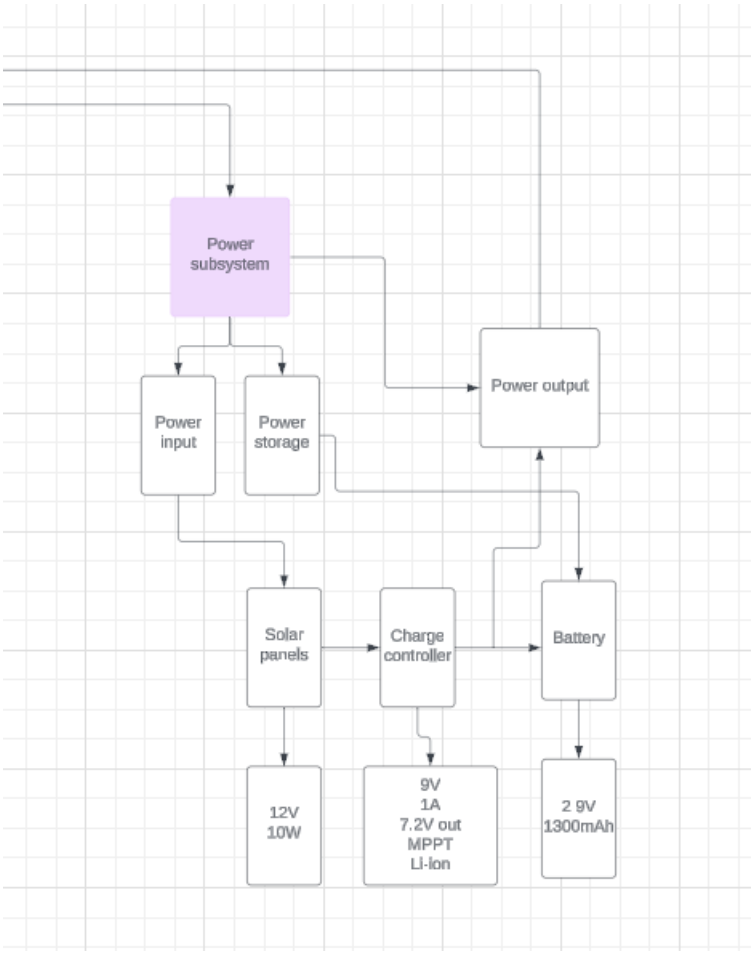

Figure 5: Solar system using lithium-ion batteries. The solar panels send voltage to the charge controller, which charge the batteries and power the Arduino. At night, the batteries power the Arduino. 9 volts is an appropriate voltage for powering the Arduino, and the according panels and charge controller work well with the rest of the design.

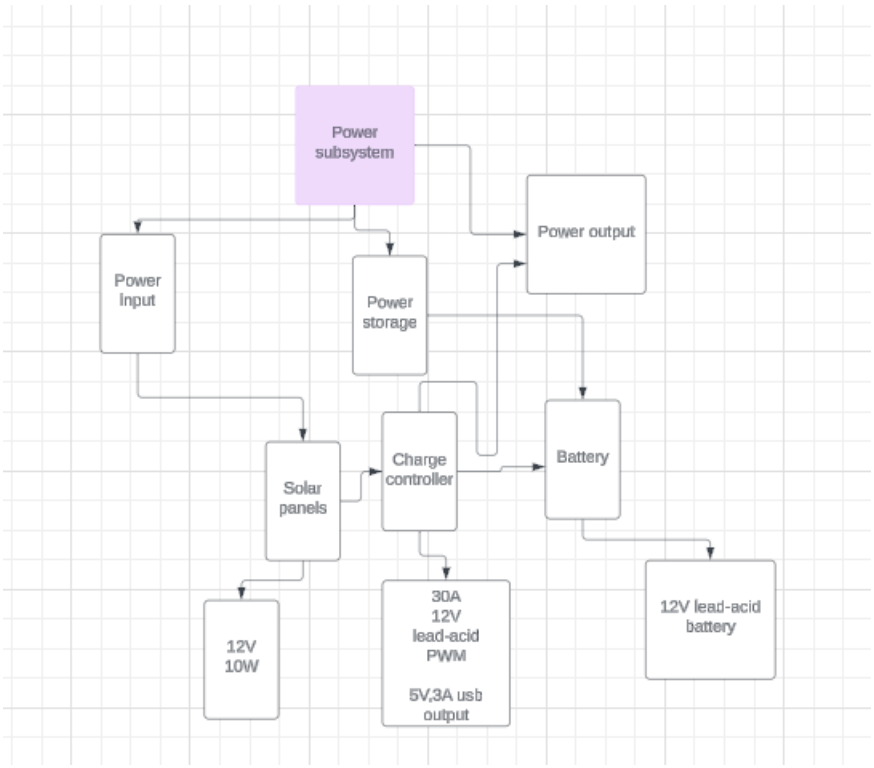

Figure 6: Solar system with lead-acid batteries and a 30A charge controller. This system works the same as in figure 5, but with different batteries and a different charge controller. The biggest variation between the 2 is the price of the different components.

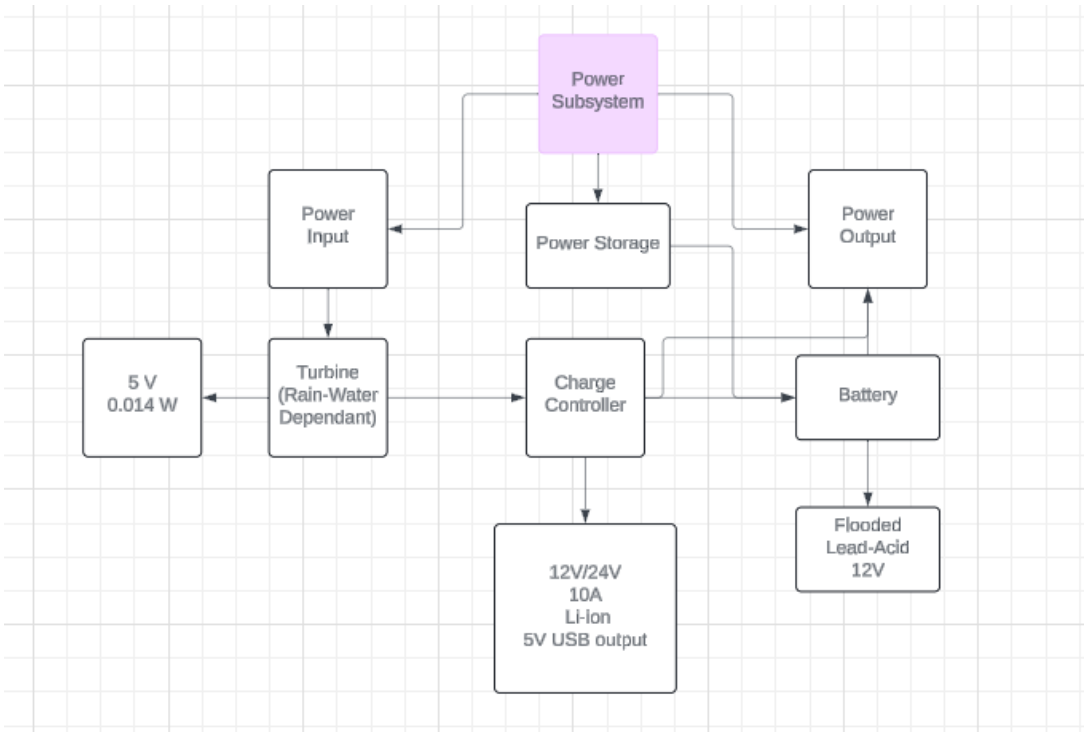

Figure 7: Rain-water turbine which powers the Arduino. Due to the inconsistent nature of rainwater, a battery is necessary and therefore a charge controller is necessary to protect the battery.

2.3. Data Storage and Communication

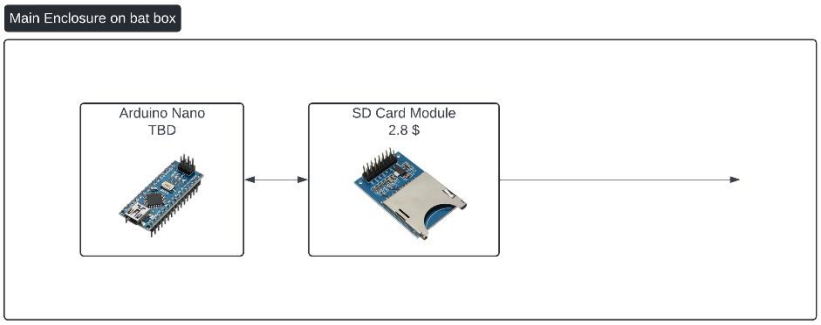

Figure 8: Most simplistic, feature-free, and cost-effective Data storage layout. SD card module for long term data storage. This design requires the least amount of power and is the least expensive, however the data can only be accessed by taking it right off the bat box. Multiple SD cards would be needed to ensure the box is never offline.

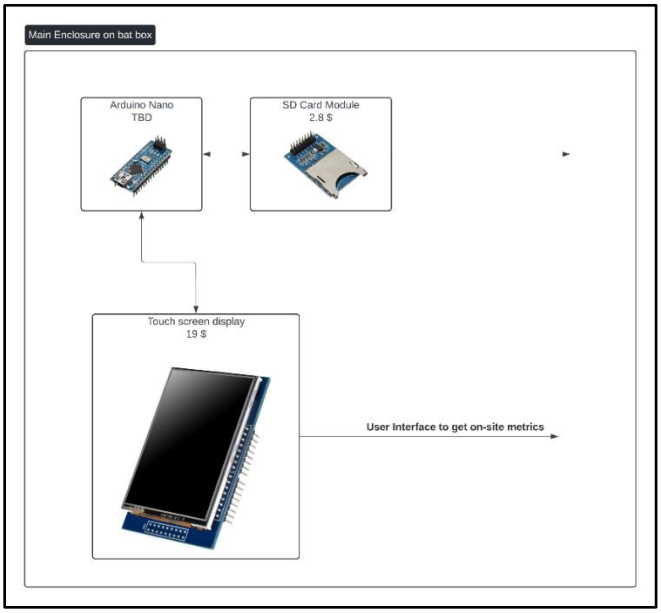

Figure 9: SD Card module for long term storage of data, and a touch screen display on the bat box for accessing on-site metrics. This display would allow someone to access the data immediately upon arriving at the bat box. This design would take more power than just the SD card alone and would require significantly more coding.

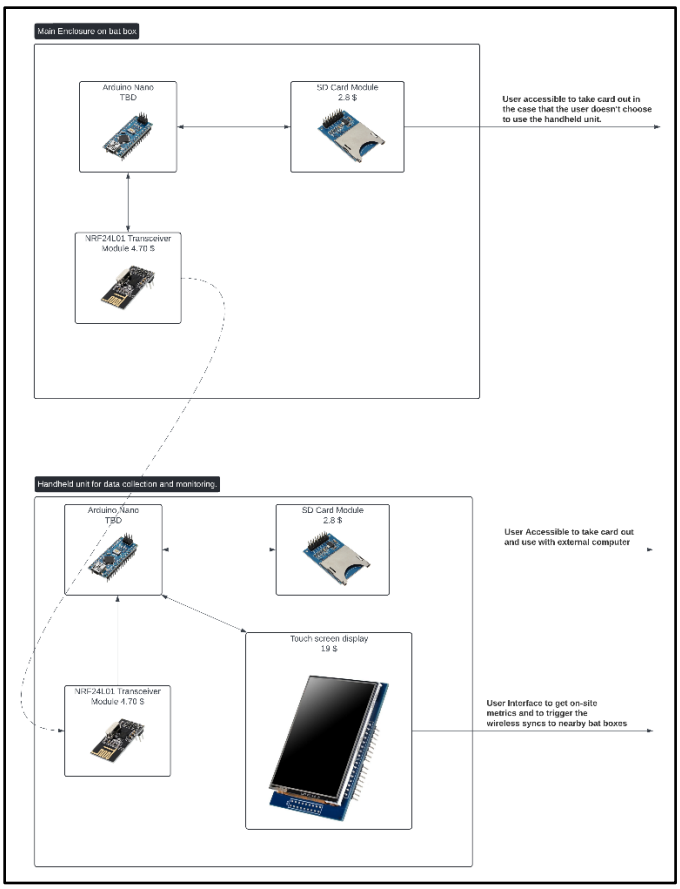

Figure 10: Concept of both a main enclosure at the bat box, as well as a handheld unit used to wirelessly sync the data down from the bat box from nearby. Allows easier access to data without needing to extract the SD card from up on a wall or pole where the box is mounted. Wireless communication done using a transceiver module on each end. One handheld unit can be used to access multiple nearby bat boxes.

2.4. Bat Box Modifications

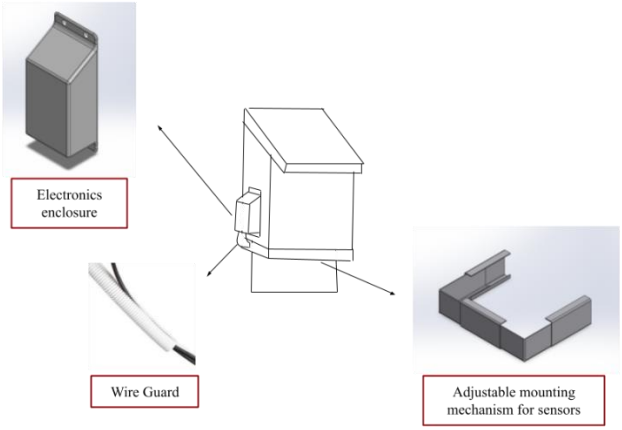

Figure 11: The first concept includes an electronics enclosure on the side of the bat box, an adjustable mounting mechanism for the sensors and a wire guard connecting the two.

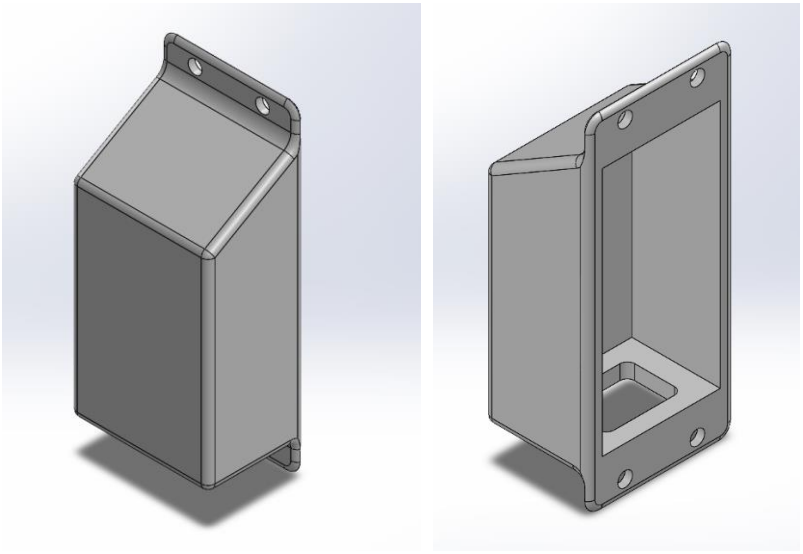

Figure 12: The electronics enclosure features a sloped roof due to their enhanced water-proofing properties. Two sets of holes at the top and bottom are for fastening the enclosure to the bat box, at the dividers, with exterior grade screws. As seen in the second image, a cutout is placed at the bottom for the wires to pass through. Furthermore, this part will be printed out of ABS as it is better suited for outdoor conditions *[3]*.

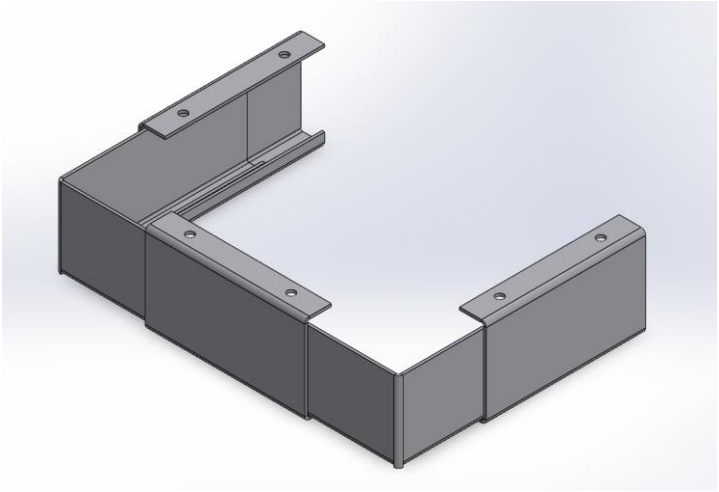

Figure 13: The adjustable mounting mechanism for the sensors is designed to accommodate any size opening and is easily attachable with the use of exterior grade screws into the panels. The purpose of this apparatus is to house the IR sensor and allow direct access to the chambers for other sensors. The IR emitter is meant to be placed on one end and the receiver on the end directly across. Channels are also built in along the front side to feed wires through. The mechanism consists of multiple parts that slide into one another, offering the user the flexibility to set the dimensions. Furthermore, this apparatus acts as an extension of the bat box, therefore does not impede with bat access and landing platform area remains the same. However, this set up becomes redundant if the emitter and receiver are chosen to be placed on the same side.

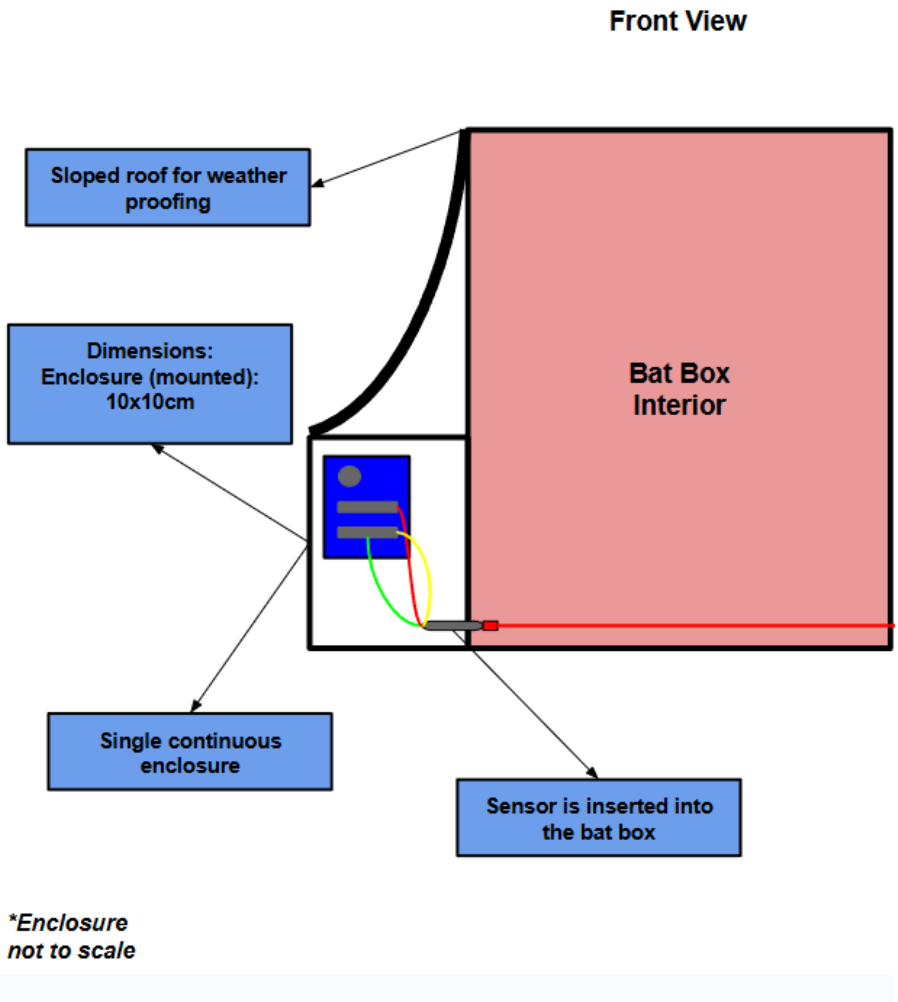

Figure 14: In this concept, one continuous enclosure would be used (thus eliminating the need for wire guards). The enclosure would be mounted to the side with a sloped roof for weatherproofing functions. The sensor would be fed into the box by cutting a hole in the panels. A disadvantage would be the more complicated mounting/dismounting process for maintenance workers.

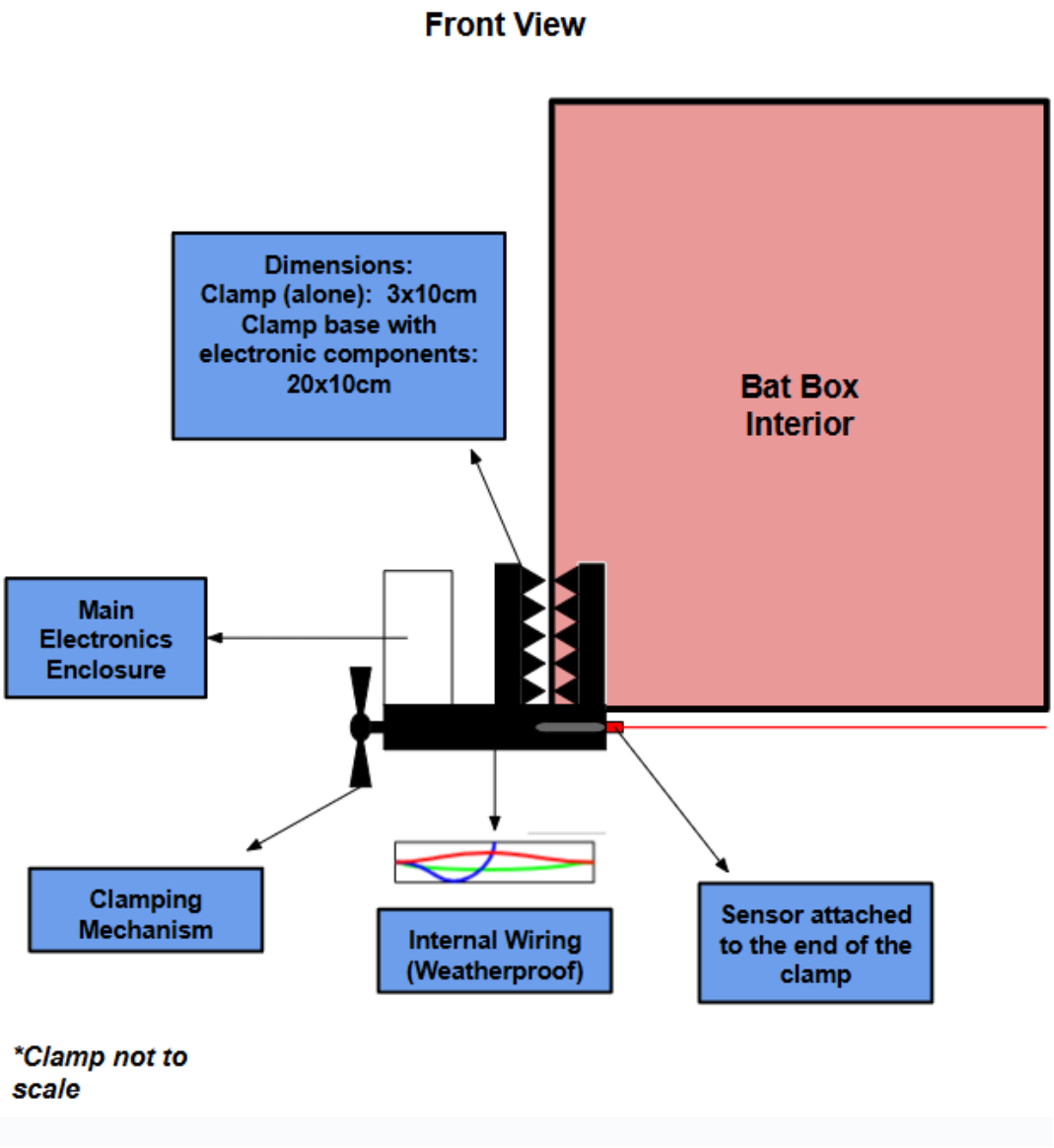

Figure 15: In this third concept, the sensor and the electronic enclosure would be a combined unit, integrated to the bat box with the use of adjustable clamps (a simple mechanism requiring no tools, perfect for non-engineers). The passive mounting process (no piercing of the box itself) would allow for quick and easy repairs. In terms of weatherproofing, the wires would be integrated in the unit itself, allowing for protection from the elements. However, the protruding nature of the clamp could interfere with the entry and departure of the bats and the weight could prove an issue regarding the durability of the clamp.

3. Functional Solutions

Below are the solutions the team has chosen to evaluate. Each solution is made up of one design from each of the subsystem categories.

3.1. Option 1

The first option consists of the temperature and light sensor and data collection system. The unit will be solar powered in conjunction with the use of lithium-ion batteries. The sensor and electronics enclosure follows the design of the adjustable mounting mechanism as it can better accommodate the through beam IR. An SD card, placed within the side electronic enclosure, will be used for long term storage and a touch screen display, fastened to the outside of the enclosure, will be present for on-site metrics.

3.2. Option 2

The second option consists of an IR sensor at the entrance of the bat box. This sensor will be housed in the clamping mechanism which, in addition, contains an enclosure for all electronic boards. Power will be supplied via solar panels in conjunction with a lithium-ion battery. With regards to data storage and communication, it will involve wireless communication with the use of a transceiver from the enclosure to a handheld device. It also includes the option of extracting the SD card.

3.3. Option 3

The third option consists of IR sensors in each roosting chamber. To better accommodate this sensor placement, the electronics enclosure that allows cutouts within the panel will be used. Material from the panel adjacent to each chamber will be removed to provide sensors with direct access to area. Power will be supplied using the rain-water turbine and long-term data storage will occur with the use of an SD card.

4. Selection Matrix

The following matrix is an evaluation of the above options. These options are each evaluated relative to each other. Since the current designs are rudimentary, it is not possible to accurately estimate specific data (i.e. cost in dollars). Instead, the estimated cost will be compared to the estimated cost of another option. A number 3 under an option shows that, relative to the other options, it is estimated to deliver the best for the criteria it is next to. Likewise, a number 1 or 2 will show that it is less functional for that specific criterion. A total score is tallied at the end, with the highest score denoting the team's chosen solution.

/	**Option 1**	**Option 2**	**Option 3**
Cost	2	3	1
Power Usage	2	3	1
Power Input	3	3	1
Power Storage	2	3	1
Data Outputs	3	2	2
Data Error/Uncertainty	3	2	2
User interface	2	3	1
Weatherproofing	2	1	3
Installation Complexity	2	3	1
Bat Accessibility	1	2	3
Adaptability for Different Designs	2	3	1
Total Score	24	28	17

5. Conclusions and Recommendations

Our final selection for the subsystem is Option 2. It integrates all the best aspects of the designed subsystems without sacrificing anything. We will use an IR sensor at the entrance to track the habits of the bats. The power will be generated via solar panel, and stored in a lead-acid battery These will all be controlled by an Arduino. The Arduino will have Bluetooth capabilities for wireless data transfer, and it will have an SD card for data storage and wired data transfer if wireless is not an option. All electronics and wires will be secured to the bat box through the clamping mechanism which also houses the sensor.

To further develop the ideas for systems we have now, more research and testing is required. The team's priority will be testing the design's power capacity. Further research into solar panel power outputs, voltage regulation and sensor current requirements will greatly affect the team's final design. It will also be important for the team to store additional power, as solar panels can sometimes lose up to 90% of their electricity production capabilities depending on the weather [4].

Should the design have extra power capacity, extra sensors and other designs may be added onto the solution. Research into how to implement wireless data transfer using the Arduino is also necessary. Furthermore, the code for the Arduino will require some experimentation during the next phases of development, as certain assumptions and optimizations will need to occur for an accurate count of the bats.

Moreover, the team will continue optimizing the design of the clamping mechanism and electronics enclosure to address concerns regarding interference with bat departure and entrance as well as weight.

5. References

[1] B. J. M. R. Bonardi Rivard, "Deliverable C - Design Criteria," uOttawa, Ottawa, 2024.

[2] EMX Industries, "Retroreflective Photo Eyes vs. Thru Beam Photo Eyes," 6 January 2022. [Online]. Available: https://www.emxaccesscontrolsensors.com/retroreflective-photo-eyes-vs-thru-beam-photo-eyes/.

[3] Anker Make, "PLA vs ABS Filament," 10 November 2023. [Online]. Available: https://www.ankermake.com/ca/blogs/guides/pla-vs-abs-filament.

[4] Southtech Solar, "Solar Panel Efficiency in Cloudy Weather: Myths and Realities," Southtech Solar, 27 November 2023. [Online]. Available: https://www.southtechsolar.com/post/solar-panel-efficiency-in-cloudy-weather-myths-and-realities. [Accessed 13 October 2024].