Team Ate

Deliverable D – Conceptual Design

GNG1103 C – Introduction to Engineering Design

Lab Section CO2 – Group 8

17 October 2024

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Abstract

Using the previously developed benchmarking, a set of conceptual designs are created for the problem statements. An analysis of these designs is done to further the development of the final solution in future steps.

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Introduction

Bat populations are a crucial part of our ecosystems. Bats help regulate insect population growth and enhance biodiversity. Due to habitat destruction and climate change, many bat species are under serious threat. For this reason, it is crucial to provide them with bat box shelters. Not only do bat boxes provide roosting areas for bats, but they also allow for monitoring their activity to help conservation initiatives.

In this report, we will be exploring various design concepts for each of the following subsystems: bat detection, weatherproofing and temperature control, box structure, and mounting methods. By analysing these concepts, three complete functional solutions will be created from the combinations. These solutions will be assessed based on how well they meet the design criteria. The best overall solution will then be chosen. Our bat box design will include effective tracking technology and weatherproofing, as well as accommodation of small and large bats at a reasonable price point.

Subsystems:

Bat Detection- Deals with sensor types used to detect and record bat entry and exit.

Weatherproofing & Temperature Control- Includes methods for air circulation, protection against rain and regulation of the internal box temperature.

Box Structure- Overall box design. Deals with bat box shape, number of chambers and landing area

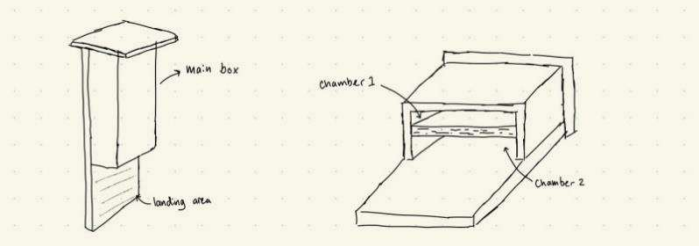
Mounting- Methods used to attach the bat box to high structures such as trees, walls, or posts.

Solutions

Solution 1

Structure:

This version of the bat box includes 2 chambers in a main box which are separated by a wooden divider. These narrow chambers replicate the crevices bats usually roost in. The box will be around 120 cm tall and 80 cm wide with a depth of 32 cm. The divider will be 3.5 cm thick, and the exterior of the walls will be 5 cm thick. The entrance is reinforced with cedar which will be at least 5 cm thick to keep out predators. The entrance will be around 2cm wide which protects against predators while still allowing the bats to enter. These dimensions will provide adequate space for big brown bats and little brown bats. However, 2 chambers limit the number of bats that can be housed and will hold less than 100 bats. There is also a landing strip that is 13 cm tall with grooves for the bat to grip on to.



- For diagram: There would be entrance that covers most of the chambers.

Sensor:

This solution utilises two sensors. One laser sensor like the Photoelectric Switch Sensor E18-B03P1 which will be attached to the outside of the box near the entrance and a motion sensor like the HC-SR501 PIR Motion Sensor which will be attached in the inside of the box, in near the divider. Having two sensors allows the box to track entries and exits by

checking which sensor was activated first. It also gives us more reliable data because if one sensor is damaged or broken, the other one can still be used. Having more than two sensors can be even more reliable, however that would increase the cost and would consume more energy from batteries. Although, two laser sensors can be easier to properly set up. By having the backup sensor be a motion sensor, it is more reliable because conditions like having a dirty bat box could render a laser sensor less functional.

Temperature control and weatherproofing:

Cedar will be the main material used for the bat box. Cedar wood is an excellent insulator, which is durable and naturally resistant to the weather. However, cedar wood is much more expensive than timber or other wood types. Furthermore, caulk and black acrylic waterproof paint will be applied to the exterior of the bat box to make sure that no heat escapes box, heat absorption is increased and there are no water leaks. No air vents will be included in this solution. This can lead to overheating, however for that to happen the temperature would have to reach at least 40 degrees, Ontario temperatures usually do not go high enough to cause the bat box to overheat, and air vents can lead to lower than ideal temperatures during certain times, like when it is windy and cold.

Mounting:

The bat box will be mounted using brackets and screws. This ensures that the box will be stable when mounted high up to a tree or post. This mounting method is reliable and long lasting, minimizing the maintenance needed.

Solution 2

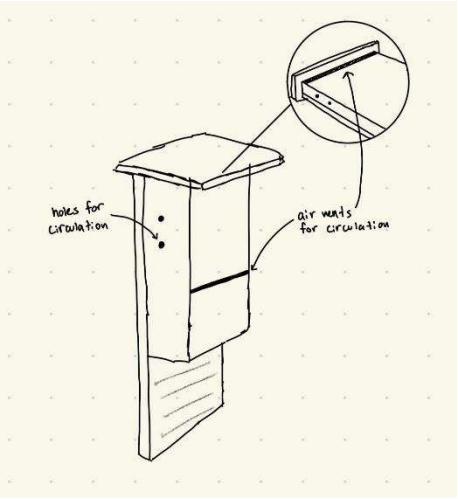
This version of the bat box includes 2 chambers in a main box which are separated by a wooden divider. These narrow chambers replicate the crevices bats usually roost in.

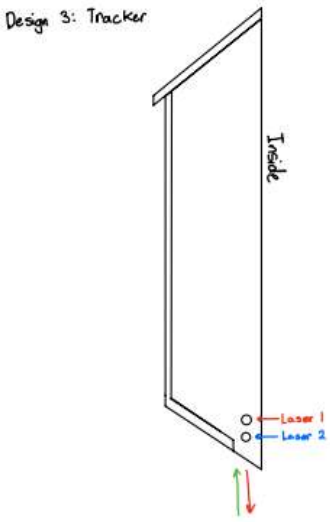
The box will be around 120 cm tall and 80 cm wide with a depth of 32 cm. The divider will be 3.5 cm thick, and the exterior of the walls will be 5 cm thick. The entrance is reinforced with timber which will be at least 5 cm thick to keep out predators. The entrance will be around 2cm wide which protects against predators while still allowing the bats to enter. These dimensions will provide adequate space for big brown bats and little brown bats. However, 2 chambers limit the number of bats that can be housed and will hold less than 100 bats. There is also a landing strip that is 13 cm tall with grooves for the bat to grip on to.

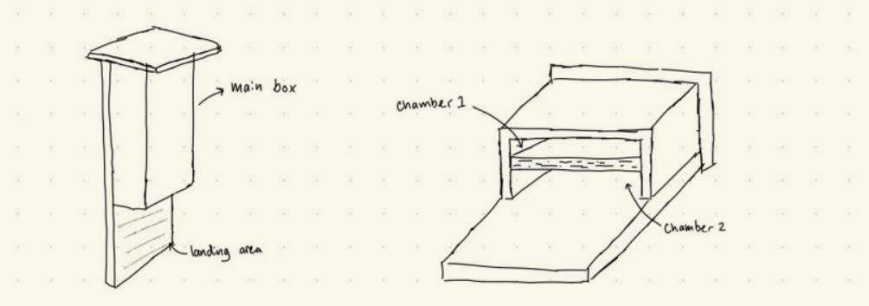
This solution uses a dual sensor design. Two laser sensors are stacked one on top of the other at the box entrance to detect the entry and exit of the bats. Two sensors allow to easily differentiate the entries from exits, depending on the order that the laser sensors are triggered. However, two sensors will increase the overall cost of this solution.

Solution uses timber material for bat box, which is an insulator that is cheap and weatherproof. However, this material can rot. Air vents will be included in this design to ensure proper air flow and temperature control. Proper ventilation will prevent the box from getting too hot during the warmer months, allowing the hot air to escape. A dark coloured paint will allow the box to absorb heat during the colder months, although it may also cause the box to overheat. To protect the box from varying weather conditions such as rain, caulking is used on the seams of the bat box. This prevents water from seeping into the chambers where the bats roost, keeping them dry.

The bat box will be mounted using brackets and screws. This ensures that the box will be stable when mounted high up to a tree or post. This mounting method is reliable and long lasting, minimizing the maintenance needed.

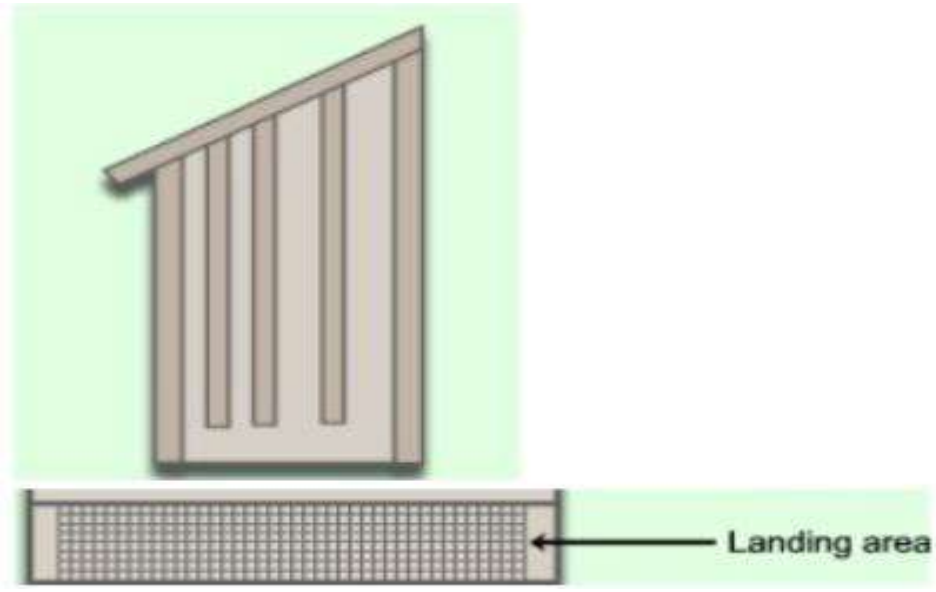






Solution 3

This final solution involves a bat box made of timber that includes 4 chambers that are separated by a wooden divider. The bat box would be 104.1 cm tall and 28 cm wide. 2 of the chambers will be around 2.6 cm wide for the big brown bats and the other 2 chambers will be around 2 cm for the little brown bats. The dimensions of this box and its chambers provide space for both the big brown bats and little brown bats. The partitions between chambers will be 2.6 cm thick and around 100 cm tall, with the outside walls being 5 cm thick. The entrance of the bat box, which would be made of timber and oak, will be around 1.7 cm wide and 5.5 cm thick. To allow better grip for the bats, the landing strip of the entrance will include groves. Although this design allows for space for both bat species while protecting them from predators, a disadvantage would be the cost of the materials needed to create the bat box, since it contains more chambers.

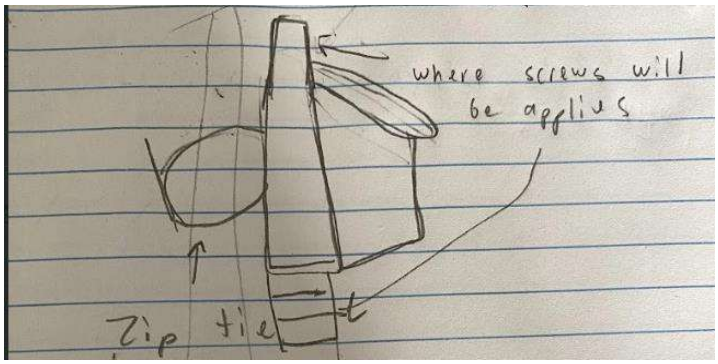


Creature Comforts. (2022). Bat box diagram with four chambers. [Diagram] https://www.creaturecomfortsinc.com/ThePetZone/BuildYourOwnBatHouse.htm

For the detection method, an acoustic sensor can be placed inside the bat box and can be used for tracking the bats by the sound of their movement. The idea has some disadvantages for its detection method. The usage of an acoustic sensor can make it difficult to track the number of bats entering and leaving the bat box due to the amount of noise being emitted. The acoustic sensor may also have trouble picking up the sound of the bats when they are not moving around in the bat box.

To help with maintaining proper temperature control of the bat box, weather resistant woods such as timber, oak, or maple wood could be used to endure the temperature changes. The bat box can be painted the colour black to help it to absorb the heat and create warmer temperatures in the bat box. However, this could cause a problem in hotter months as the bat box could overheat and create uncomfortable temperatures for the bats. Caulking the open spaces of the bat box can be beneficial in preventing cold air from entering the bat box.

For the mounting of the bat box, there are two methods that can be used. The first involves using screws and drilling them into the bat box to attach it against its desired surface. This method is great for ensuring the bat box is nicely secured but it could pose as a less effective solution when the bat box is being attached to thin and slippery surfaces like a pole. This leads to the second method that involves using large zip for the mounting of the bat box. This idea would be effective when using these on the thin/slippery surfaces. Some disadvantages for this method would be that the zip ties could loosen/break and when used on other surfaces, they are not as strong as the screws. Also, the cost and time required to make the zip tie like structure.



Selection Matrix

Criteria	Weight	Solution 1	Solution 2	Solution 3
Capacity	4	<100	<100	<200
Chambers	3	2	2	4
Maintenance Free	4	No	No	No
Tracking Device	5	Laser and Motion Sensor	2 Laser sensors	Acoustic sensor
Weatherproof	4	chalk, cedar wood	chalk, timber,	chalk, Oak, timber, and maple wood
Multispecies usage	2	Yes	Yes	Yes
Fit for Ideal Temperature	4	Cedar wood, black paint, small entrance	Timber, air vents, black paint, small entrance	Oak, timber, and maple wood, black paint, small entrance
Safe from Predators	5	Yes	Yes	Yes
Mounting Method	2	Brackets and screws	Brackets and screws	Large zip tie and Brackets and screws

Cost	3	2 chambers and cedar wood, motion, and laser sensor	2 chambers and timber, 2 laser sensors	4 chambers, Oak, timber, and maple wood and zip tie mounting apparatus
Total		85	93	82

Best Option - 3

Worst Option - 1

Middle Option - 2

Reasoning:

-Solution three had the largest capacity of around 200 bats.

- Solution 3 had the most chambers for the bats

- None of the solutions were maintenance free as they required batteries to replaced off sensors.

-Soultion 2 had the best sensors, as laser sensor are the best at detecting bats over motion and acoustic sensors and having them 2 of them gives reliable data.

- All had viable methods of waterproofing, and materials used are equally weather resistant.

- All solutions could house both species of bats.

- All solutions had viable methods of regulating the temperature within the bat house. Although solution 2 had air vents and the others did not, since air vents are situational, one solution is not necessarily better than the other.

- All houses provided protection from predators.

- Solution 1 and 2 used screws which are more secure than zip ties and most of the time bat boxes will be used on trees which do not require the zip tie apparatus.

- Solution 2 is the most cost-effective bat house, because it only has two chambers therefore requiring less materials and it is made of timber which is cheaper cedar wood.

Best Option

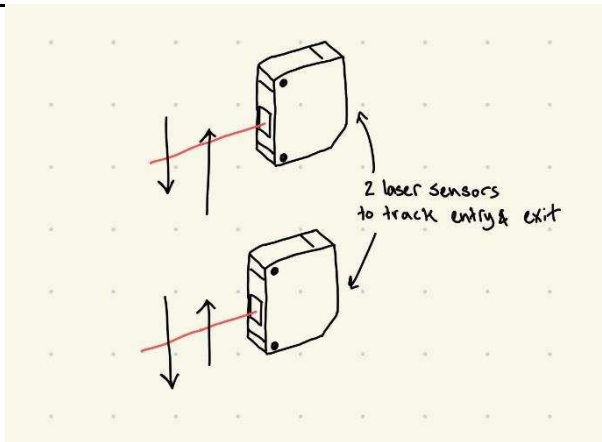
Based on the scores from the selection matrix, option 2 would be the best solution for the bat house. This solution has 2 chambers, 2 lasers sensors for tracking, a well-regulated temperature, a weatherproof enclosure and is the most cost-effective option. However, this solution needs monthly maintenance.

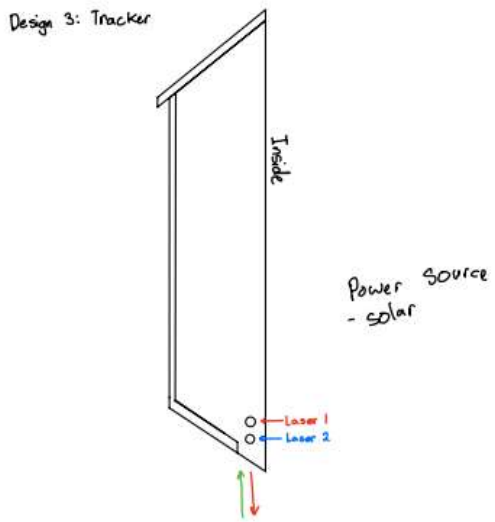
Conclusion

In this deliverable, we looked at different ideas and solutions for our problem statement. We accurately developed collaborative solutions that reflect the ideas of all group members. These solutions consisted of specific ideas that have been developed through many group meetings and multiple revisions to ensure the best designs possible. These designs, however, have not been accurately tested or gone through calculations to ensure the most efficient design possible. In future revisions of our final design and after testing, the design will continue to improve in quality. Regarding group meetings and procedures, our group effectively continues to organize group meetings and ensure that all group members know their roles and deadlines to have assignments completed by. We have come to a consensus decision to choose our best solution as outlined in this deliverable. In future testing, we will improve our effectiveness of the box by meeting with the client as well as continuing to revise our ideas based on feedback given.

Appendix

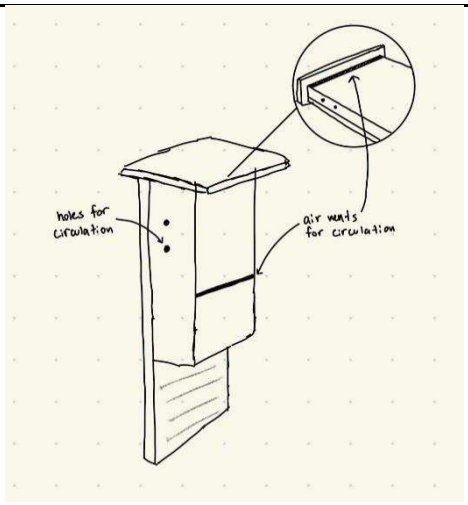
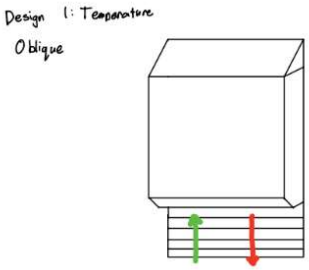
Subsystem: Sensor detection

Person	Idea
Haneen	 - 2 stacked laser sensors which allow for accurate entry and exit tracking

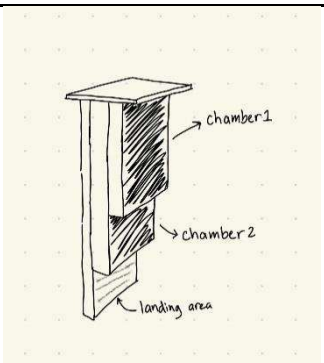
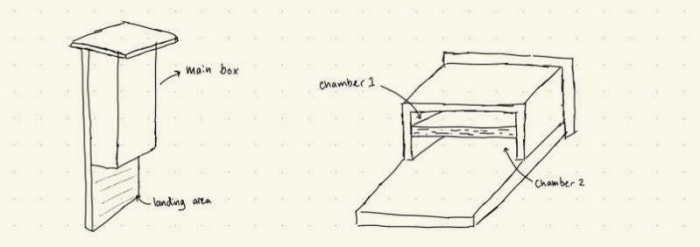
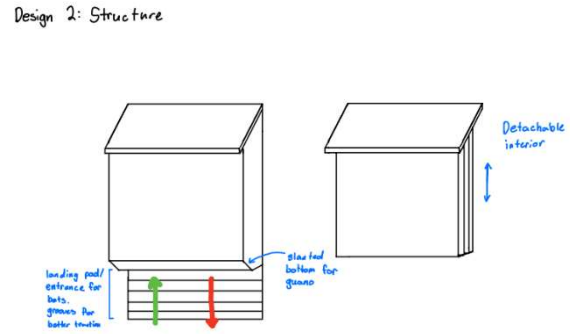
	- Drawback: 2 sensors will increase the overall cost of the design
Makia	- 2 laser sensors are used to track the entrance and the exit of the bats. Placed one upon the other - Sound sensors can be used to track bats
Coulton	 - Two stacked lasers so entries can be differentiable from exits. - More reliable data - But increase in cost.
Mujibullah	- 1 Laser sensor on the outside of the entrance - Another motion sensor on the inside of box near the entrance. - Two sensors are more reliable and allow to track entry and exits separately, however this more expensive. - Backup sensor being a motions sensor instead of laser makes it more reliable because if the conditions inside box are dirty laser sensor could be less functional. - However, laser sensor is more effective than motion sensor for bats.
Ryley	- Motion tracking sensors inside the box that track the bats movement - 2 Laser sensor to track bats entry and exit - (Solution is not cost effective but provides a lot of information on the bats)

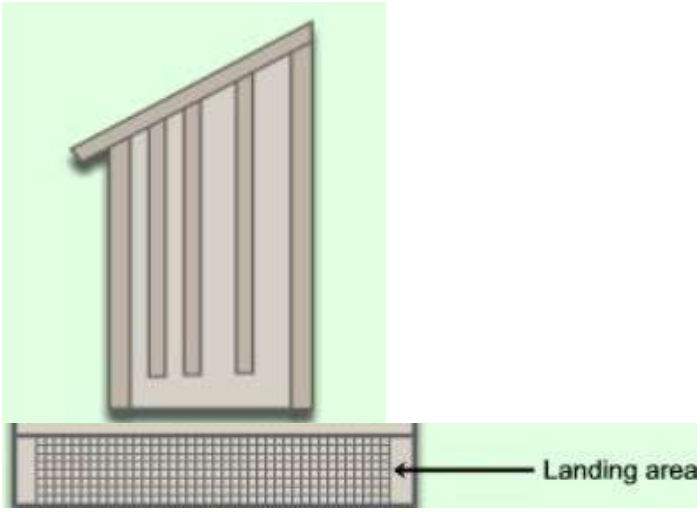
<u>Subsystem: Weatherproofing and temperature control</u>

Person	Idea

Haneen	 - Air vents/holes for circulation - Advantage: ensures box does not overheat; hot air can escape - Drawback: cold air can enter during nights of colder months
Makia	- Bat houses should be made with weather resistant wood such as oak, maple, or cedar wood - Entrance of bat house is not too big to avoid low temperatures
Coulton	- Use untreated cedar wood. - Paint box black to absorb more heat. 
Mujibullah	- Made box out of Cedar wood, which is insulating, weatherproof and durable. However, it is more expensive than timber and other materials. - Apply caulk, and black paint to outside of box to not allow water leakage and improve heat absorption. - 4 chambers allow for better insulation. - Small entrance for better insulation.
Ryley	- Make box out of timber, which in an insulator - Con: timber can rot - Seal box with silicone caulk Varnish box with oil-based varnish to weather-proof the box

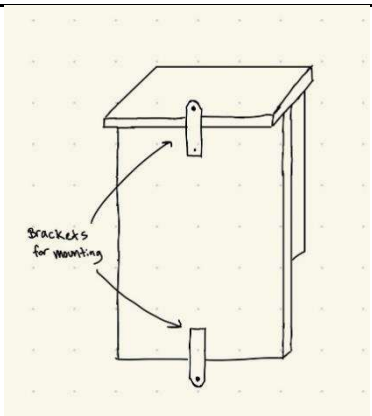
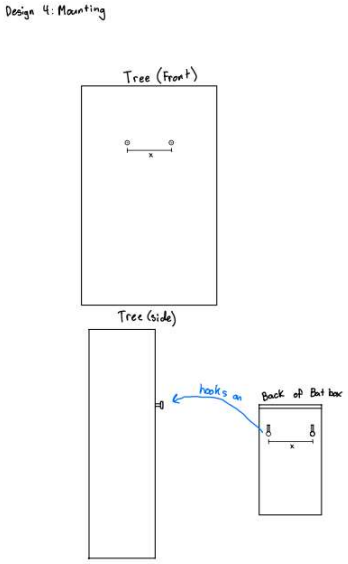
Subsystem: Structure (chambers, entrance, etc…)

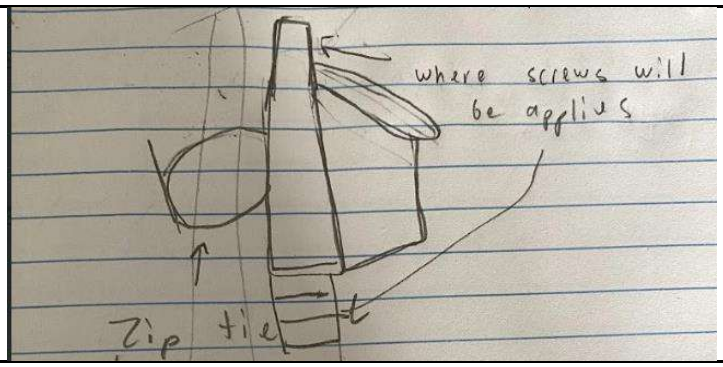
Person	Idea
Haneen	 - 2 separate chambers stacked on top of one another - Advantage: allows for a size difference in the chambers to accommodate different bat species - Drawback: Design is more complex to build  - One main box separated into 2 chambers with a wooden divider - Advantage: allows for a size difference in the chambers to accommodate different bat species
Makia	-Bat house with more than one chamber. Includes a landing pad hanging at the bottom of the house with grooves that allow for bats to climb up. -Multiple chambers allow for better insulation and more bats, but they can require more materials.
Coulton	 - Add a slanted bottom to dispose of guano and reduce the need for maintenance - 4 chambers allowing for larger capacity and better insulation - Requires more materials

Mujibullah	-Contains 4 chambers; 2 chambers will have more space and are for the big brown bats. The 2 other chambers will be smaller and are for little brown bats. This allows for both species to use box and, gives it larger capacity than single boxes. -Landing strip attached to bottom of box, contains groves that bat box can grip onto. -Entrance will be reinforced with layer of cedar and oak. This provides more protection from predators.  Images: Creature Comforts. (2022). Bat box diagram with four chambers. [Diagram] https://www.creaturecomfortsinc.com/ThePetZone/BuildYourOwnBatHouse.htm
Ryley	- Box is shaped like a hexagon to allow more room for bats inside - Shape could cause more heat loss. - Box contains two chambers inside and has a piece hanging below the box for bats to latch onto when climbing into the box

Subsystem: Mounting

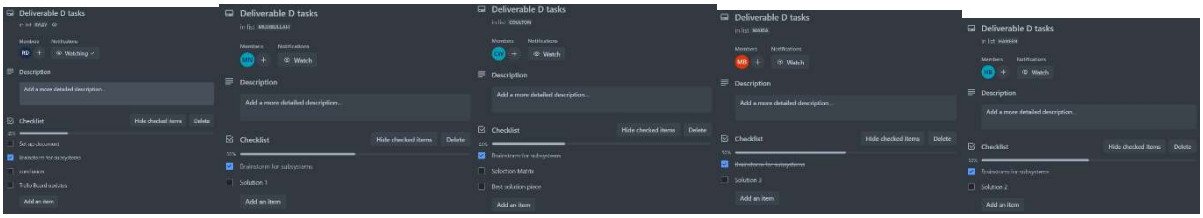
Person	Idea

Haneen	 - Two brackets with screws to mount the box - Advantage: reliable method of mounting that will last long
Makia	- Screws can be used to drill the bat house. Bat house can be mounted 9 feet above the ground
Coulton	- Use screws to attach to tree. - Easy to remove and attach. 
Mujibullah	Screws will be applied to thin boards at the top of bat boxes and at the landing stripes to screw onto things like trees. Large zip tie will be attached to boxes. They will be used on structures like metal poles which are thin and do not allow for screws. This can allow box to be attached to more things but could increase the cost and time required to make the zip tie like structure.

		
Ryley	- Screw box onto tree, or wood stake in ground about 6’ off the ground	

Trello Board updates

- Individual tasks board with assignments have been added



References

Craig, Juliet. Building homes for bats. https://www.bcbats.ca/attachments/Bat_houses_in_BC_2015.pdf (accessed Oct 17, 2024).

Creature Comforts. (2022). Bat box diagram with four chambers. [Diagram] https://www.creaturecomfortsinc.com/ThePetZone/BuildYourOwnBatHouse.htm

Ontario Parks. How to build a bat house. https://www.ontarioparks.ca/parksblog/diy-bat-box/ . (accessed Oct 17, 2024).

Wisconsin Department of natural resources. Building a Bat House. bat house handbook new.pub (batworld.org) (accessed Oct 17, 2024).