BPS - Bat Preservation Society

Deliverable D: Conceptual Design

Team C03-14

Engineering Design GNG1103

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Abstract

In the previous deliverable, design criteria were defined which were used as an outline for the benchmarking of similar products. Target specifications for our device were obtained from the client's needs and benchmarking. These criteria and specifications were used to design three subsystems for our product. This deliverable highlights the conceptual designs of the subsystems and compares them to conclude our final design.

Table of Contents

List of Figures

List of Tables

1. Introduction

Design criteria and constraints were outlined in the last deliverable (Deliverable C) and were used when as guides when generating conceptual designs. This deliverable contains drawings of conceptual designs for the three subsystems that were identified as a group. The three subsystems include the bat box, the sensor/tracking device, data storage.

This deliverable will include the following:

- Subsystem Conceptual Designs (Bat Box, Sensor/Tracing Device, Data Storage)
- Benchmarking
- Final Design

2. Conceptual Designs

2.1 Bat box

The first design concept that we considered for our design was Jett's. Jett's box featured a simple landing pad with ridges on it to allow for easier climbing, with two roosting areas for the bats once they entered. His box also had a camera attached to the bottom, so it had a clear view of the landing pad and would be used in combination with the sensor designs to verify entrances. This design meets the criteria of being easily constructed and the wooden box would be decently durable. It would also prevent any light from getting in which would allow bats to roost.

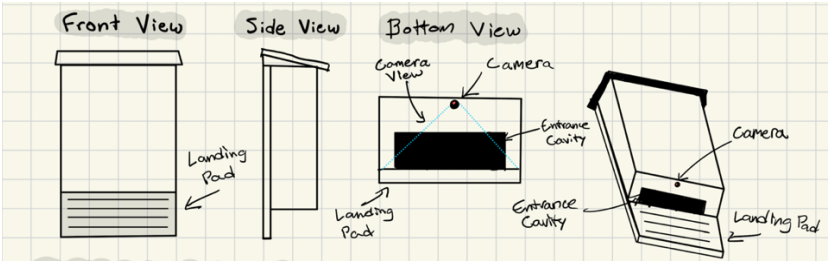

Figure 1 : Jett's Conceptual Bat Box Design

The second design concept that we considered is Tawfiq's. Tawfiq's box was a simple 15x12x3" box with a ridged landing pad, a ¾" inch entrance, and two roosting sections partitioned off by a plank of wood. This design differs from the others with the inclusion of a door on the front of the box. This would allow for easy access to the inside for maintenance as well as easy data retrieval in the case that sensor data is stored internally. This design is slightly harder to construct than other designs due to it requiring a door but makes up for it with the ease of maintenance. It also may have problems with keeping light out due to the cracks in the door but that can be circumvented with the addition of thin pieces of wood behind where the cracks would be.

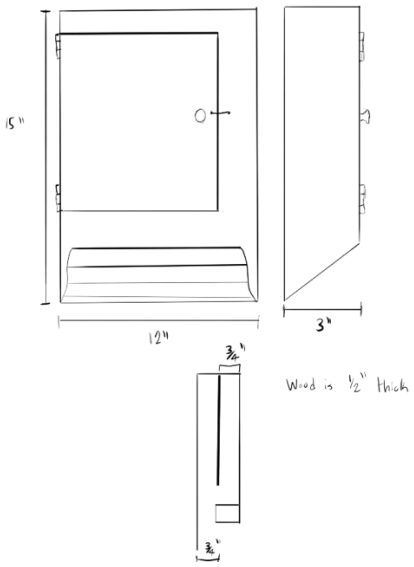

Figure 2: Tawfiq's Conceptual Bat Box design

The third design concept was made by Kian. Kian's box consisted of a landing pad with grooves and inside and 4 roosting sections with widths of ¾" to prevent pests from entering the roosting area. Additionally, Kian's design features a weatherproof outer box for the Arduino so that it doesn't take up space in the box and making data retrieval simpler in cases where an SD card is used.

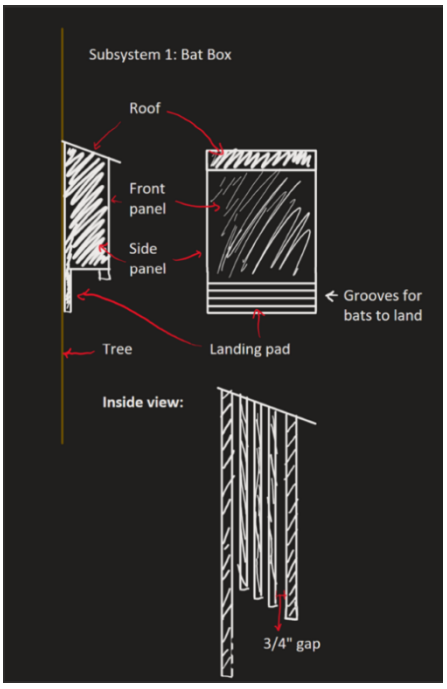

Figure 3: Kian's Conceptual Bat Box Design

The fourth was made by Jake. Jake's design was like the one created by Jett, with a simple box with a ridged landing pad, however it did not have a camera.

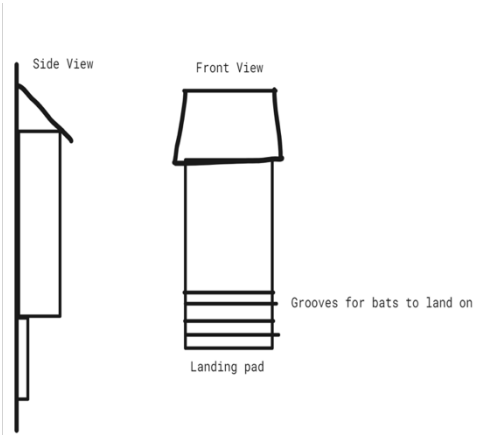

Figure 4: Syamalan's Conceptual Bat Box Design

The fifth design concept designed by Syamalan features similar design features as the other concepts. It includes a landing pad with grooves for bats to latch onto. It is made of a simple wooden box with 4 ¾" roosting sections evenly spaced out inside the box. It also features an entrance at the bottom of the box for the bats to enter and an exit at the top of the box.

2.2 Sensors

The first sensor was a shared idea between Jett and Tawfiq. This method utilized a weight sensor placed behind the landing pad that would be triggered if enough force was applied to it. When the sensor detected enough weight from the bad landing onto the pad it would log one entry. In Jett's version of this there would also be a camera that would start recording when the sensor was triggered to gather additional data. Since this design would rely on the landing pad to track bats it would only track entrances and not exits, meaning the data wouldn't have to be adjusted with population data.

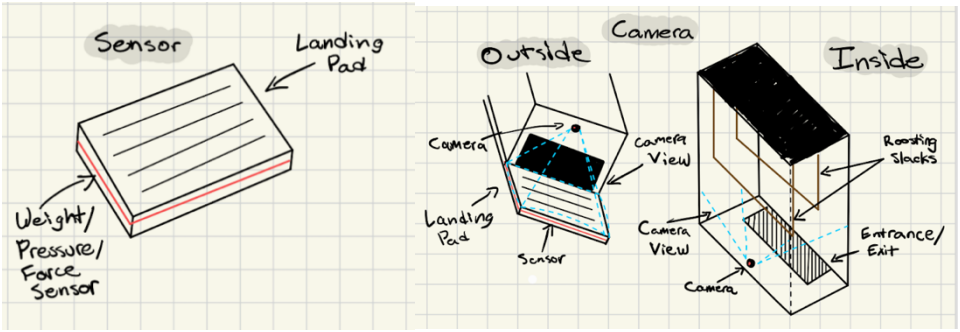

Figure 5: Jett's Conceptual Sensor Design

The second concept was a distance sensor designed by Tawfiq. Right at the entrance to the box is a distance sensor that's records the amount of distance between it and the other wall of the box. If this distance shrinks it will record an entrance into the box. This design has the problem of not being able to differentiate between entrances and exits and would therefore have to have the data adjusted based on population sizes.

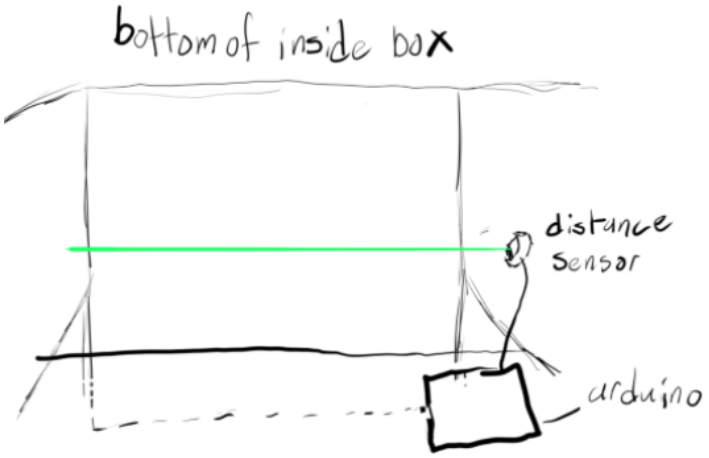

Figure 6: Tawfiq's Conceptual Sensor Design

Jake's concept for the sensor is a two light sensor system. Jake's design has two light sensors placed at the entrance of the bat box, one higher than the other. When a bat enters the box, it will break the laser on the first light sensor and then break the second, causing this to be logged as an entrance. However, if the top light sensor is broken first and then the second sensor then this won't be logged as an entrance. This design uses its dual light sensors to ensure that it only tracks the entrances of bats, leading to more accurate tracking data.

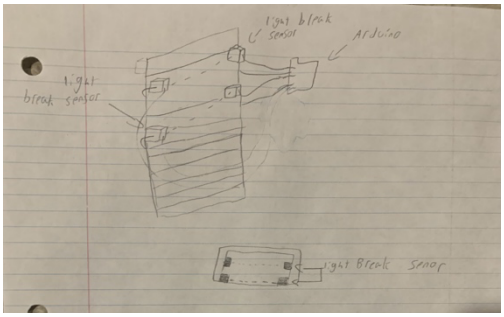

Figure 7: Jake's Conceptual Sensor Design

Kian's sensor design uses a light motion sensor that is capable of tracking direction. At the entrance of the box is a light motion sensor that will detect anything that enters the box. Since the sensor has direction tracking capabilities it can tell whether something is entering or leaving the box. This ability makes the sensor capable of tracking only entrances which makes

data analysis easier. The problem is this sensor is more expensive than the ones discussed in our other design, leaving less money for data storage and box construction.

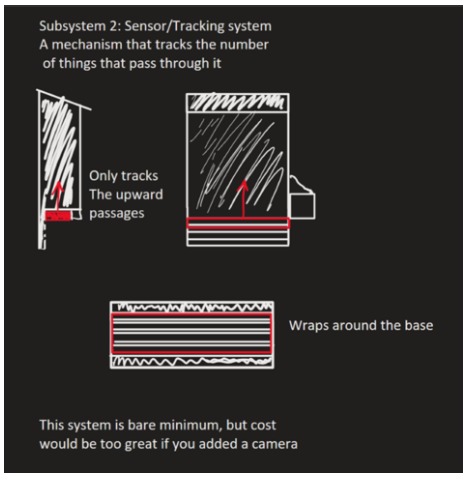

Figure 8: Kian's Conceptual Sensor Design

Syamalan's sensor design is like that of Jake's. It consists of a dual light sensor to ensure that it only tracks the entrances of bats, leading to more accurate tracking data.

2.3 Data Storage and Application

For the data storage and application Kian, Tawfiq, Jake, and Syamalan came up with essentially the same design. To the Arduino they would attach a data storage module that would be able to format data and upload it to an SD card. This method is very cost effective as storage module and SD card would cost less than $25. This does have the problem of the data only being accessible when the scheduled maintenance is done once a month but that is acceptable according to the client.

Jett came up with a design that would use an app to work. In Jett's design, the data is stored via cloud storage and can then be accessed through an app that will allow you to look at the data of your registered BPS device. This design does have the problem of cloud storage relying on an internet connection to upload the data which could cause a problem depending on the bat box location.

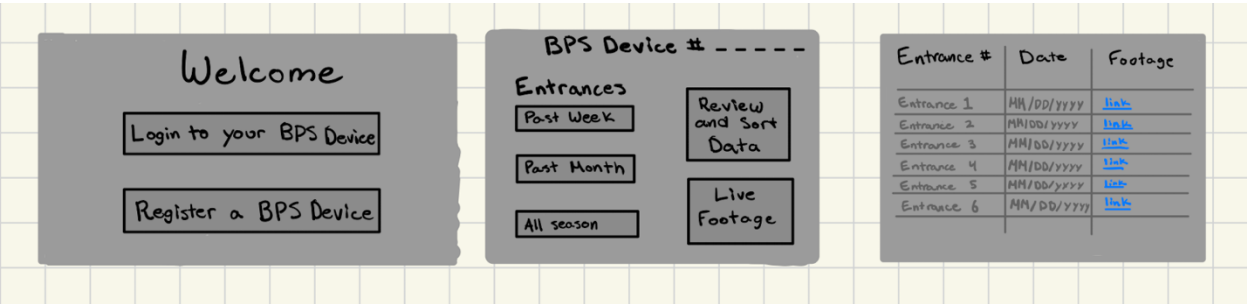

Figure 9: Jett's conceptual design data storage and application

3. Final Design

After discussing all designs and considering all design criteria and client's needs, we have decided on a final group design. Ideas and concepts from all members were taken into consideration to produce our final design.

3.1 Final Bat Box Design

For the final bat box design, we've decided to go with a simple bat box design that incorporates Tawfiq's idea of having a door to make the inside of the box more accessible when performing maintenance and Kian's idea of having a small box on the side to protect/store the Arduino. The box will be on the smaller scale and will have two roosting slots ¾ inches thick. The landing pad will be spacious and contain ridges for the bats to grip onto as they land.

3.2 Final Sensor Design

For the final sensor design, the designs that were able to differentiate between entrances and exits were favoured. Our choice was between Jake's light sensor and Jett's/Tawfiq's weight sensor, however we chose the weight sensor due to its lower cost. Jett's version of the design also allows us to incorporate the idea of a camera which would be useful for further analyzation.

The light sensor design proposed by Jake and Kian was not our final choice but was our second favourite. For this design to be able to differentiate between entrances and exits, we would need two sets of light sensors. As a result of this, the cost for this design would be between double to triple the cost of the weight sensor. This design also lacked the concept of having a camera to collect additional data, which was an additional reason for why this design was not chosen.

3.3 Final Data Storage Design

Our final data storage design consists of using cloud storage and a user application to access the data. The data storage applications will be simple and neat. Firstly, it will prompt the user to either log into their BPS device or register a new BPS device. Then the user will be able to access different sections such as entrances, revision of data, sorting of data, and live footage (if camera is used).

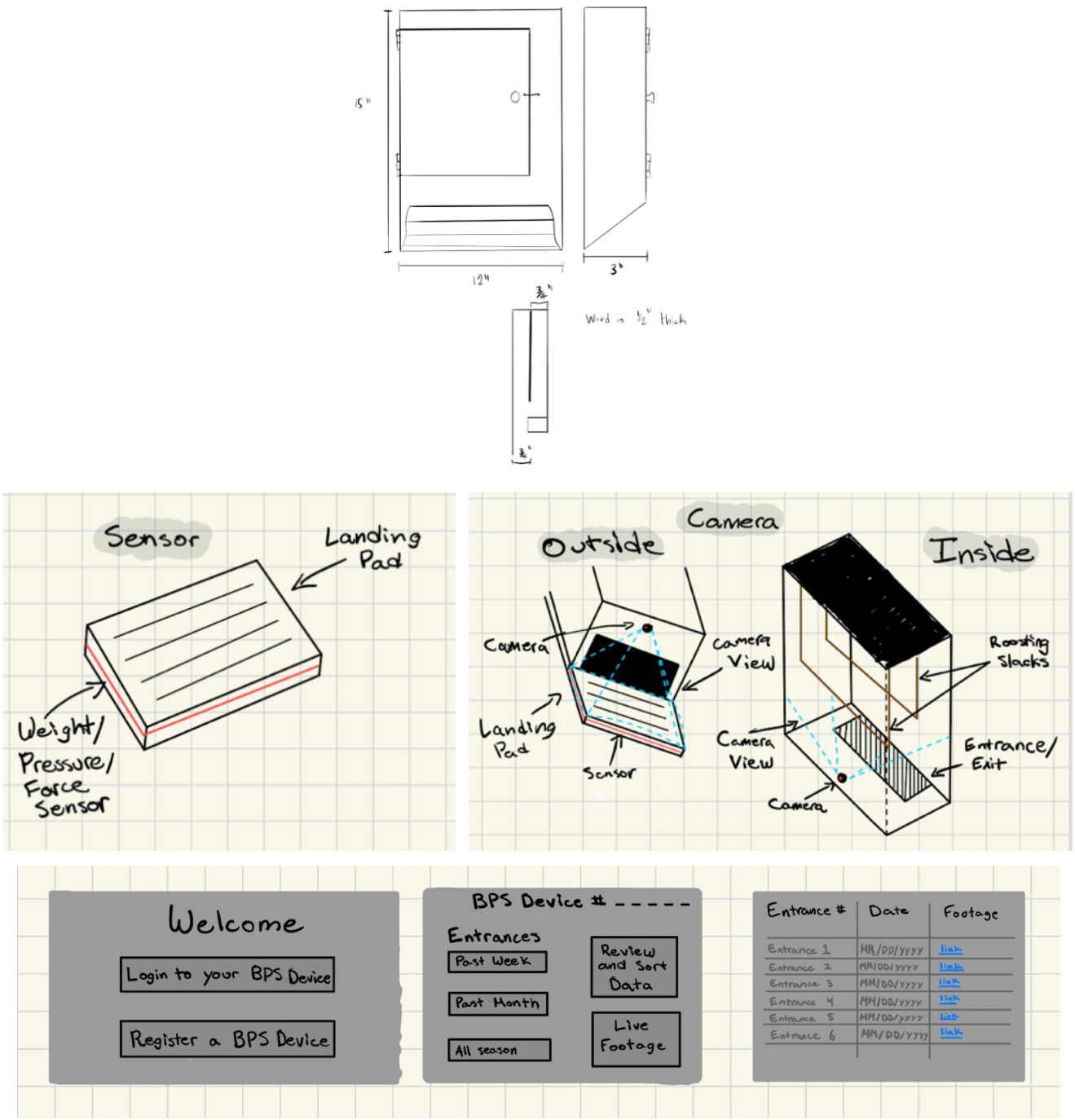

Figure 10: Final Design

4. Benchmarking Summary

Table 4.1: Comparison of Individual Conceptual Designs

Concept designer:	Jett	Tawfiq	Jake	Kian	Syamalan
Bat box design	Simple design has all essentials.	Simple design has all essentials and a door	Simple design has all essentials.	Simple design has all essentials.	Simple design has all essentials.
Landing pad	Has grooves for bats to land	Has grooves for bats to land	Has grooves for bats to land	Has grooves for bats to land	Has grooves for bats to land
Box separations	Has 3-4 sections in the box for the bats	Has 2, ¾" sections for the bats	Has 4, ¾" sections for the bats	Has 3-4 sections for the bats	Has 4, ¾" sections for the bats
Unique qualities	Larger base to hold a camera to record landing pad	Lockable door on the front panel, used to retrieve data and clean	Small box on side panel, for data collection		
Sensor/tracking system	Downward and inside camera, and a pressure pad to record entrances	Distance sensor, tracks when the distance is altered	A dual light sensor, records when bats pass through both	Light sensor, records what passes through the bottom area of the box	A dual light sensor, records when bats pass through both
Sensor	Pressure pad within landing pad, triggered when bats land on the pad	Distance sensor, activated when distance changes	Two light sensors, activated when bats move through	Light sensor, activated when bats move through the frame of the sensor	Two light sensors, activated when bats move through
Camera(s)	Two cameras, one overlooks landing pad to track bats that enter the box,	N/A	N/A	N/A	N/A

	another inside the box, there to record inside				
Entrances and exits	Can see entrances and exits, due to multiple tracking devices	Entrances and exits not determined, guano activates distance sensor.	Entrances and exits determined, two light sensors, can see direction	Entrances and exits not determined, could be programmed to see direction	Entrances and exits determined, two light sensors, can see direction
Data collection system	Application that holds all gathered data, and a live viewing capability etc.	A simple design where an Arduino gathers the data and dumps it into an SD card or USB.	A simple design where the data is gathered and is dumped into an SD card or USB.	A simple design where the data is gathered and is dumped into an SD card or USB.	A simple design where the data is gathered and is dumped into an SD card or USB.

Table 4.2: Conceptual Design Rankings Based on Design Criteria

Conceptual Design:	Importance	Jett	Tawfiq	Jake	Kian	Syamalan
Tracking	5	3	3	3	3	3
Tracks Entrances vs. Exits	4	3	3	3	3	3
Data Storage	5	3	3	3	3	3
Automatically Uploads Data	4	3	2	2	2	2
Low Cost	5	3	3	2	1	2
Weatherproof	3	3	3	3	3	3
Low Maintenance	3	2	3	2	2	2
Easy to Assemble	2	3	3	3	3	3
Total		90	89	81	76	81

Table 4.3: Comparison of Global Conceptual designs

Global Design:	Design 1 (Weight or Light sensor + SD card storage)	Design 2 (Dual light sensor + cloud storage)	Design 3 (Weight sensor + cloud storage)
Tracking	Yes	Yes	Yes
Tracks Entrances vs. Exits	No, only has observation	Yes, only tracks when bat comes from below	Yes, tracks every time a bat lands on landing pad
Data Storage	Yes, USB or SD card	Yes, wireless to application	Yes, wireless to application
Automatically Uploads Data	No, stored in SD card	Yes, via cloud storage	Yes, via cloud storage
Low Cost	Yes >$150 but requires buying physical storage	Yes >$150 but more expensive than design 3	Yes > $150
Weatherproof	Yes	Yes	Yes
Low Maintenance	Yes, low energy use and data can be retrieved whenever	Yes, low energy use and data is uploaded automatically	Yes, low energy use data is uploaded automatically
Easy to Assemble	Yes, design is simplistic	Yes, design is simplistic	Yes, design is simplistic
Total	72	84	93

Table 4.4: Comparison of Similar Products with our Final Design

Product Name:	Cavity Peeper	Digital Borescope	Apodemus Bat Counter	BPS Final Design
Tracking	No, only has observation	No, only has observation	Yes	Yes
Tracks Entrances vs. Exits	No, only has observation	No, only has observation	No, only total passages	Yes, tracks every time a bat lands
Data Storage	Yes, USB or SD card	Yes, wireless to mobile device	Yes, SD card or email	Yes, wireless to mobile device
Automatically Uploads Data	Yes, if connected or just SD card	No, must be connected within 50 feet	Yes	Yes, via cloud storage
Low Cost	No, $749	Yes, $149	No not at all, $2,849	Yes > $150
Weatherproof	No, meant for short term observation	Kind of, is more durable but also meant for short term	Yes, metal frame is coated with a durable treatment	Yes, bat box is made to last for a long time
Low Maintenance	Yes, very easy to use	No, must stay close and be wary of transmitter position	Yes, data collection is simple	Yes, uses low amounts of energy and data only needs to be uploaded once per month
Easy to Assemble	Yes	Yes	No, must be plugged into battery and set up	Yes, design is simplistic

5. Conclusion

After all ideas and design concepts were discussed with all team members, we have decided on a final design that will be presented to our client, Tiree, for analyzation. The feedback received will be used to edit and improve our design going forward.

6. References

[1] *Cavity Peeper Camera - Wireless*. (2024). Bat Conservation and Management, Inc. https://batmanagement.com/collections/digital-inspection-cameras/products/cavity-peeper-camera-wireless

[2] *Digital Borescope - Dual lens, 1080P resolution*. (2024). Bat Conservation and Management, Inc. https://batmanagement.com/collections/digital-inspection-cameras/products/digital-borescope

[3] *Apodemus Bat Counter*. (2024). Bat Conservation and Management, Inc. https://batmanagement.com/products/apodemus-bat-counter

[4] *Adafruit. Strain Gauge Load Cell - 4 Wires - 5KG.* https://www.adafruit.com/product/4541

[5] *Adafruit. Ir Break Beam Sensor with Premium Wire Header Ends - 5mm LEDs.* https://www.adafruit.com/product/2168