Deliverable F

Prototype I and Customer Feedback

GNG 1103C

November 3rd, 2024

Group 15

Anson Moorey

Dina Jamani

Nicola Bonardi Rivard

Matthew Rispoli

Jordan Boulé

Abstract

This document contains records of the team's first prototype and the tests performed. The purpose of this information is to provide insight into the team's design process. From the testing done, the path forward has changed; justification for this is provided throughout the deliverable.

Table of Contents

1 – Introduction

The team has developed Prototype I to test the design's viability at an early stage. The design incorporates the most basic electronic components necessary to test data collection. This is important to prove that the team's initial concept will be successful when expanded upon. Prototype I was developed throughout the week, and tested after the lab session on Thursday, October 31st. The testing took about 2 hours, with mostly successful results.

Below is a technical description of the team's prototype, followed by the testing performed. Next, feedback from various other groups is discussed. After, a plan for Prototype II is discussed along with a timeline. Then, the test results and how they impact the design are analyzed. Finally the team's updated design and BOM will be explained.

2 – Prototype I

The team intends for Prototype I to be a simple way to check if the core ideas behind the chosen design are viable. This first prototype will only include the IR sensor and Arduino Nano, as well as the circuit that is needed to connect the two. While this circuit is simple, it will allow the team to test the limits of both the IR sensor and the team's coding knowledge.

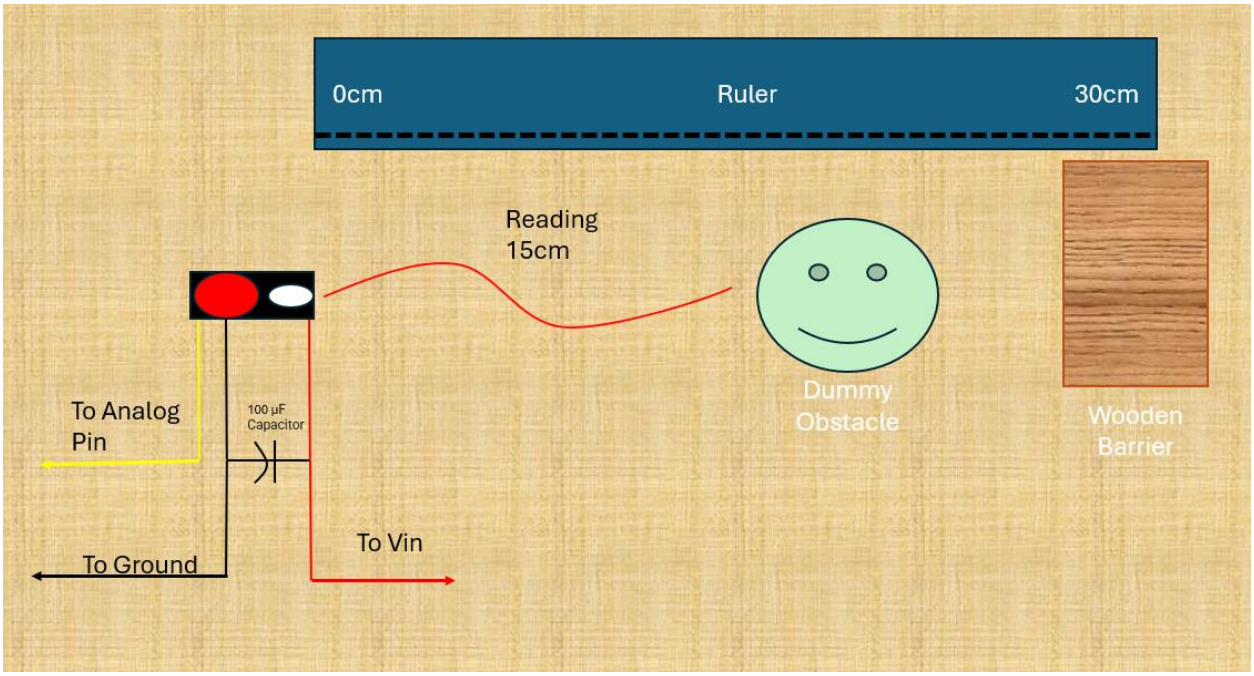

Figure 1: Diagram of Prototype I. The team used a dummy obstacle to test how the sensor's readings would change as the IR beam is obstructed. A capacitor was added into the circuit to reduce noise.

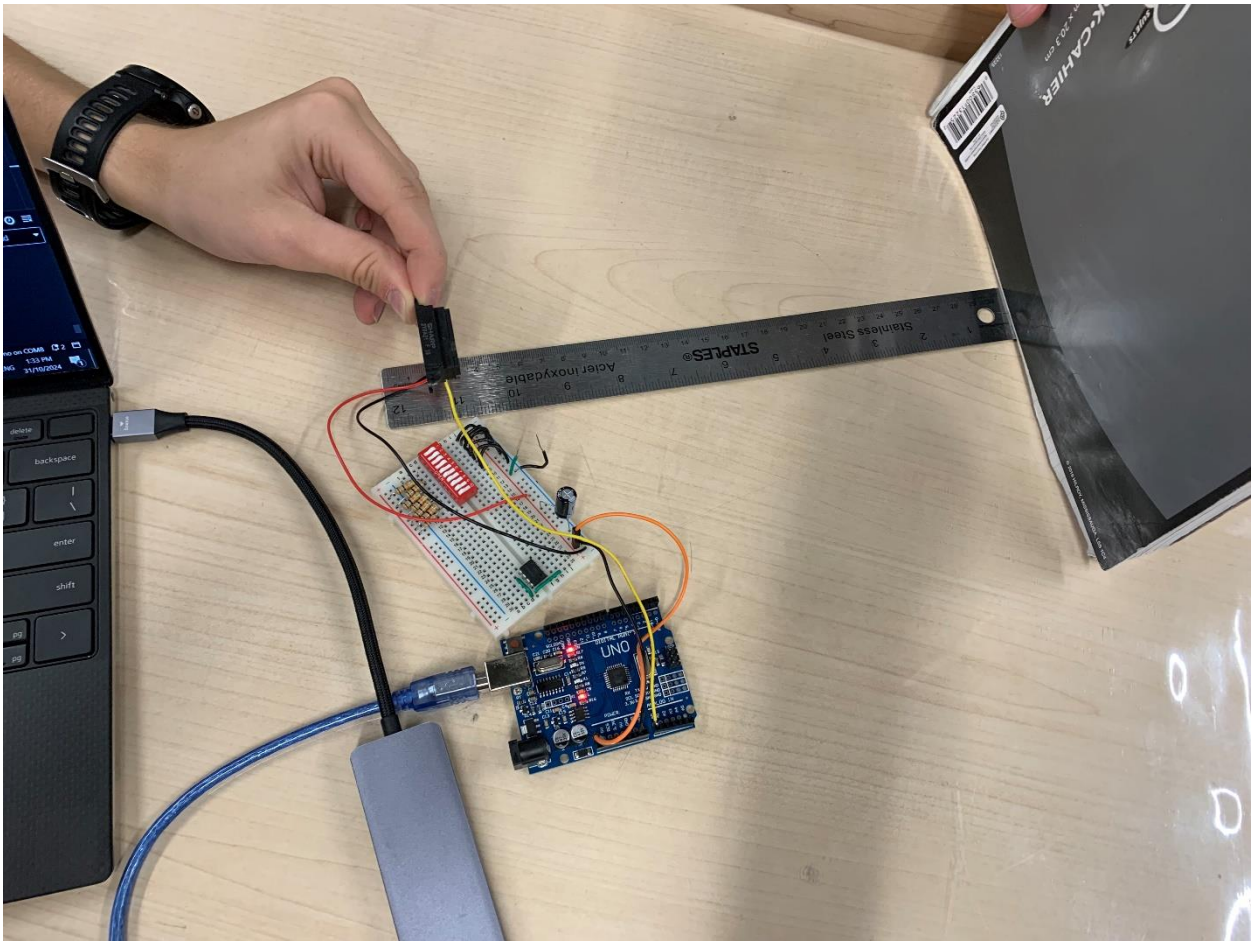

Figure 2: Photo of Prototype I during testing. For this test, the wooded block was substituted out for a notebook to see how the sensor would interact with different colours and materials. The results were unaffected.

2.1 – Prototyping Test Plan

The testing of Prototype I will begin with the assembly of the circuit. This will involve connecting the Arduino Nano to the IR sensor and a capacitor. The capacitor is added to reduce noise and improve the accuracy of the sensor.

First the team will check the voltage being sent from the Arduino to the circuit. While this is theoretically 5 volts, measuring it will provide a higher degree of accuracy in the results.

Next, the team will observe what values the IR sensor is sending to the Arduino. It is important to see what values are being returned, as it will let the team calibrate the IR sensor for this design's needs. As it is vital that the Arduino detects when the sensor returns a value that indicates when a bat will pass by, the team needs to simulate those conditions. Using different objects to interfere with the sensor at different speeds and angles, the team will be able to code the sensor to count those specific cases.

The sensor was also tested recording data at different intervals. When bats are climbing into the box, recording data at larger time intervals will not impact the data in a significant way. However, for bats dropping out of the shelter, the frequency would need to be higher to detect such a quick pass-by.

Finally, the team will test the code's ability to properly count the number of bats passing through. As a bat could stumble in the entrance and trigger the sensor more than once, or more than one bat could enter in rapid succession, the team needs to account for this possibility. The team will check these possibilities and record the results.

2.2 – Analysis and Results

Test	Result
Voltage reading	4.22 V
Sensor range	10 cm to 80 cm
Detection range	0 cm to 80 cm
Code	Successful
Accuracy	±2 cm
Interference at different speeds	Detected
Interference at different angles	Detected

Table 1: Quantitative test results obtained from Prototype I.

3 – Feedback

The team received feedback from 4 other groups and the two TAs. In terms of positive feedback, most other groups mentioned that they liked the universal clamp idea. This idea really sets Group 15's design apart from the other designs. It was also suggested that this team should work more on lowering the current cost of materials, as it would be best to incorporate as many ideas as possible.

Some more constructive feedback that the team received included the advice to seek other materials to form the structure of the bat box. This includes making a switch from plywood to MDF for the final prototype as it can be sourced at a lower cost. The MDF in the final prototype will represent the use of exterior grade plywood in the actual product design. Additive manufacturing was also suggested and will be researched in the coming weeks. More specifically, ways in which the clamp can include more 3D printed parts. It was also suggested that Group 15 should focus more on the critical data that is being collected. Ensuring that the important data (bat activities) is clean and accurate is far more crucial than collecting other, less useful data.

A concern that was brought to the attention of the team is if guano falling will trigger the sensor giving it a false positive. To address the concern, the slant of the floor will be angled away from the opening with a slot for the guano to fall through.

Furthermore, reflecting on the conversations the team had with others it appears that the budget is restricting the design to be more or less similar to other teams. However, what will make the design of the team stand apart from others is the fact that the bat box and sensor can be placed in remote locations far from power sources and Wi-Fi signals. In addition, making room in the budget to incorporate the clamp in the design will also give the client additional flexibility to incorporate device on existing boxes.

Updates to the detailed design and BOM based on feedback are shown is sections 5.1 and 5.2.

4 – Prototype II Test Plan

The Test Plan below highlights the necessary tests that will be completed to ensure that Prototype II is a success, and the design plan steps for the following prototypes can then be undertaken. The Prototype II has four distinct steps, each with an important part to play. The first test is to examine the core functionality of the power system; the multimeter will measure the watts flowing through the system to ensure that is working as planned and analyze the workings of the power sub-system. The second test will be used to determine the operational time of the sensor, which is an integral part of the project. By testing the duration that the sensor is registering the data (using the outputs from the Arduino program), important adjustments to increase the efficiency of the sensor (which is important, because the reliability of the sensor data was a key point brought up by the client during Client Meet 2) can be made. The duration is subject to change, but the maximum time (12 hours) was written for the sake of the Test Plan. The third test is to determine the method and the efficiency of data exportation, this will help the team better understand the way the sensor inputs the data and also how better to adapt the data to the needs of the client (ex: if the exportation isn't smooth, further steps might need to be taken in order to ensure the client can retrieve the data efficiently). The final test is a full system check, which will test the ability of the power system to provide current to the sensor without any external electrical supports. This is a key test; by iterating and passing it, the team can be confidant that its design and methods are valid. It will also reduce the risk of failure later in the design stages.

Test ID	Test Objective	Description of Prototype used and of Basic Test Method	Description of results to be recorded and how they will be used	Estimated Test duration and planned start date
1	Determining the input and output of the batteries when	Prototype II will be used, along with a	The results that will be recorded will be the charging	1 Hour 11/5/2024

	connected to the solar panel system.	multimeter (a tool that provides a myriad of measurements, including voltage (units are volts, V) and current (units are amperes, A).	capabilities (by measuring the watts entering and exiting the system) by the multimeter. These results will then be used as a comparison to the expected power consumption of the sensor, in order to verify that the system can support its hardware. Stopping criteria: Once the outgoing and incoming watts are measured reliably.	
2	Determine the length for which the sensors can remain operational when connected to the power sub-system (with the solar panels).	Prototype II will be used, along with the sensor and the power system equipment (batteries, charge controller, solar panels, wiring). The unit that will determine the operational time will be hours.	The results of this test will be the length for which the sensor can be operational for (in other words, how long it can track the bats while relying on the power system), recorded by the code output from the Arduino program written during the Prototype I tests. These results, if they highlight certain issues, will be used to adjust the connection between the power system and the sensor itself. Stopping criteria: once the operational length is deemed appropriate for the scope of the project (maximum 12 hours).	12 Hours 11/5/2024
3	Determining how the data is exported from the Arduino to an external system (laptop) and its efficiency (thus reducing risk and uncertainty)	Prototype II will be used, along with a laptop (provided by one of the team members) and all previously mentioned equipment (sensor and power system). This feature will be tested and measured based solely on its functionality (no set metric, simply	The results will be recorded using a team member's laptop, where the data will be exported (if the test is successful). The entire export process will then be examined and discussed by the team, which will allow for growth-oriented iterations of this feature of the prototype. Necessary changes will then be made	30 minutes 11/5/2024

		observations from team members).	after this discussion (ex: alternative external system). Stopping criteria: successful export of the data to the laptop.	
4	Determining the efficiency of the complete integrated power system and sensor when operated outside of external power.	Prototype II in its entirety, which is the IR sensor as well as the complete power system, for a full-scale test meant to serve as a conclusion to all the previous tests, integrating all the iterations made to render a more efficient system.	The results will be recorded using the Arduino program output, which will give the team much needed data about the sensor's accuracy as well as the power system's reliability. Stopping criteria: Accurate continuous data flow from the sensor when connected only to the power sub-system.	2 Hours 11/9/2024

Table 2: Prototype II Test Plan. This table a description of the various tests that will be implemented for Prototype II. If the Test ID number is red, it highlights the fact that the test requires the completion of the previous tests (reach the stopping criteria).

5 – Conclusions and Updates

Having completed the testing for prototype I, the team can now make more informed decisions about how to best utilize the IR sensor. First, it was clear that using the *Sharp.IR* [1] Arduino library would be an asset to the design. While the team is capable of coding similar functions, the library saves time and is a little more accurate.

When the team used a multimeter to test the voltage sent to the circuit from the Arduino, 4.22 volts was observed to reach the sensor. This is about what was expected, and the code was updated to reflect this number. In future installations, voltage will always be tested before running the code to ensure accuracy.

Next the team set up the IR sensor with an object about 30cm away. The IR sensor would return values within ±2 cm when the object was moved closer or farther away. Occasional fluctuations occurred, but this was due to an environment full of outside interference; something like this is unlikely to occur when the sensor is implemented into the bat box. Otherwise, the results were as expected. The sensor's range is between 10cm and 80cm; anything outside that range will give an inaccurate response (usually around 15cm). This will not be a problem, even if a bat triggers the sensor when closer than 10cm. The team's code will detect any rapid changes in the sensor's values, so no matter where the bat enters and how quick they are it will be logged.

Finally, the team has decided to save the notable sensor data as well as an estimated count of the bats. The team will save a group of several sensor readings whenever a spike is detected. This gives the data a rough timeframe and can be used to sort out sensor readings that may not have been bats.

Moving forward, the team will continue to develop Prototype II. This second prototype can incorporate the power system. This will be easier, now that the exact voltage expected is known. The team can also start testing loads on the structures the team expect to build. The Bill of Materials will also be updated frequently, as the chosen design will change because of testing results.

5.1 – Updated Detailed Design

The above feedback obtained on Prototype I has led the team to make changes in its intended design. Below is the team's current design for the project's bat box.

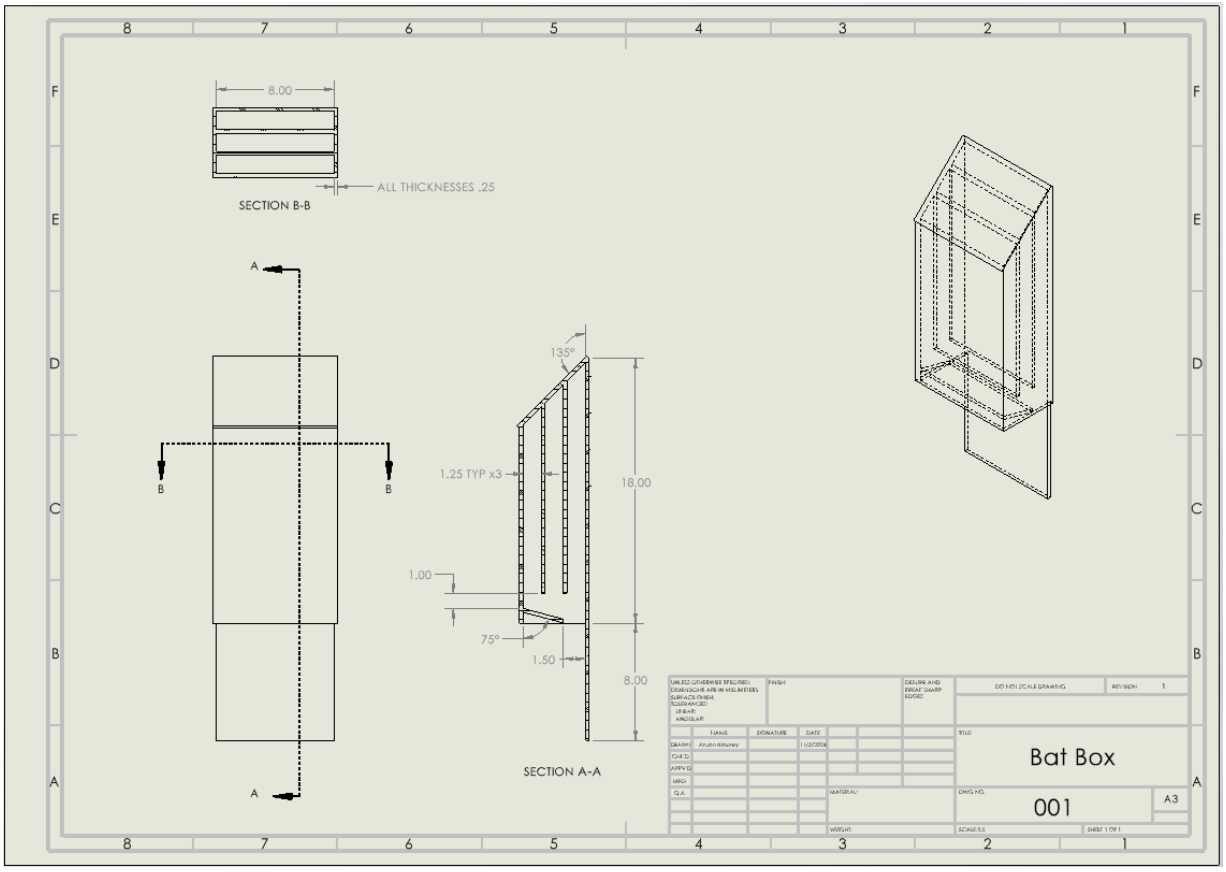

Figure 3: Updated design of the 8" x 26" x 4.75" bat box. It features three 1.5" wide chambers, a 1.5" wide entrance, a grippy panel below the entrance, the roof at a 45° decline, and the floor at a 15° decline.

Below is the team's updated Bill of Materials:

Item	Quantity in Pack	Quantity needed	Cost Per Pack	Packs needed to buy	Real Cost	Project Cost	Exclude from Project Cost	Justification	Link
IR Sensor	1	1	$13.37	1	$13.37	$13.37	☐	To tell when bats enter the box	https://www.amazon.ca/GP2Y0A21YK0F
3.7V/3100mAh battery	1	2	$10.00	2	$20.00	$20.00	☐	To power the arduino	Makerstore
9V/333mA Solar Cell	1	1	$16.01	1	$16.01	$16.01	☐	To charge the batteries	https://www.amazon.ca/Polycrystalline-Battery-Charger
9Vin/7.4Vout Charge controller	1	1	$7.41	1	$7.41	$7.41	☐	To regulate the battery charging	https://www.amazon.ca/Controller
Arduino nano	1	1	$8.00	1	$8.00	$8.00	☐	Smaller and doesn't include redundant con	Makerstore
Solder wire	1	1	$0.39	1	$0.39	$0.39	☐	To connect electrical components	https://www.amazon.ca/Solder Price per gram
SD card reader	1	1	$2.50	1	$2.50	$2.50	☐	To send sensor data to micro sd card	Makerlab
Micro SD card 16Gb	1	1	$7.00	1	$7.00	$7.00	☐	To store sensor data	Makerlab
Thumb screw	1	1	$3.80	1	$3.80	$3.80	☐	Responsible for producing clamping force	https://www.rona.ca/
MDF	1	3	$3.00	3	$9.00	$9.00	☐	Bat box final prototype material	Makerstore
ABS filament	1	1	$3.90	1	$3.90	$3.90	☐	For clamp and enclosure	Makerstore
Drywall screws	100	100	$5.40	1	$5.40	$5.40	☐	Used for securing parts of bat box together	https://www.homedepot.ca/
SPI.h library	1	1	$0.00	1	$0.00	$0.00		Used to send data from Arduino to SD card	
SD.h library	1	1	$0.00	1	$0.00	$0.00		Used to send data from Arduino to SD card	
SharpIR library	1	$1.00	$0.00	1	$0.00	$0.00		Used with IR sensor	
						Final Project Cost:			
						96.78			

Figure 4: Updated Bill of Materials. The team has changed the design to better fit the $100 budget. More supplies have been sourced from the Makerstore thanks to aid from the TAs. ABS filament will be used to create more specific parts the designs will need via additive manufacturing.

6 – References

[1] G. Masino, "SharpIR," 7 April 2018. [Online]. Available: https://docs.arduino.cc/libraries/sharpir/. [Accessed 31 October 2024].