GNG 1503
FALL 2023
SECTION A02 – FA24

DELIVERABLE G: PROTOTYPE II AND CUSTOMER FEEDBACK

Member of the team	Student Number
Elmahdi Barroug	300354668
Zakariae Boulayad	300342278
Belmkaddem Ziyad	300341780
Brou Deva	300343931
Elie Saliba	300383637

Submission Date: 12th of November 2023

University of Ottawa

uOttawa

Summary

In the preceding deliverable, Deliverable F, we've built our first prototype of the final solution design. Now, as we progress to Deliverable G, our focus shifts to the second round of testing and prototyping results. This phase involves a thorough analysis of our systems and soliciting valuable feedback from our selected clients. The analysis is primarily concentrated on finalizing critical physical components, such as ensuring sufficient space for electronics in the casing, something that was impossible in the previous design, as well as troubleshooting battery problems, RFID reader connector issues, and fixing the app development environment.

Materials Table

Introduction

As upcoming design engineers, it is important that we keep a structured and organized work discipline, following specific and precise steps and instructions, as well as detailed in-sights of what and how the work will be done. As such, following the conceptualization steps of the Design Thinking process, we view it crucial to create a focused prototyping and testing schedule for the next 3 weeks of project work. Throughout this period, the team will be delivering one prototype overview and customer/user feedback report weekly (Deliverables F, G and H). The report will also include information about future work to be done on the prototypes, and improvements made to the design along the way.

In this deliverable, we present the second prototype which corresponds to an updated version of prototype 1. In order to optimize the reliability and efficiency of the final product we took into consideration the feedback from the third Client Meet then identified several flaws in prototype 1 and corrected them for prototype 2. We've also included feedback from a selected potential user, regarding the adequacy of using lithium batteries in our circuit, and the efficiency of success-failure detection feedback (using LED lights). This way we have a better understanding of the design as a whole so we can improve our product for the next prototype.

Detailed Description of Customer Feedback

After presenting the final concept to the clients, during the 3rd client meet, positive feedback and reinforcement was received on their end, with no negative remarks or critical observations made, which means that the team has effectively met all of the clients' product needs and requirements, such as :

- Using an RFID reader with a shorter range like the (RC 522) RFID reader (the one that we used) because they were not interested in a long range scanning system.
- The portable aspect of our system
- An easy to use and very accessible interface for the app
- An autonomous System
- The System validates rapidly the data

As all the other teams were doing their presentation, we took some notes permitting us to develop our next prototypes. The relevant thing we've noted was to add a Failure Detection System to our Final Concept.

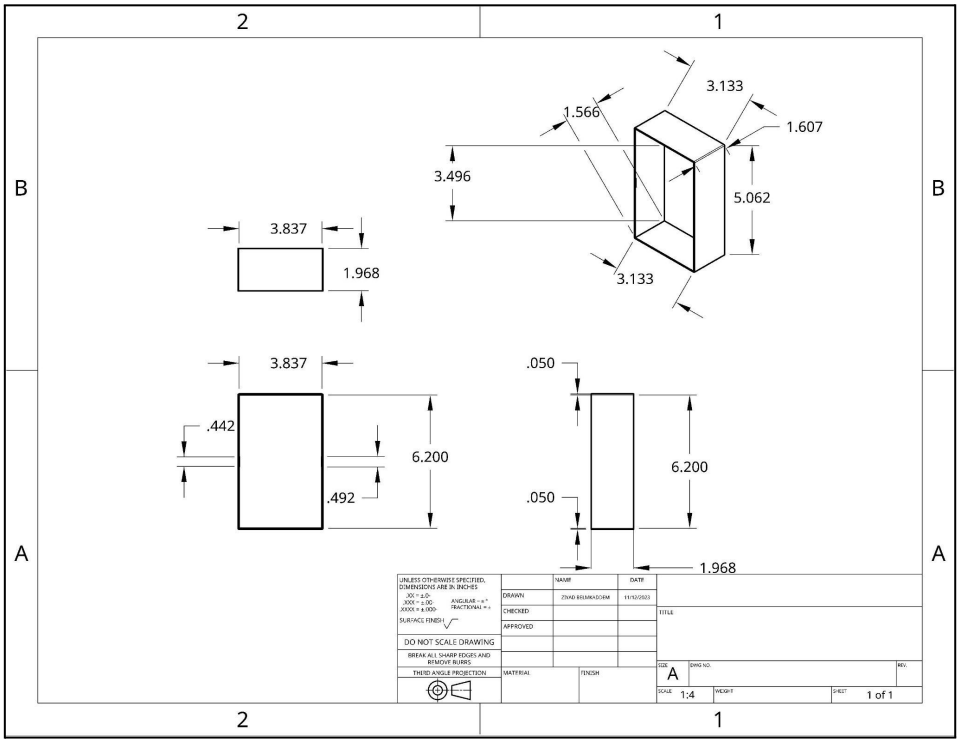
Prototype 2 Components

The second prototype was a partially comprehensive, physical prototype. This is due to the fact that it does not include a complete and usable app interface.

ELECTRONICS CASING

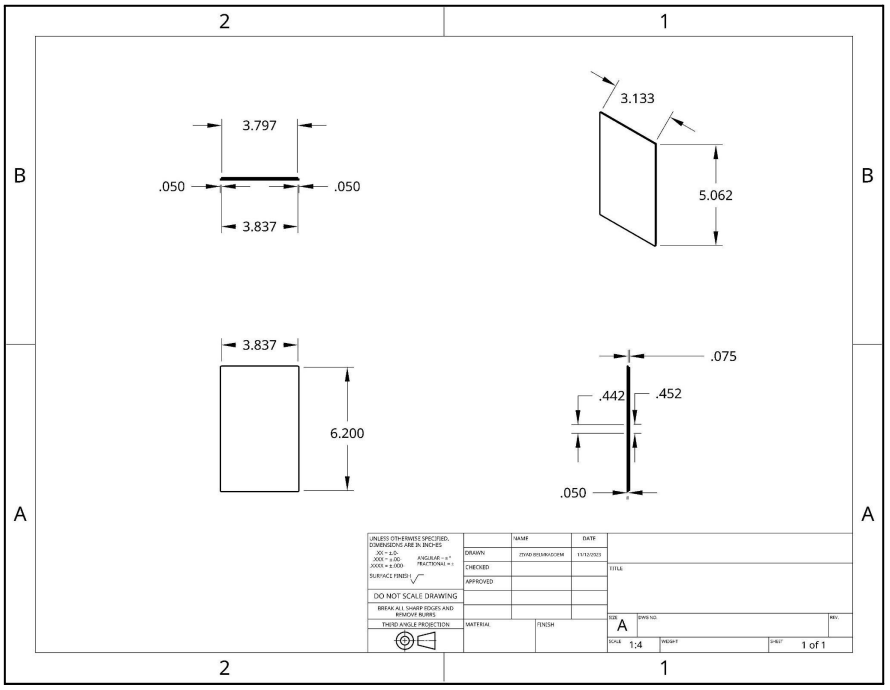
For our Electronic Casing, since we've encountered that our 1st prototype box was too small, we decided to change our dimensions and make it bigger :

ELECTRONIC COMPARTMENT

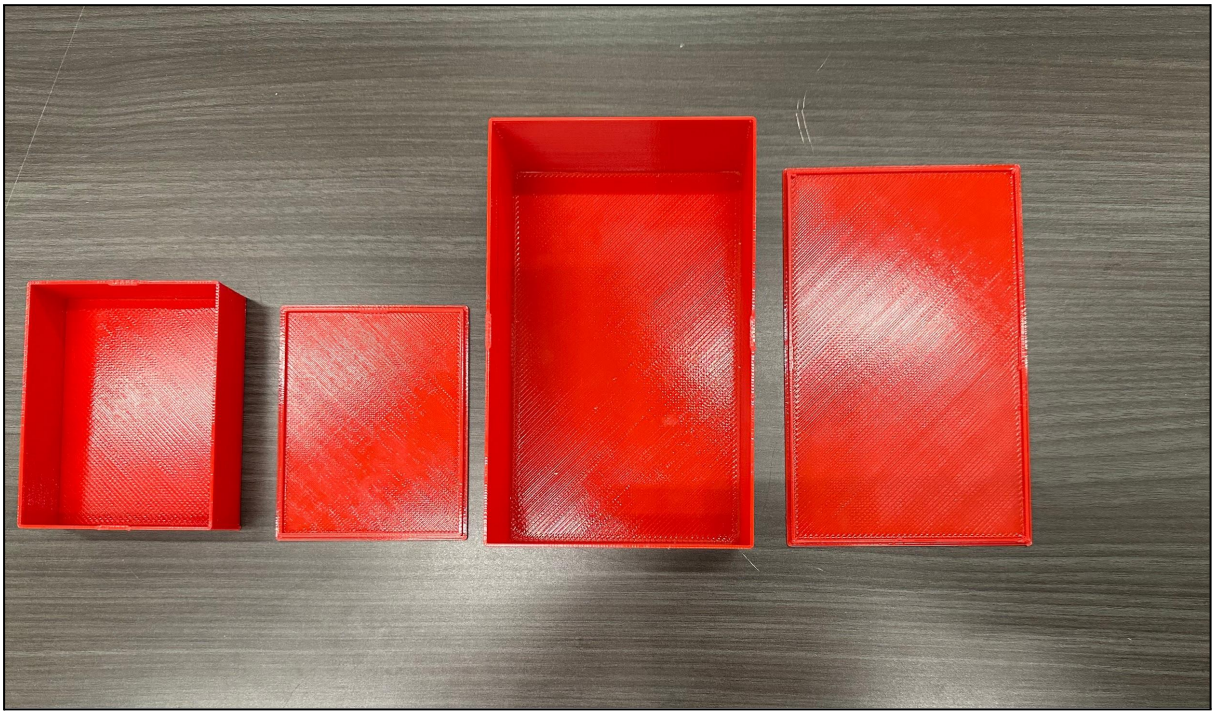


Compartment measurements and schematics

COMPARTMENT COVER



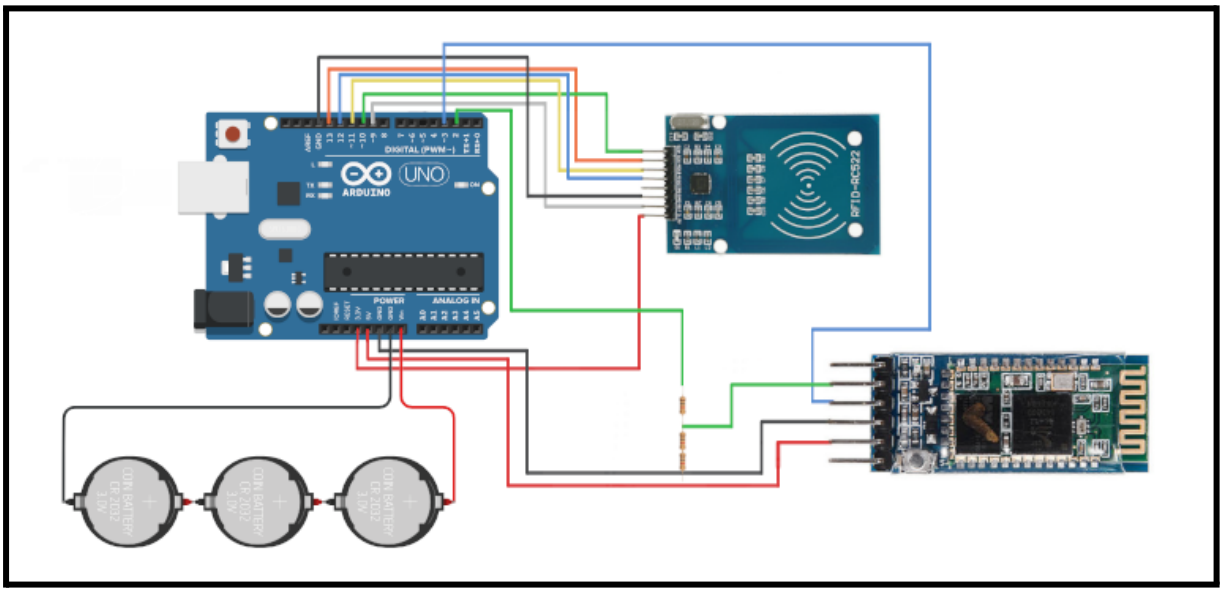
Cover measurements and schematics



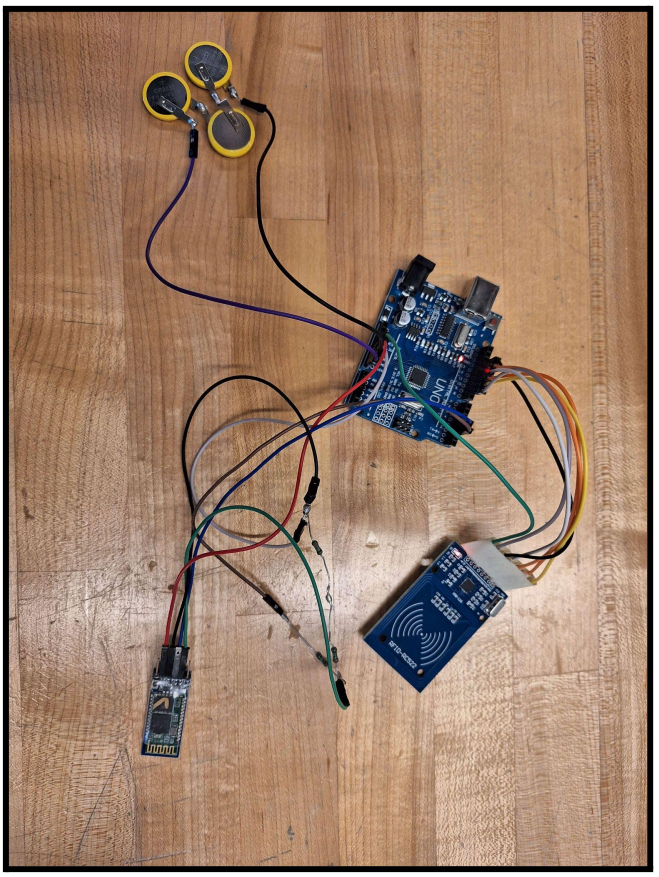
Comparison between the Prototype 1 casing (left) and the Prototype 2 casing (right)
This serves as an experimental modelization of the casing and its properties

ELECTRICAL LAYOUT

For the second prototype, the team chose to abide to the following circuit:



By abandoning the usage of a breadboard and adopting soldering as our main connection method, the team managed to save even more space in the electronics compartment, allowing for more freedom when it comes to cable management and handling, as well as components positioning.



A picture of the complete and final electrical circuit

For this prototype, progress was also made in the Arduino code that will manage input from the RFID, translate it to comprehensible and usable data, then send it to whatever device is connected to the Bluetooth module as if it were a serial input. It is then up to the app to receive this serial input and translate it to a list item, as to simulate an item in an inventory.
GitHub link to access the code:
https://github.com/ZackPaster/GNG1503-FA24-team/tree/3e0302cd7c5545ddedcdbba6179543830f5ddf62

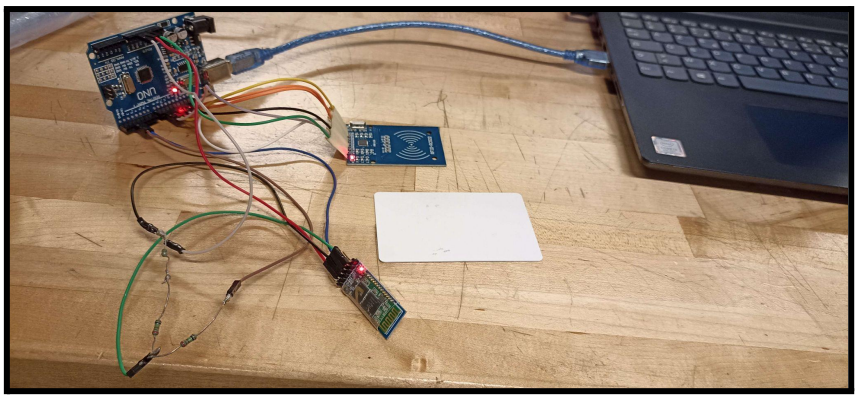
ADVANCEMENTS IN APP DEVELOPMENT TOOLS

There is no app interface for this prototype. However, progress was made in setting up the app development environment that would be used for this particular project (Microsoft Visual Studio), as well as obtaining the right tools, plugins, add-ons and frameworks required for the development of the user interface.

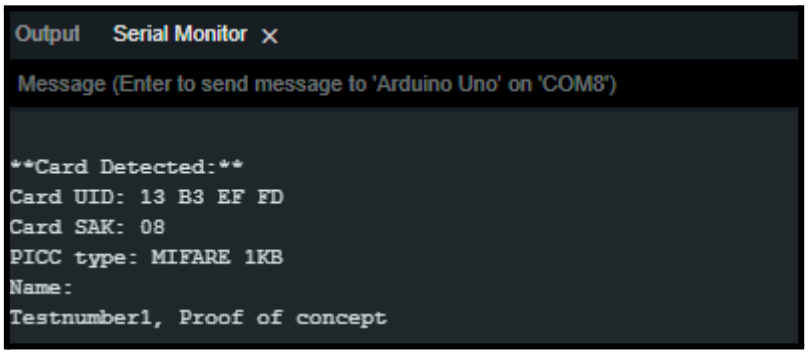
Prototyping Test Results

TEST #1: ARDUINO CODE

In order to ensure that the Arduino microcontroller has the ability to receive information from the RFID reader about the targeted tag, and transmit it to the nearest Bluetooth relay station (whether it were a phone, a computer, or a Bluetooth router), then the Arduino code and program has to be meticulously planned and adapted to our intended purpose. For this, the following Arduino code was uploaded to the Arduino, it is a mix of two library examples (MFRC522's "rfid_read_personal_data" and basic take-and-send instructions from the SerialPrint default Arduino IDE library):
https://github.com/ZackPaster/GNG1503-FA24-team/tree/3e0302cd7c5545ddedcdbba6179543830f5ddf62
For this test, we used a different program, from the MFRC522 example code of "rfid_write_personal_data", to insert data into a selected tag. We then used the previously mentioned code, in order to send this information to a mobile phone, connected to the HC-05 module by Bluetooth. The app used on the phone for displaying this information is: "Serial Bluetooth Terminal".



Test setup used, circuit on the left, central computer on the right for debugging, and the white RFID tag-containing card on the right



Serial Monitor output on the central debugging computer

Terminal display on the receiving mobile phone

This test proves to be crucial, because it demonstrates the effectiveness of the Bluetooth module in transmitting our required information, which would be the name of the product, the tag's identifier (A string of couples, made up of numbers and letters, that are unique to a certain tag), its quantity, manufacturer or provider, and description.

TEST #2: BATTERY EFFICIENCY AND FUNCTIONALITY

The aim of this test was to confirm the effectiveness of the 3 CR2032 3V batteries, in a series arrangement. Please refer to Prototype 2 components, electrical layout, picture #2 in order to get an idea of the circuit used. Note how only the Arduino LED and the RFID RC522 LED are turned on, but even they are faint, minimal, and barely visible, indicating poor current feed and non-operability of the HC-05 Bluetooth module.
The main observation obtained from this test is the unresponsiveness of the HC-05 Bluetooth module. Further analysis would give the following results:
Each CR2032 3V battery gives out around 0.2 mA, based on the CR2032 datasheet from Energizer:

Simulated Application test
Typical Performance at 21°C (70°F)

Schedule:	Typical Drains: at 2.9V (mA)	Load (ohms)	Cutoff 2.0V (hours)
Continuous	0.19	15,000	1245

CR2032 Lithium-Magnesium ion coin battery specifications sheet [1]

In a series arrangement, we obtain a total initial current intensity of ~0.2 mA.
In contrast, the Arduino board alone requires a minimum of 0.5 A to function properly.
Minimal working current intensities for all electrical components are:
-Arduino UNO microcontroller: 0.5 A
-RC522 RFID reader: 13 mA [2]
-HC-05 Bluetooth module: 50 mA [3]
Adding up all of those values, gives us the total minimum current intensity that the batteries must provide for optimal functionality:

0.563 A ,significantly larger than the CR2032 capacity of 0.00019 A, meaning a current deficiency of <99.96%.

This, in turn, results in an underfeeding of the entire circuit.

This test proved to be essential, because it highlighted an oversight from the electrical designer's part. As replacement, more research will be done regarding the appropriate power supply for our project.

TEST #3: COVER LOCKING MECHANISM

The newly 3D printed cover is placed on the compartment and firmly attached.
While flipping the casing upside down, it only takes a few pushes and nudges for the cover to fall down. The mechanism manages to hold the cover in place, however slight disturbances cause it to fail and open the compartment.
This calls for a redesign of the mechanism, by adding more attachment points, potentially 4, with one in each mid-segment of the cover's surface.

Picture of one of the casing's two attachment points (a small extrusion of 1.2 cm in length and 0.5 mm in depth)

Picture of the full casing, compartment with the cover attached

Potential User Feedback

In order to obtain feedback on our current approach to the final solution, we took in Dr. David Bruce's advice on sustainability regarding our product, which would greatly help us develop the product's results in a Life-Cycle and Sustainability Assessment, which prove to be an important factor in today's market.

Dr. David Bruce is a professor at the University of Ottawa's faculty of engineering, primarily in the GNG5140 course. He has a PhD in Chemical engineering, with expertise in different disciplines of engineering as well.

Thanks to Dr. Bruce, it was brought to the team's electrical designer's attention that the usage of three CR2032 Lithium-Magnesium ion coin batteries arranged in series, is not an efficient way of supplying our circuit, that goes without mentioning the potential environmental and social risks that come with it.

These batteries pose a challenge when it comes to proper disposal, and looking at how unlikely it is that they would last very long **(previous calculations proved that they cannot exceed ~30 minutes of operation at full capacity, see Deliverable F for calculation details)**, that means it would be a very frequent issue to encounter.

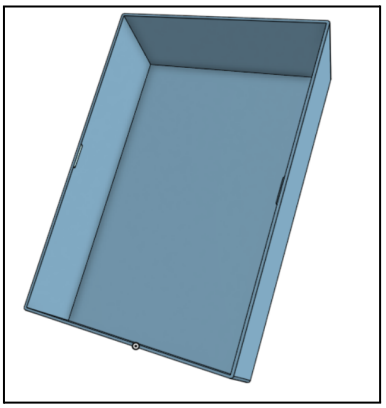
In addition to that, the usage of these batteries would mean a very low life-cycle assessment score, due to their implications in matters of child labour, social inequity and climate change, when it comes to intensive Lithium and Magnesium mining methods.

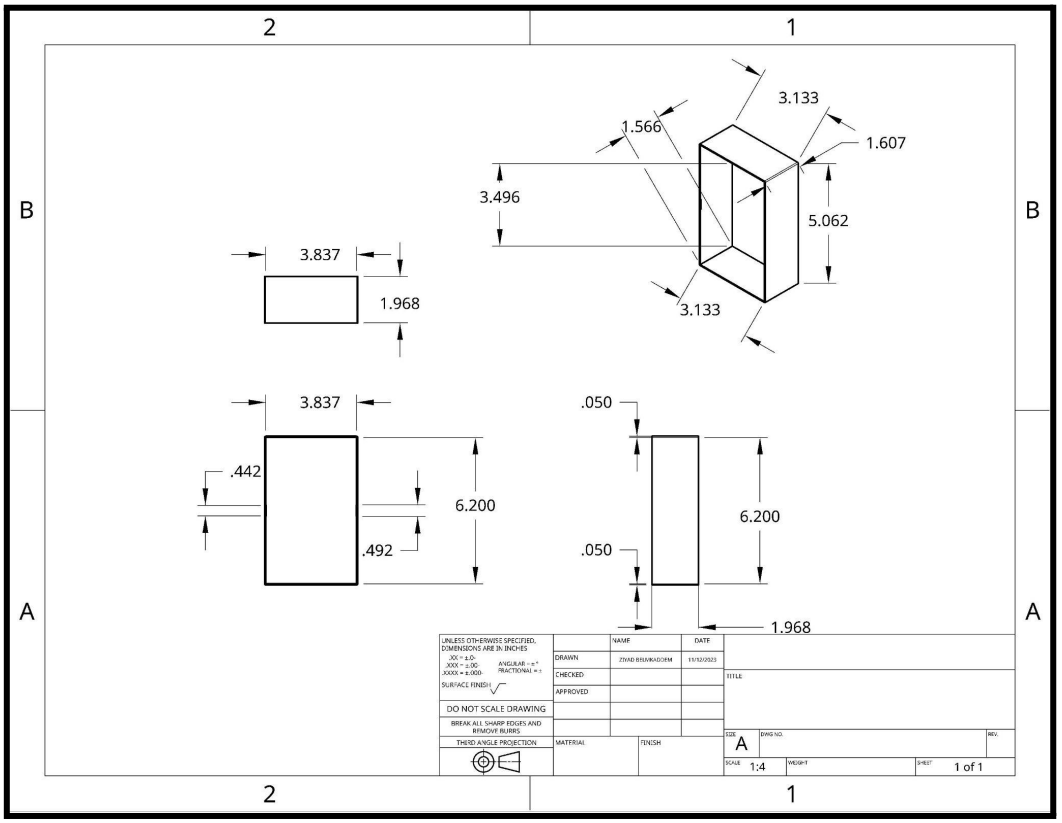
Feedback from Dr. David Bruce proved to be influential on our approach to solving the issue, with the team aiming towards a more sustainable solution as our main goal.

Updated concept based on prototype testing results

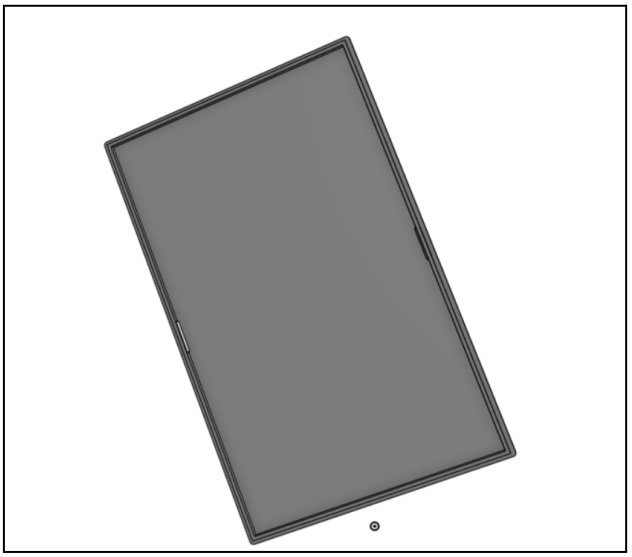
ELECTRONICS CASING

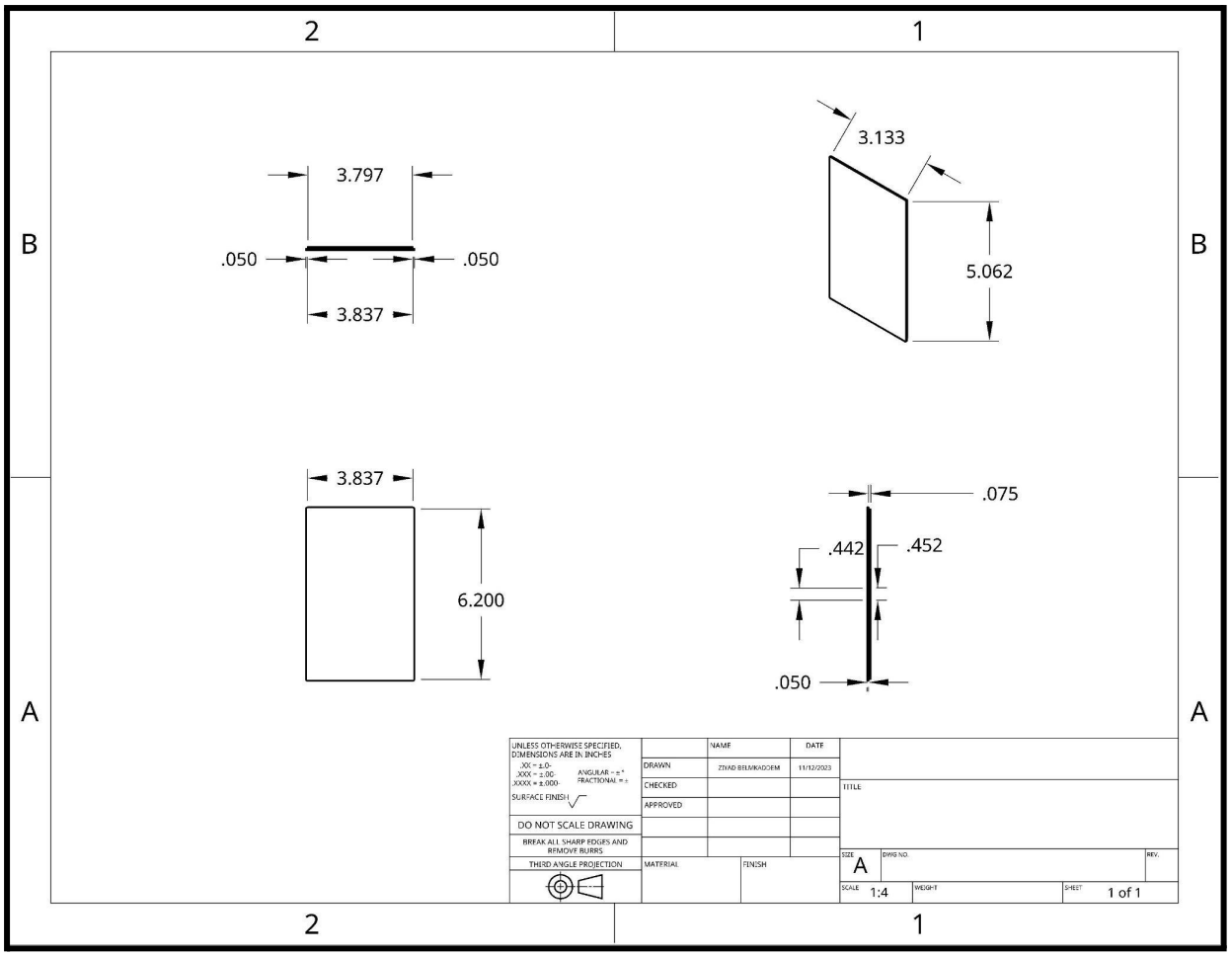
ELECTRONIC COMPARTMENT





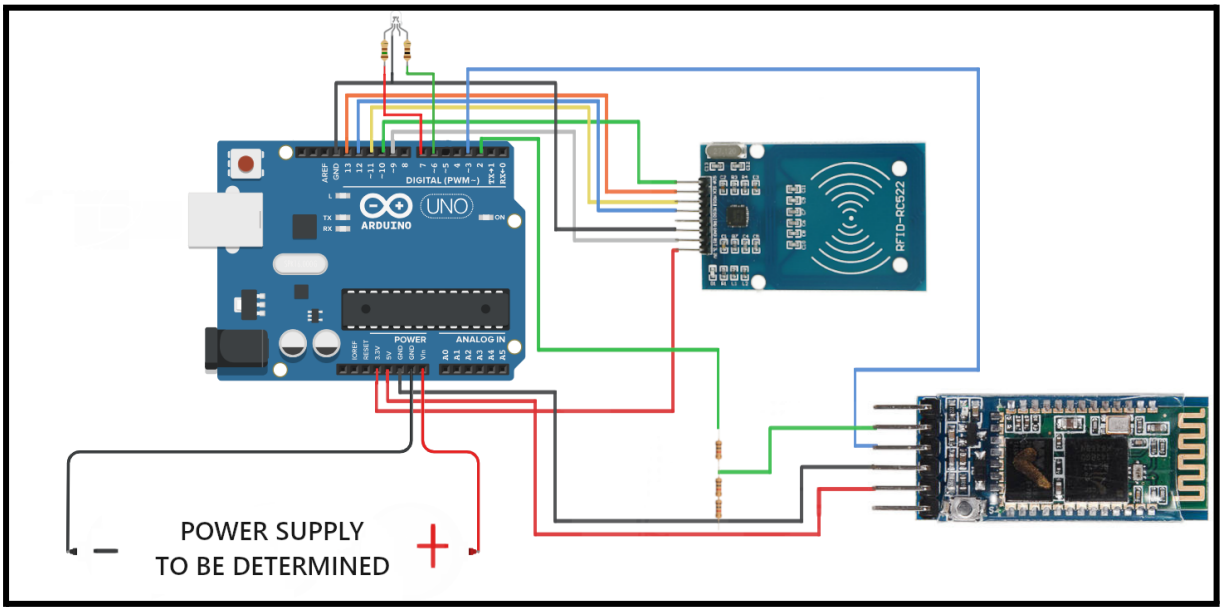
COMPARTMENT COVER





As 24BEES members thought about a failure detection system using an LED, adding a hole by drilling the compartment cover so that we can see the LED is going to be a part of the 3rd prototype. For the 3rd prototype, as we are using new batteries we should consider their size so that we can manage the dimensions of the box in a way that all the electrical components fit into it.
For the 3rd prototype we have to come up with a better secure mechanism. The one used for the first prototype doesn't last for a long period of time (1 week).

ELECTRICAL LAYOUT



New electrical layout for prototype 3, based on prototype 2 testing (POWER SUPPLY HASN'T BEEN AGREED UPON YET)

As 24BEES members, we thought to include those several updates for the 2nd prototype to produce our 3rd prototype :

- We thought about adding a failure detection system using an LED. We should modify our electrical layout by adding 2 new cables for the LED and 1 LED (It switches to two distinctive colors (green/red))
- The batteries are actually delivering a voltage of 7 V and not 9V. It is a big issue for our final concept because the bluetooth module doesn't work because of the low voltage that is delivered. So we decided to buy new off-the-shelf 9V batteries.

WIREFRAME

Here is the wireframe for the application. This one is high fidelity, compared to the low fidelity, this one has 5 new pages.

The old pages

The interface: which is the main menu, where you have access to every option that the app provides .

Reglages (Settings) : in which we can change the language, the display, the notification you receive and the sound.

Aide (Help) this page gives you access to the FAQ (for more general questions about how the application works) and to a phone number and an Email to contact when you have a more specific problem.

ITEM: This page shows the information about the item that you are searching for : the serial number, the location, the date of entry(=When did the item enter the inventory), the history of this item(= every move in the inventory). With the option « partager »(share) you can share the information you found with other members of your team.

Historique (History): provides the user with their items' search history .

Enterprise: From there, the user can chat with all their colleagues who use the application.

Scan: allows the owner of the app to use their cellphone as a scanner for the item.

Informations : provides the information about the person that logs in; their name, their email, their phone number and the name of their company. Furthermore, they can edit their personal information at any instant.

Notifications : we can track any item's registration activity within the inventory.

Login page: From here the user can log in to their account using either their email address or their phone number and entering their password.

FAQ page: From here the user has access to several questions through which the answer to his problem can be found.

Two discussion pages: From the first discussion page, the user has access to all their conversations with their co-workers and on the second one, the user can chat with one specific co-worker.

The new additions

Notifications setting page: Here the user can choose which notifications he wants to receive.

Sound setting page: From here, the user can activate the sound of the application or deactivate it.

Languages pages: from here the user can configure the language of the application. He has the choice between English and French.

Display setting page: from here, the user can change the font display.

The validation page: This page is only available on the version of the application that the office's boss owns. From there, He can choose to accept or to decline the modification that an employee wants to do on an item.

Wireframe pages

MATERIAL NAMING

	Item Name	Description	Unit of measurement	Quantity	Unitary Cost	Expected cost	Link
1	RFID reader (RC 522)	Scanner + tag	Unit	1	5$	5$	https://www.amazon.ca/CANADUINO-RFID-Starter-13-56MHz-Keyfob/dp/B07B2CV31T/ref=sr_1_2?crid=YZTDLLULKJU5&keywords=RFID+reader+Arduino+UNO&qid=1698606710&sprefix=rfid+reader+arduino+uno%2Caps%2C89&sr=8-2
2	Arduino UNO	Arduino UNO microcontroller(processing unit)	Unit	1	17$	17$	https://makerstore.ca/shop/ols/products/arduino-uno-r3/v/A001-WTH-USB
3	Bluetooth module (HC 05)	Bluetooth transceiver replacing the serial cable	Unit	1	9$	9$	https://makerstore.ca/shop/ols/products/hc-05-wireless-bluetooth-module-with-at-button
4	Jumper cables	1x 10-pack Male-to-Male (20 cm) 2x 10-pack	Unit	3	1$	3$	https://makerstore.ca/shop/ols/products/jumper-cables-

		Male-to-Female (20 cm)					per-10/v/JMP-CBL-20C-ML
5	Battery	TO BE DETERMINED	Unit	N/A	N/A	N/A	N/A
6	Resistors	-1KΩ -100Ω -150Ω	Unit	-3 -1 -1	1$	5$	N/A
7	LED	-Diffused RGB 5mm LED	Unit	1	0.60$	0.60$	https://makerstore.ca/shop/ols/products/diffused-rgb-5mm-led
8	Data base	SQlite	N/A	N/A	0$	0$	N/A
9	RFID case	A plastic case that contains the Arduino, the RFID and the batteries (3D-printed)	Unit	1	0$	0$	https://cad.onshape.com/documents/8f4b0cc50aac21c20323d64b/w/f1718eea2c8e68708ef56824/e/fe41029a669a977626162548?renderMode=0&uiState=653ea72120e66a34a1bbd021
10	Code librairies	-MFRC522 -Software Serial	Unit	2	0$	0$	https://github.com/miguelbalboa/rfid
	Total without Tax or delivery fee					≃39.60$	N/A
	Total with Tax and delivery fee					≃45.40$+0$	N/A

[4]

Prototyping Test Plan (Prototype 3)

N° of the test	Objective of the test	Description of the prototype used and test methodology/procedure.	Description for results to gather and how they will be used	Estimated duration and time of beginning of the test
1	Verify app interface user-friendliness	Analytical and partially comprehensive, we will allow a test-user (a friend, or random person) to use the app for a few minutes and discover its features (Simulating an early-access phase of the app)	User feedback and suggestions. These suggestions will be taken into account during the development of the third prototype, where we will consider the test-user's rating for each functionality and its usability. Any functions with a notably low rating will be reworked and improved upon.	30 minutes, 18th of November, 2023

[5]

Conclusion

After completing our first prototype and receiving the customers' feedback, we were able to refine our work and make a better version of the product for our second prototype. This prototype includes a simplified electrical circuit, a bigger and more convenient RFID casing, and a richer, more developed wireframe design. We plan on improving certain aspects of our project in the following week such as, the closing mechanism of the casing, adding LED lights to the circuit in order to indicate success or failure of scanning, simplifying the circuit and organizing the cable connections, developing a functional mobile app that is connected to the bluetooth serial terminal, and replacing the current power supply by a (0.5 A, 9V) battery.

References

[1] https://data.energizer.com/pdfs/cr2032.pdf
[2]https://robu.in/product/rc522-rfid-card-reader-module-13-56mhz/
[3]https://www.electronicwings.com/sensors-modules/bluetooth-module-hc-05-
[4] Développement professionnel/Gestion de projet/Guide d'achat — Wiki CGEC
[5] https://uottawa.brightspace.com/d2l/le/content/382673/viewContent/5596392/View