Deliverable G

Prototype I and Customer Feedback

GNG 1103C

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Group 15

Anson Moorey

Dina Jamani

Nicola Bonardi Rivard

Matthew Rispoli

Jordan Boulé

Abstract

This document contains records of the team's second prototype and the tests performed. The purpose of this information is to provide insight into the team's design process. Results obtained and the team's analysis are documented in this deliverable as well as subsequent adjustments made to the process.

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1 – Introduction

To continue the design process, the team has created Prototype II, with the goal of integrating all the electronics systems; as well as test their compatibility and overall efficiency in order to have a better understanding of the next steps (such as Prototype III and the final design). By testing both the sensor and the power system (including the solar panels, which are a key part of the final design) it allows the team to understand how these components will function in the final design (ex: voltage, input/output). Testing the sensor this early in the design process thus allows the team to iterate and optimize the electronics components to have a more complete Prototype III while also allowing a greater focus on other tasks (ex: the box itself and the design day presentation). Below is a technical description of Prototype II followed by the tests as well as a plan for Prototype III and feedback received during this design process phase.

2 – Prototype II

The team's second prototype was designed to incorporate all the electronics of the design together. It includes the Arduino Nano, solar cell, IR sensor, 2 LiPo batteries, a microSD card reader and writer, a capacitor, and a charge controller.

The Arduino Nano was set up in a similar fashion to how it was in Prototype I. The IR sensor and a capacitor were connected, but for this round of testing the microSD writer was also attached. From there, the Arduino's power source was connected to one end of the charge controller. It was always necessary to connect the charge controller's output before connecting the power source; otherwise, the capacitors in the controller would overload and possibly explode. Finally, the solar cell was connected to the charge controller, and the full system was tested.

Initially the team had some issues when connecting the solar cell to the charge controller, as voltage was not flowing through. It turned out that the panel's red and black wires were not correctly colour-coded: The red wire was ground, and the black wire was Vout. Once the team recognized this, the wires were marked and the system was properly assembled.

Below is a circuit diagram demonstrating how these components are connected:

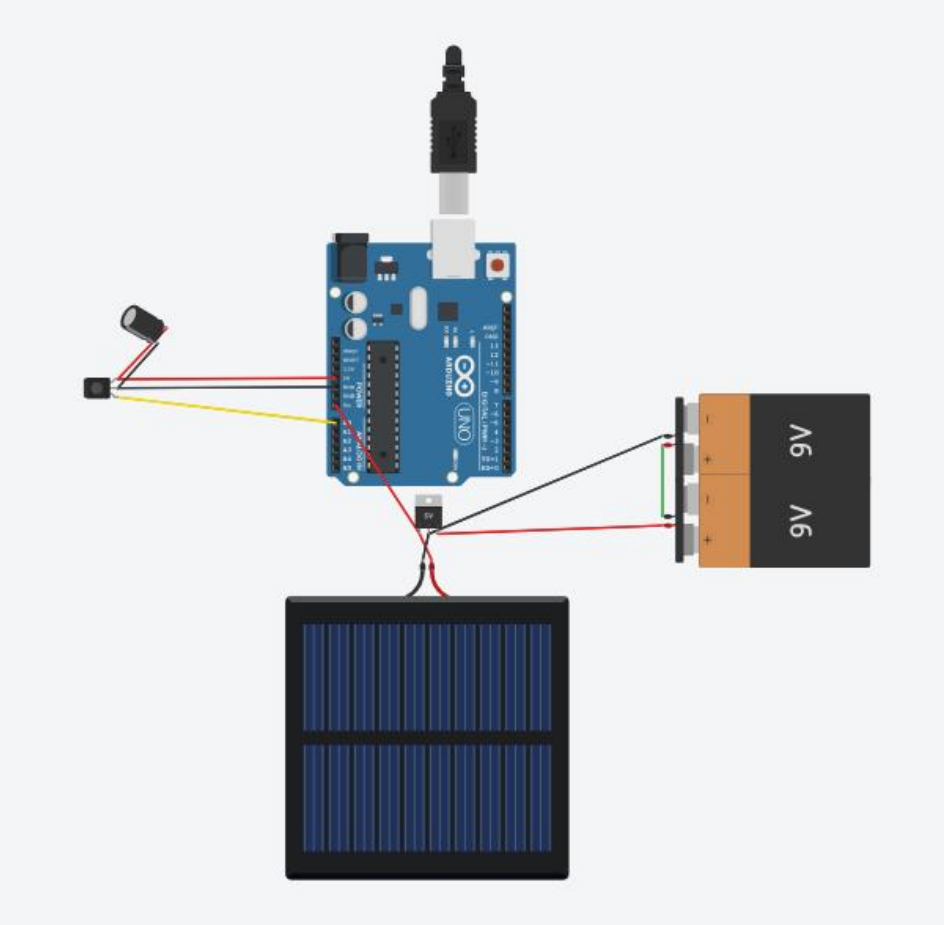

Figure 1: A circuit diagram of Prototype II. The 9V batteries represent the LiPo batteries in the team's BOM, and the voltage regulator represents the charge controller.

To test this prototype, the team assembled the above design and included a microSD card writer to export the sensor data. This card read plugs directly into the Arduino Nano and has only a small effect on the design's power usage.

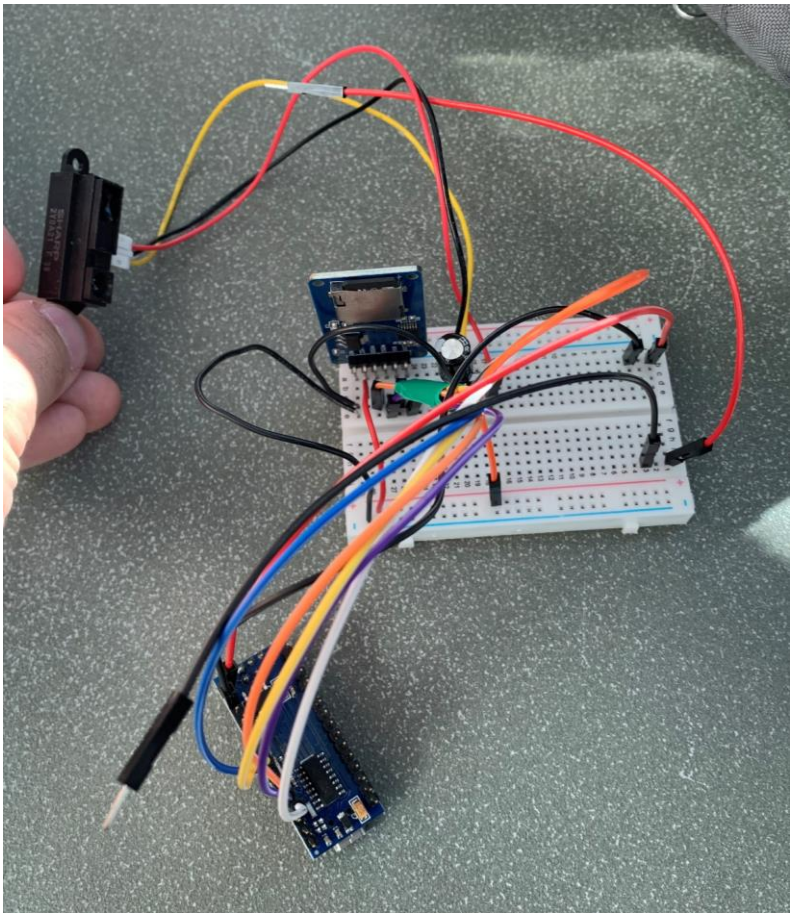

Figure 2: An assembled breadboard for testing. The batteries and solar panel are not connected in this figure. This design allows the team to easily test the breadboard, sensor, microSD card writer, and code all at once. For the final design, a breadboard need not be used, as all the components can just be soldered together.

The testing of all the electronics is crucial in the design process. Because of Prototype II, the team is confident that a working demonstration can be prepared for the client within the timeline. A breadboard was used as it allowed for easier testing of the individual components. Had the components all been soldered together, multimeter testing would become more difficult.

2.1 – Prototyping Test Plan

The first test performed involved the functionality of the solar cell. The team worked in a sunny environment and used a multimeter to observe the voltage and current outputted depending on the level of sun.

The next test was checking the voltage and current outputted by the charge controller and solar panel together. The team adjusted the potentiometer on the charge controller and achieved the desirable outputs to power the Arduino. As long as the solar panel was in enough sun to produce 12 or more volts, the charge controller would output an optimal voltage and current to both the batteries and the Nano.

Finally, the team tested whether all the electronic components together could function. When all was connected and the solar panel was in enough sunlight, the Arduino and IR sensor were powered and fully functional.

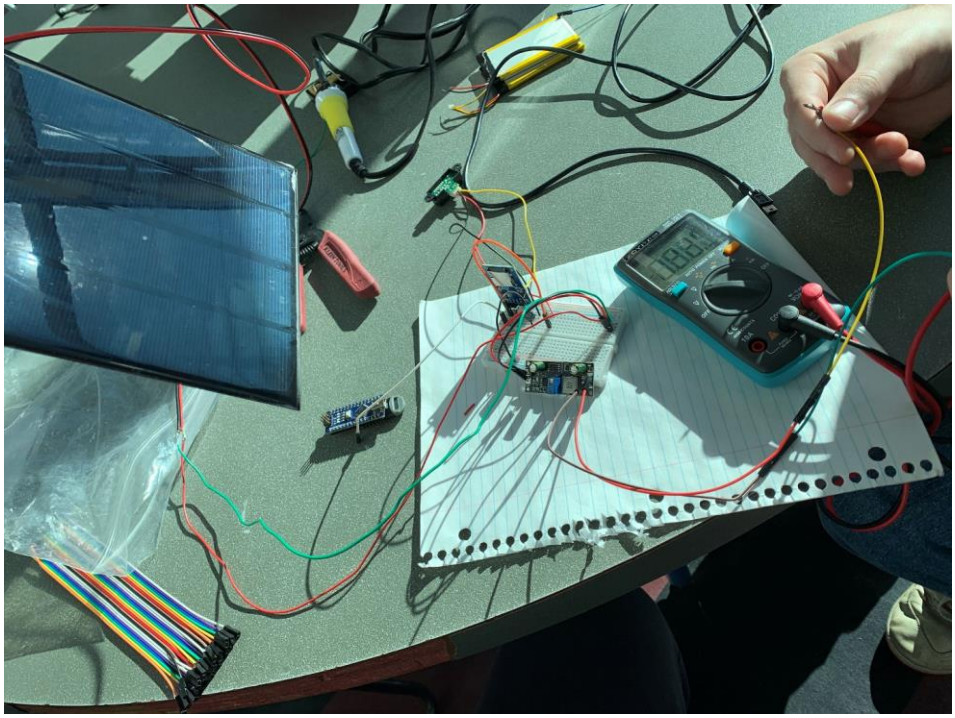

Figure 3: Testing of the electronic components. The team is pictured testing the voltage outputting from the charge controller and solar panel. The team was able to have all components functioning during this test.

2.2 – Analysis and Results

Test ID	Test	Result	Analysis
1	Battery Voltage	3.650V	This is the voltage from one 3.7V battery. This value was the expected result and might have been slightly lower than 3.7V because of the charge level of the battery.
2	Solar Panel Voltage in Sun	13.6V	This was also expected, as the true output voltage of a solar panel is always slightly higher than the panel's specified value.
3	Solar Panel in Shade	11.3V	This value is less than the required value for the input of the charge controller, but it was known by the group that direct sunlight was needed for the panels to be effective.
4	Voltage through controller	8.39V	The charge controller was calibrated and outputted the correct value for charging two 3.7V lipo batteries in series.

Figure 4: Table of testing analysis and results from Prototype II. These results are all successful, and the team can proceed to Prototype III.

3 – Feedback

Although Client Meet 3 was a brief presentation focused on the team's progress, with limited time for direct feedback, we were still able to confirm that we were on the right track. Additionally, we gathered valuable insights from feedback on other presentations that were applicable. From the client, the main feedback was to ensure that the team can do a fully integrated test of all subsystems working together. This will be the focus for prototype III as the subsystems have already been tested independently for the previous prototypes and all components needed for a fully integrated test are now available. Further feedback that was shared with other teams included making the slope at the bottom steeper to avoid guano build up. To act upon this, the team changed the CAD of the bat box to incorporate this steeper slope. Finally, the client stressed the importance of having a well-defined window for what counts as a bat entrance. By deciding on this window, it will help with the accuracy of the data collected by eliminating false counts from guano falling or anything in the environment that can trigger the sensors. Also, it can further distinguish between an entrance, exit and guano falling as the latter

two occur fast. To fulfill this, the code will clearly define what constitutes a count, through measuring the time of the sensor break. Guano will fall much faster and trigger the sensor less than a bat entering or exiting the box. While the team doesn't expect guano and other debris to trigger the sensor, the microSD will record all anomalies in the sensor just in case. That way, the clients can come to their own conclusions from the sensor data.

Commented [DJ1]: How would we do this in our code?

4 – Prototype III Test Plan

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 functioning of the solar panels, charge controller, batteries all together	Prototype III will be used, as this test is meant to serve as a conclusion to the major electronic system testing (with the full integration of all components) and also as a good starting point for the rest of the Prototype III tests. The expansive nature of this test means the metrics are varied and subject to change (ex: voltage output, successful running of the code).	The results will be recorded using a laptop (with which the team will be able to observe the code and the output of the sensor) as well as the general workings of the completely integrated system (ex: it outputs voltage). The stopping criteria will be: the sensor runs and is accurate while being powered by the solar panel (which is in turn connected to the other components)	11/14/2024 1-2 hours
2	Testing the SD card writing	The SD card is an important part of Prototype III and will be tested not by a metric (ex: writing speed) but by its functionality. The SD card serves to record the data collected by the sensor, which is a core part of the project.	The SD card will be used to record the data which will then be transferred to the client (bat entries and exits), for this reason, by testing whether or not the SD card fully records the data and how efficiently it does so, it will allow the team to iterate and provide the client with more expansive information	11/14/2024 30 minutes

			regarding data collection. The stopping criteria will be SD card records data and can be extracted easily.	
3	Determining the structural stability of the box itself	The box is an integral part of Prototype III, as it is also a core part of the project (the bat box is one of the requirements). The stability of the box itself will thus be an important test, with the goal being to understand its limits and the force it can withstand.	The testing will take place in a safe environment and will involve increasingly rough handling of the box (with a focus on safety and reducing the possible damage to the components). There is no specific metric, but the team is testing a functionality (can the box function under reasonable stress). The stopping criteria is thus can the box maintain structural integrity (no compromising damage) while under strain.	11/14/2024 15 minutes
4	Determine the efficiency of the electronics over a more extended period of time.	Previous tests focused on short-term functionality, but this test is very important when regarding the scope of the project (the box must remain functional over long periods of time without regular extensive maintenance). Thus, testing the electronics over a longer period will give a better overview of the box when function autonomously without human workers.	The long-term electronics test will have the data being recorded by the SD, which will then be removed when the test is completed. Since the test is meant to be mostly off-hands regarding the team, the data will be recorded by the system itself and will then be evaluated. The stopping criteria will be functionality-driven: can the electronics system properly function (output data) over a longer set period of time.	11/14/2024 2 hours (or more if needed)

Table 1: Prototype III Test Plan. This table a description of the various tests that will be implemented for Prototype III. 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

Overall, testing Prototype II was a success. The team was happy to see that all the electronic components functioned properly. It has made the team confident in its design and more motivated to end this project with an impressive, demonstrable prototype.

Prototype III will be the team's final prototype, and it is the design expected to be demonstrated to the client and on design day. As it will incorporate all aspects of the team's design it will take the most work to assemble and test.

The CAD design for the bat box is progressing smoothly, and all measurements and designs are completed. Next week, the team will assemble the box completely and test how it holds together.

Finally, the team will need to prepare some kind of presentation alongside the demo. Either a poster board or projectable PowerPoint would be helpful in showing off the design. This will be discussed with the class TAs in the coming week.

5.1 – Updated Detailed Design

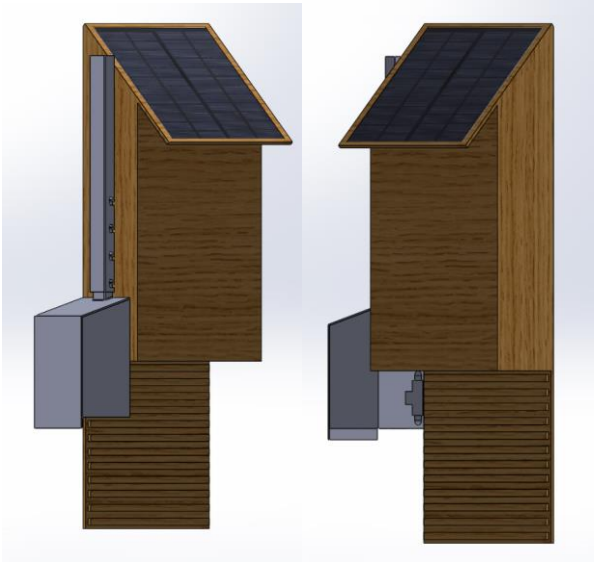

Figure 5: Bat Box design with enclosure, wire guard and solar panel.

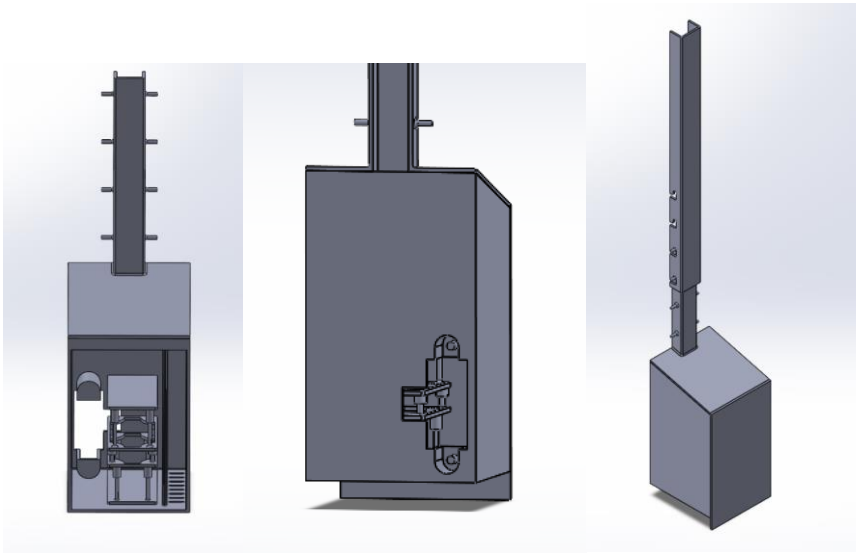

Figure 6: Design of the enclosure. The enclosure contains a slot for the LiPo battery to protect it from the boards, there is also vents to prevent it from overheating. An end protrudes from the back of the enclosure to prevent water from dripping underneath the enclosure and entering through the vents. A cutout for the IR sensor is present on the front. The wire guard is adjustable to different heights of the bat box.

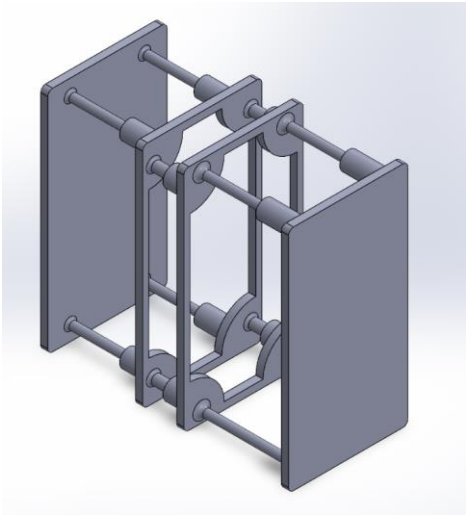

Figure 7: Board Support. The first support from left to right is to hold the nano, the next one is to hold the SD card reader, and lastly the charge controller.

5.2 – Updated BOM

Item	Quantity In Pack	Quantity needed	Cost Per Pack	Packs needed to buy	Real Cost	Project Cost	Exclude from Project Cost	Justification
IR Sensor	1	1	$13.37	1	$13.37	$13.37	☐	To tell when bats enter the box
3.7V/3100mAh battery	1	2	$10.00	2	$20.00	$20.00	☐	To power the arduino
12V/3W Solar Cell	1	1	$19.96	1	$19.96	$19.96	☐	To charge the batteries
9Vin/7.4Vout Charge controller	1	1	$8.58	1	$8.58	$8.58	☐	To regulate the battery charging
Arduino nano	1	1	$8.00	1	$8.00	$8.00	☐	Smaller and doesn't include redundant con
Solder wire	1	1	$0.39	1	$0.39	$0.39	☐	To connect electrical components
SD card reader	1	1	$2.50	1	$2.50	$2.50	☐	To send sensor data to micro sd card
Micro SD card 32Gb	1	1	$7.99	1	$7.99	$7.99	☐	To store sensor data
MDF	1	2	$2.50	2	$5.00	$5.00	☐	Bat box final prototype material
ABS filament	1	30	$0.13	30	$3.90	$3.90	☐	For clamp and enclosure
9/16 in Brad Nails	1600	40	$9.18	1	$9.18	$0.23	☐	Used for securing parts of bat box together
Velcro	4	28	$0.13	7	$0.91	$0.91	☐	For fastening enclosure and solar panels to
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	$0.00	1	$0.00	$0.00		Used with IR sensor
						Final Project Cost:		
						90.8295		