

**Screws Loose**

Project Deliverable H - Prototype III and Customer Feedback

**Group 9**

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**1. Simple Analysis:**

For this prototype, two sets of infrared (IR) break beam sensors are critical for accurately monitoring bat activity within the bat box. The sensors work by detecting the entry or exit of bats based on the sequence in which they are triggered. This data enables us to estimate the number of bats present at any given time.

To store the sensor data, an onboard microSD card is employed, while a Bluetooth module facilitates transferring this data from the microSD card to the user’s phone for convenient access.

In the initial stages, each component was individually tested with an Arduino Uno microcontroller to ensure functionality before integrating them into the final system using the Arduino MKRZero microcontroller. Consistent voltage supply, provided via a 5V output pin, was crucial to maintaining stable performance, as even minor voltage fluctuations could disrupt the sensitive electronics.

We continued using the Arduino IDE for programming, as it supports efficient code uploading and debugging, minimizing the risk of errors. Breadboards and jumper wires were initially used for modular testing setups; however, to address the risk of loose connections, we opted to solder small components and connectors. Special attention was given to proper wiring to enhance durability and prevent short circuits during operation.

**2. Prototype 3, 5, 6 & 7 Results:**

| **Prototypes** | | | | **Tests** | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **Type** | **Objective** | **Priority** | **Method** | **Expected Results** | **Duration** | **Results** |
| 3 | Core Function: Sensors | Do the sensors work as expected, in tandem. | 3 | Set up the series of sensors as intended. Use the same bat model from Prototype 2 | Observe if all sensors detect movement in the expected order, under varying conditions | ~1-2 hrs | The two break beam sensors work together to detect motion and determine the direction whether it's an entrance or an exit, based on the sequence in which the sensors are triggered. |
| 5 | Core Function: System | Verify Accuracy, Precision, and error bounds | 2 | Test system's output against known standards or simulated bat data | Data output matches expected precision and accuracy | ~1 hr | After simulating 25 entrances and 25 exits, the sensor system demonstrated an accuracy rate of 96%, correctly detecting 48 out of 50 events and uploading the data to and from the microSD card to the bluetooth module. |
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| 6 | Structural:  Enclosure Integrity | Inspect for weaknesses, potential points of failure, and waterproofing | 3 | Evaluate enclosure in various simulated environmental conditions | Enclosure maintains integrity without leaks or damage | ~24-48 hrs | The enclosure was dropped five times from a height of 2.2m onto a concrete floor and showed no signs of chipping or damage. Additionally, after being placed upside down in a container of water for 24 hours, it remained completely watertight, with no water inside the enclosure. |
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| 7 | Structural:  Cable Management and Ease of Access | Verify speed of replacement and check cable channel options | 2 | Test cable arrangement options and inspect ease of access during battery replacement | Cables are secure, the battery is easily replaceable, and safely routed within the time frame | ~30 min | The battery connectors were removed and reattached, followed by a successful simulation of data transfer to a local device, all completed in under 5 minutes, significantly faster than the initially considered 30 minute maintenance period. |

*Note: higher priority means more importance*

**3. Prototype Reflection and Future plans:**

In continued testing for prototype 3, we replaced the PIR sensors with IR break beam sensors due to the PIR sensors’ inability to detect motion quickly enough to track bat movements. The IR break beam sensors functioned as expected, detecting direction with 96% accuracy during testing. This has significantly improved the system’s reliability in tracking entrances and exits, which was a major challenge in previous iterations. We decided to replace the SAMD21 with the Arduino MKRZero, which features an onboard SD card slot. This change simplified the design and eliminated the need for configuring SPI communication with an external microSD breakout board. Additionally, Bluetooth connectivity was integrated into the system for easy data transmission, enabling wireless communication with local devices. This addition enhances the flexibility of the system, allowing for more convenient data access and analysis without the need for physical connections. The bat box was made using laminated whitewood, which provided a sturdy enclosure. The laminated wood ensures durability while keeping the overall weight manageable. Testing has shown the enclosure to be resistant to impact and waterproof, meeting the necessary durability standards for outdoor use. Moving forward, we plan to complete field testing and simplify some wire runs by soldering them to improve maintenance and ease installation for future users.

Image 1: Enclosure Setup



Image 2: IR sensor Setup



Image 3: Bat box enclosure setup

**4. Feedback on Prototype and Testing Methods**

To enhance the design’s effectiveness, we presented our prototype and testing methods to group 10 in our lab session for input on potential improvements to be made in our prototype and testing methods. Their comments and suggestions were invaluable for refining both aspects of the project, ensuring that our design makes sense, and that our testing methods covered as much as possible.

Unfortunately, we could not get any feedback from the client, as the third client meet was pushed back until after the due date for this deliverable.

| **Group Number** | **Feedback on Prototype** | **Feedback on Testing** |
| --- | --- | --- |
| Group 10 | Positive feedback, no suggestions made. | Positive feedback, no suggestions made. |
| Teaching Assistants | Positive feedback, no suggestions made. | Suggested some presentation strategies for design day. |

**5. Prototype Plan (Types: Structural: Integrity/Cable Management & EOA, Core function: Sensors/Microcontroller/System )**

| **Prototypes** | | | | **Tests** | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **Type** | **Objective** | **Priority (1-3)** | **Method** | **Expected Results** | **Duration** | **Team member(s)** |
| 1 | Core Function: Microcontroller | Does the microcontroller program run as intended | 3 | Run the program on the microcontroller | Program runs without producing errors | ~30-50 min | Amin  Mohammed  Waleed |
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| 2 | Core Function: Sensors | Do the individual sensors function as expected | 3 | Set up the system as intended. Model a bat to mimic movements in and out of the box | Observe if sensors detect movement accurately | ~30-50 min |
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| 3 | Core Function: Sensors | Do the sensors work as expected, in tandem. | 3 | Set up the series of sensors as intended. Use the same bat model from Prototype 2 | Observe if all sensors detect movement in the expected order, under varying conditions | ~1-2 hrs | Amin  Mohammed  Waleed |
| 4 | Core Function: Data Processing | Does the system log data in the correct format on the micro SD card | 3 | Use sensors from Prototype 3 to log data to SD card | Check file structure and formatting to work as listed in Fig. 2 | ~1-2 hrs | Amin  Mohammed  Waleed |
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| 5 | Core Function: System | Verify Accuracy, Precision, and error bounds.  Read/Write data to and from Bluetooth module | 3 | Test system's output against known standards or simulated bat data | Data output matches expected precision and accuracy | ~1 hr | Hossam  J’afar |
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|
| 6 | Structural:  Enclosure Integrity | Inspect for weaknesses, potential points of failure, and waterproofing | 3 | Evaluate enclosure in various simulated environmental conditions | Enclosure maintains integrity without leaks or damage | ~24-48 hrs | Hossam  J’afar |
|
|
| 7 | Structural:  Cable Management and Ease of Access | Verify speed of replacement and check cable channel options | 2 | Test cable arrangement options and inspect ease of access during battery replacement | Cables are secure, the battery is easily replaceable, and safely routed within the time frame | ~30 min | Hossam  J’afar |

*Note: higher priority means more importance*

*Materials needed for each prototype*

| **Prototype ID** | **Equipment Needed** | |
| --- | --- | --- |
| **1** | * SAMD21 microcontroller * Breadboard * Jumper wires * Power supply * Arduino IDE |  |
| **2** | * SAMD21 microcontroller * 2 PIR sensors * Model of a bat (for movement simulation) * Breadboard * Jumper wires | * TMP36 Thermocouple * Boost Converter * Arduino IDE * Power supply * Arduino Uno |
| **3** | * Arduino MKRZero microcontroller * 2 IR break beam sensors * Model of a bat (for movement simulation) * Breadboard | * Arduino IDE * Power supply * Arduino Uno * Jumper wires |
| **4** | * SAMD21 microcontroller * Micro SD card and breakout board * NFC PN532 chip * Breadboard * Jumper wires | * Arduino IDE * Boost Converter * Power supply * Arduino Uno |
| **5** | * Arduino MKRZero microcontroller * 2 IR break beam sensors * Model of a bat (for movement simulation) | * Arduino IDE * Power supply * Jumper wires * Breadboard * HC-05 Bluetooth Module |
| **6** | * Enclosure * PG 11 Cable Fitting * Water filled container | * Tape measure |
| **7** | * Battery * Enclosure * Jumper wires * 2 IR break beam sensors * HC-05 Bluetooth module | * Bat box * PG 11 Cable fitting * Arduino MKRZero microcontroller * Breadboard |

**6. Bill of Materials**

| BOM Level | Parts and Components | Unit Cost | Quantity | Total Cost |
| --- | --- | --- | --- | --- |
| 2 | [IR Break Beam Sensor](https://secure.sayal.com/STORE4/prodetails.php?SKU=244550) | $ 6.95 | 2 | $ 13.90 |
| 1 | [Arduino MKR Zero](https://www.pishop.ca/product/arduino-mkr-zero-i2s-bus-sd/) | $ 36.95 | 1 | $ 36.95 |
| 2 | [DHT11 Temperature and Humidity Sensor](https://www.pishop.ca/product/arduino-compatible-digital-temperature-humidity-sensor-module-dht11/) | $ 2.95 | 1 | $ 2.95 |
| 3 | [Enclosure](https://www.amazon.ca/Waterproof-Outdoor-Shockproof-Storage-Container/dp/B07F1BPP8P?source=ps-sl-shoppingads-lpcontext&ref_=fplfs&smid=A1NLZ2O05BC4KE&th=1) | $ 13.33 | 1 | $ 13.33 |
| 2 | [Bluetooth HC05](https://universal-solder.ca/hc-05-bluetooth-master-slave-mode/?gQT=2) | $ 4.00 | 1 | $ 4.00 |
| 1 | [3.7V 12000mAh Li Battery](https://www.aliexpress.com/item/1005006556927592.html?spm=a2g0o.productlist.main.35.3d8144cdYAGReW&algo_pvid=213afca7-d758-4992-81d8-feec46d639b2&algo_exp_id=213afca7-d758-4992-81d8-feec46d639b2-17&pdp_npi=4%40dis%21CAD%2114.52%213.14%21%21%2173.24%2115.84%21%402103010f17311744523868227ed58a%2112000037660146667%21sea%21CA%210%21ABX&curPageLogUid=Za7a3S72GibL&utparam-url=scene%3Asearch%7Cquery_from%3A) | $ 9.89 | 2 | $ 19.78 |
| 3 | Batbox Wood | $ 33.00 | 1 | $ 33.00 |
| 3 | [1/4" PG11 Cable Fitting](https://www.accessotronik.com/) | $ 5.20 | 1 | $ 5.20 |
|  |  |  |  |  |
|  |  | Total | 10 | $ 129.11 |

*Note: The table excludes any taxes. Created by Mohammed on October 26th, 2024. Modified by J’afar Assaf on November 10th, 2024.* *Modified by Waleed Sakalla on November 23rd, 2024.*