GNG 1103 – Engineering Design

Project Deliverable F

Prototyping and Customer Feedback I

Group#15

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1.0 Introduction

First prototypes are defining moments in a project. In these moments, the work and theory of the ideation stage is finally put to the test. It is important when first creating prototypes that basic assumptions and conditions are confirmed and established. This allows for the rest of the prototyping process to be carried out with the group having a more thorough understanding of what the product can do. This understanding will be founded in real results obtained through the testing of components that have been purchased.

In this document, the objectives of the group in the first phase of prototyping will be explained, with a plan to demonstrate how those objectives will be achieved. Furthermore, in light of the client's feedback the group has decided to cut the camera module in favor for a second DHT22 temperature and humidity sensor. This choice was recommended by Mo from JAMZ, as a better alternative in terms of budget, workability with existing libraries, and it is more in line with JAMZ's need for consistent and accurate climate data. A second temperature sensor will allow for an average of data instead of simply relying on one sensor. This allows minimizes the risk of a total failure of a sub-system because if one DHT22 sensor fails data can still be read from the backup. In the camera's place the group has decided to integrate an accelerometer into the module, with the possibility of including a shake alarm. This will add a second layer of data transfer to the main computer without relying on a sperate acceleration sensor module. The accelerometer will be tested during this prototype phase as well.

2.0 Prototyping Objectives

The prototyping done initially will be more focused and more analytical. Components will be tested individually as a series of sub-systems to properly divide out the prototyping tasks and to lessen the risk of failure if everything was tested as one single system to start.

The goals from this round of prototyping are to analyze different components of every subsystem, from the casing to the sensors, and ensure that every subsystem works together. The code must be efficient and compliable while taking up as little memory as possible, while the casing must be strong and sturdy while not interfering with the components.

2.1 DHT22 Code

The objective for the first test of code for the DHT22, a temperature and humidity sensor, is to ensure it can be compiled using the Arduino library and to present the logic in a clear fashion. Since the code requires data to be tested properly, the best possible option for testing the code is simply to ensure it can be compiled using the Arduino IDE. This way, when the sensor does come in the mail, it can immediately test the code with the sensor without worrying about the syntax not being correct, or if the Arduino compiler is not able to compile the code to send it to the physical Arduino.

2.2 Accelerometer Code

The accelerometer code objective is the same as the DHT22 code. Since the sensor is not physically available at this moment, the objective is to ensure the code will compile with the Arduino IDE with proper syntax and to present the code logic clearly. This will make the sensor testing ready as soon as it arrives. This objective is especially important with the accelerometer because the libraries associated with the accelerometer are more niche and harder to work with then the DHT22 library. Thus, this prototype will simply be the verified code associated with the accelerometer, and its accompanying flowchart for the basic logic behind the code.

2.3 Sensor Case Module

The goal for the sensor case module prototype is to ensure the case will fit all necessary components including, two DHT22 sensors, one accelerometer, wires, and all the M3 screws that will keep the components in place. The best prototype for this objective is a CAD model as it does not require any physical materials. The creation of this model can use the dimensions obtained from benchmarking the sensors and the screws obtained from the hardware list sent out by JAMZ. Thus, without printing anything out, the metrics of the sensors can be built into the case before buying any material.

2.4 Arduino Case Module

The objective of the Arduino case prototype is the same as the sensor case module, it will simply ensure the dimensions of the case module coincide with the dimensions of the Arduino, breadboard, and wires. The best option to achieve this objective is a CAD model. As previously mentioned, a CAD model will function as a low fidelity model of the case without requiring the purchase of any physical material, but it can be designed to ensure the dimensional restrictions

are satisfied. This model will also allow for the volume to be easily calculated using the correct dimensions, so a choice of material can be made.

2.5 Physical Model

The prototyping of the physical model is simply a proof of concept for the entire system. It is simply there to verify the feasibility of all the subsystems built together as one full system and to give a richer visual aid to what the concept will roughly look like all together. The test to verify feasibility comes down to whether the components will all connect to each other and talk to each other. Due to this being a low fidelity prototype, not all sensors are included, and the case modules are made with cardboard, so the goal of this test is simply to connect similar electronics together in the configuration the design adhere to and see if power will reach all the electronics connected in this manner. This objective will serve as a proof of concept for the overall design.

3.0 Prototyping Tests and Results

The plan for the prototyping phase one is to ensure all the sub-systems adhere to the dimensions of their associated electronic components and that the code for each sub-system is free of syntax errors. This will be done in a timely and efficient matter by splitting up all the prototypes by sub-system and creating models and analyses that match the initial prototyping designs to the design specifications. Throughout the week of March 1st to the 8th each member will be responsible for creating an initial prototype that corresponds with each prototyping objective. In addition, each member will analyze the prototype and compare it the product specifications. The plan as it stands has Noah prototyping the accelerometer code, Rakshita responsible for the DHT22 code, Timi responsible for the Arduino case CAD design, Lucas in charge of the sensor case design, and Riley in charge of the physical model of the prototype.

3.1 Accelerometer Tests and Results

The code for the LSM6DS3, an accelerometer sensor built with a gyro scope, is tested using the Arduino IDE compile verifier (check mark) to ensure the code will run with the absence of any syntax errors. Also, to demonstrate the logic of the code concisely, the logic has been formatted into a process flowchart. The results obtained from this test have indicated that the code will compile with the current use of methods. However, the fact that this does compile does not indicate very much about how it will interact with the sensor. It is assumed that the logic used in the code will work in conjunction with the sensor data, but that is not guaranteed.

One test that Riley was able to perform briefly with the sensor demonstrated unknown characters appearing on the serial monitor. This could be due to a bound error using the *serial. Begin* command i.e., the value of 9600 may not be compatible with the sensor. Figures 1 and 2 show the code in its compiled form and the logic presented clearly as per the prototyping objective. While this test has completed the objective set for phase one of prototyping the code still requires physical testing with the sensor.

Figure 1: Accelerometer code using the acceleration and calculating the jerk.

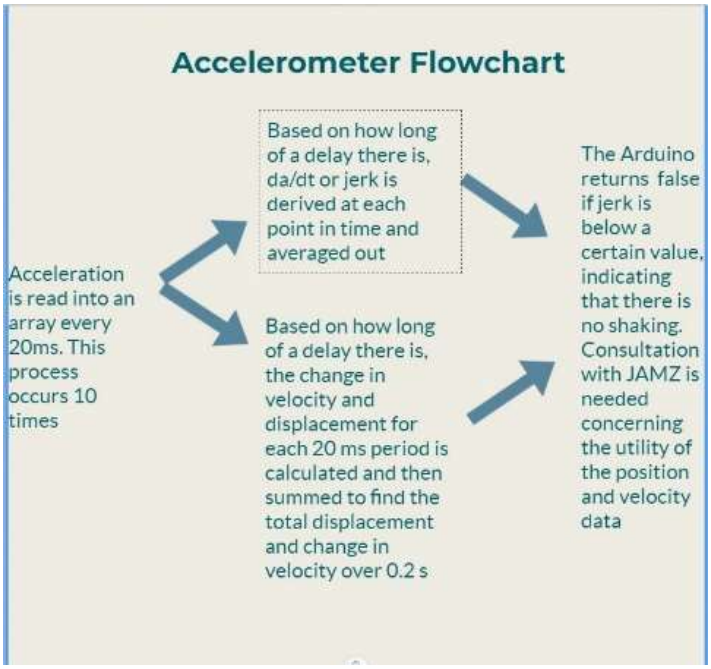

Figure 2: Flowchart for the accelerometer code

3.2 DHT22 Code Tests and Results

Similarly, the code for the DHT22 is tested through the Arduino IDE verifier to check to see if it will compile without any syntax errors, and the logic is presented using a flowchart. The result of this test has returned true, the code will compile. However, like the accelerometer code, this assumes the logic used and the manipulation of the data received from the sensor will coordinate with the sensor itself. It remains unknown whether the code will compile with the DHT22 connected. It could happen that the library used with the DHT22 requires a different serial. Begin value like with the accelerometer. Within the code itself it reads the data and can perform an analysis of whether the temperature is in range of -5 to 25 degrees Celsius and return a Boolean indicating whether it is. This Boolean method of checking whether the temperature and humidity is in range falls in line with the target specs as well as the client's request for simply a temperature check rather than the full raw data. For the moment though the fact the code does compile with the Arduino IDE, and that the logic used is sound is enough feedback at this stage to continue forward with the next phase of prototyping. Figures 3 and 4 show the code compiled and verified within the Arduino IDE and the clear flowchart of the logic used in the code as per the prototyping objective, respectively.

Figure 3: Figure 3: Code reading and analyzing DHT22 temperature and humidity values.

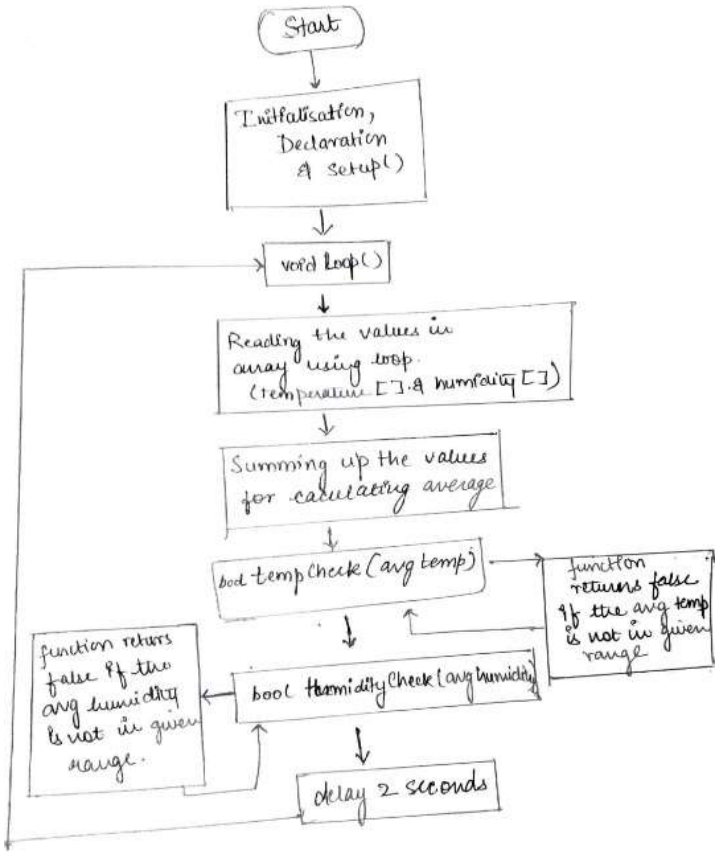

Figure 4: Flowchart for the code in figure 3

3.3 Sensor Case Module Tests and Results

The testing method for the sensor case is done through a CAD model using On Shape. The test CAD model is built using the dimensions of the sensors considering enough clearance for the sensors within the case. This will ensure the case design adheres to all sensor design specifications. The results of this model are like the Arduino case as they show the case adheres to the sensor dimensions. One assumption made in this prototype is the head of the M3 screw, this model assumes a flathead M3 screw, and depending on availability it could have to be changed to fit the modules inside, and the countersinks on the outside. From presenting the prototype to the TA's and PM and receiving feedback, a solution to the attachment of the bottom case to the top case is needed. 3D printing threads is not a valid option. Instead, two options are being taken under consideration: a simple nut at the end of the bolt to keep it in place or a threaded insert that will fit within a hole made in the bottom case module and act as the threads inside for the bolt to screw in. Analysis of the case itself shows that the nut design would not work as it will impede upon the point of attachment to the drone which must remain as is to keep

everything as stable as possible. The heat threads would work, but they depend on availability. In keeping with the target specifications for the weight of the module, figure 7 is a simple analysis of different materials considered for the case including MDF, plastic, and acrylic. Compared to the target specification of <5kg this model, whether bigger screws are used or not, is much less than the max mass for the module using any of the three materials. Due to this fact, and with time constraints in mind the decision to laser cut the module has been made. Figure 5 and 6 show multiple different views of the case. Specifically, the top and bottom parts of the case, seen in figure 6, will be exported into sketch files that can be used in Inkscape to be laser cut. The CAD model itself is completed adhering the dimension objective set out in this phase of prototyping, but the physical aspect of it is still on going into phase 2 of prototyping.

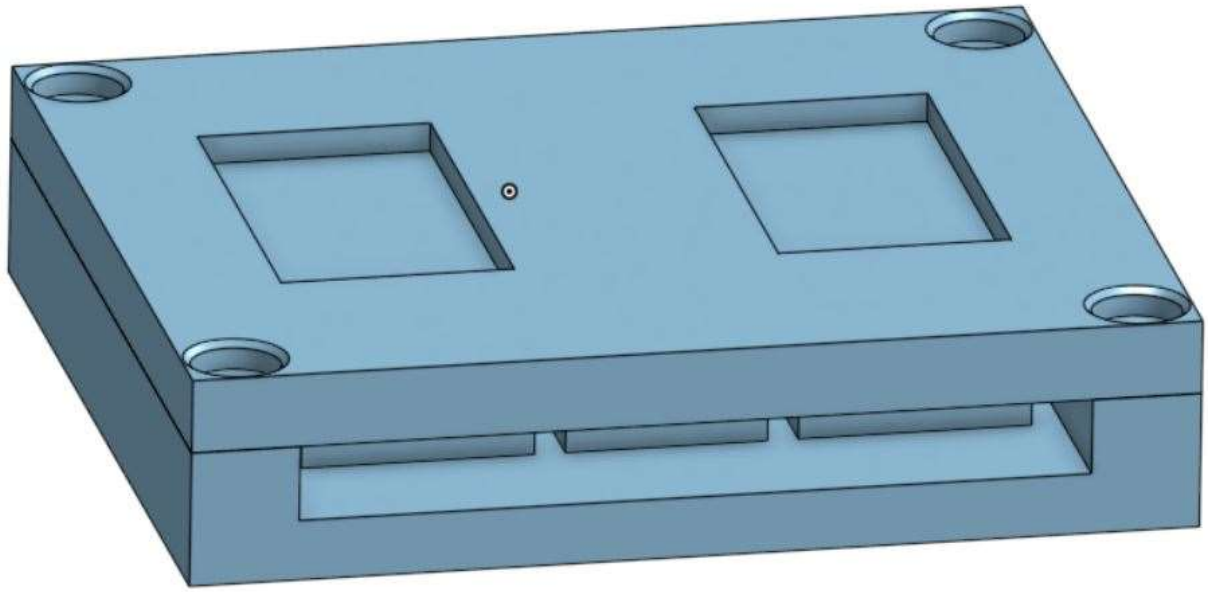

Figure 5 Perspective view of the sensor case module

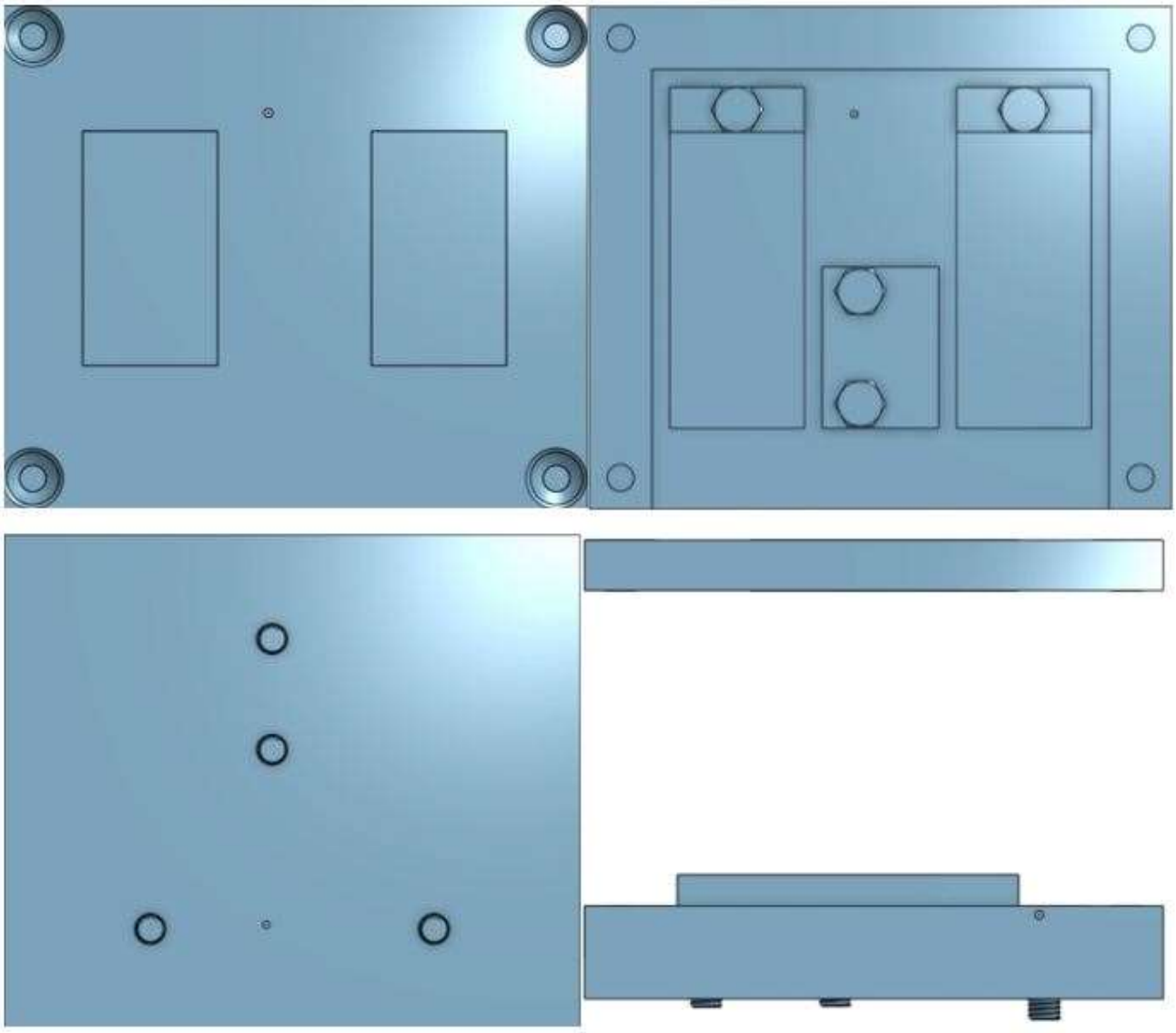

Figure 6: Top view of outer case shell (top left), Top view of inside of case (top right), Bottom view of case (Bottom left), Side view of case (Bottom right)

Weight Analysis of Sensor Case Module	
Lucas Siviero	

Constants		Amount
g =	9.81	-
Mass (kg)		-
DHT22	0.0024	2
LSM6DS3	0.0007	1
M3	0.384	7
M3.5	0.514	7
Total Mass (M3)		2.6935
Total Mass (M3.5)		3.6035

Note the mass of the screws are approximated

Material	MDF	PLA	Acrylic
Density (g/cm^3)	0.8	1.024	1.19

Component	Top Case	Bottom Case
Volume (cm^3)	19.9131	13.5794

Mass Using MDF		
Component	Top Case	Bottom Case
Mass(kg)	0.01593048	0.01086352

Mass Using PLA		
Component	Top Case	Bottom Case
Mass(kg)	0.0223027	0.0152089

Note this assumes the PLA is 10-30% filled
Filament diameter 1.75 mm

Mass using Acrylic		
Component	Top Case	Bottom Case
Mass(kg)	0.023696589	0.016159486

Assumes that all screws used are either M3 or M3.5.

Material	Total Mass (M3)	Total Mass (M3.5)
MDF	2.720294	3.630294
PLA	2.7310116	3.6410116
Acrylic	2.733356075	3.643356075

Figure 7: Weight analysis of sensor case module using PLA, MDF and acrylic

3.4 Arduino Case Module Tests and Results

The case module for the Arduino, breadboard and wires is made through Solid works and tested in On Shape. To coincide with the objective, the case is built using the dimensions of the Arduino with consideration for clearance for the wires inside the case. The CAD model is built adhering to the dimensional constraints of the Arduino, and On Shape takes this model and calculates the volume to be used in material analysis. The results of this model show that the case adheres to the relative of dimensions of an Arduino Uno R3. From the resulting CAD model, it is unclear whether the wires will have enough clearance to hold steady within the module. Without a physical model it is tough to tell, so for the moment it is assumed that the height of the Arduino will have enough room to house the wires as well. The CAD model also brought forward a debate over the choice of material relative to the amount of time spent in production. From the box shaped model of the case, 3D printing is a feasible option as well as laser cutting. Thus, the analysis in figure 10 checks the volume of the module and compares it to different densities of material. Then the weight of the material is calculated considering the Arduino, the wires, and the breadboard. The analyis indicates that the weight of this case module is similar to that of the sensor case module. This means that the combine weight may is close to 5kg; however in terms of the objetcive of this specfic prototype the fact that it fits the components is enogh for now. In the next phase of protoyping the case may need to be redisnged in order to decrease the weight. Figures 8 and 9 show the case module from two perspective views.

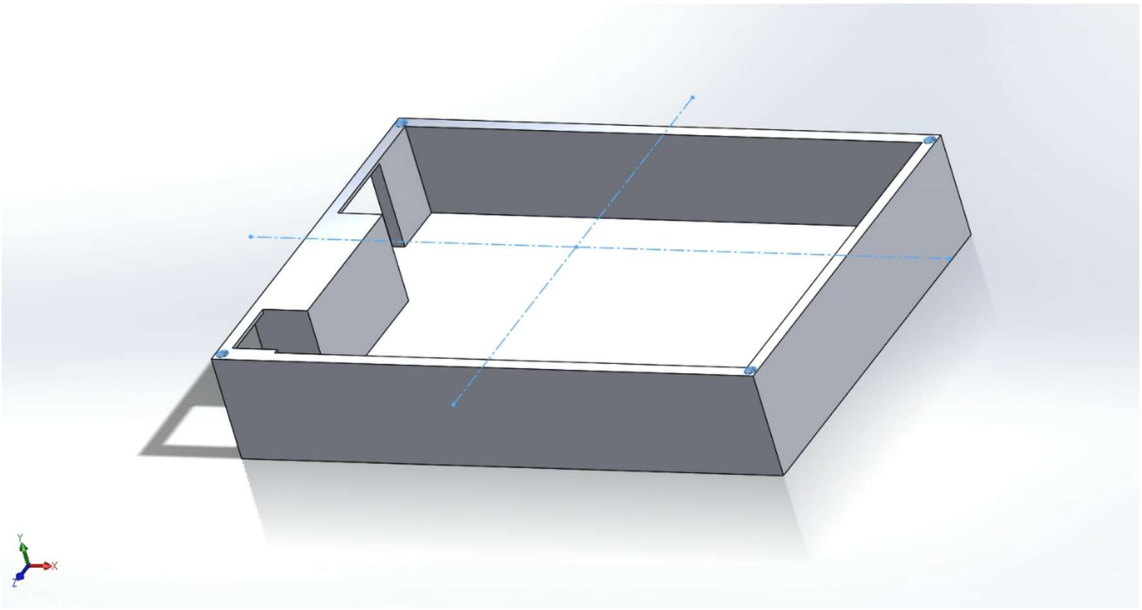

Figure 8:First perspective view of Arduino case module

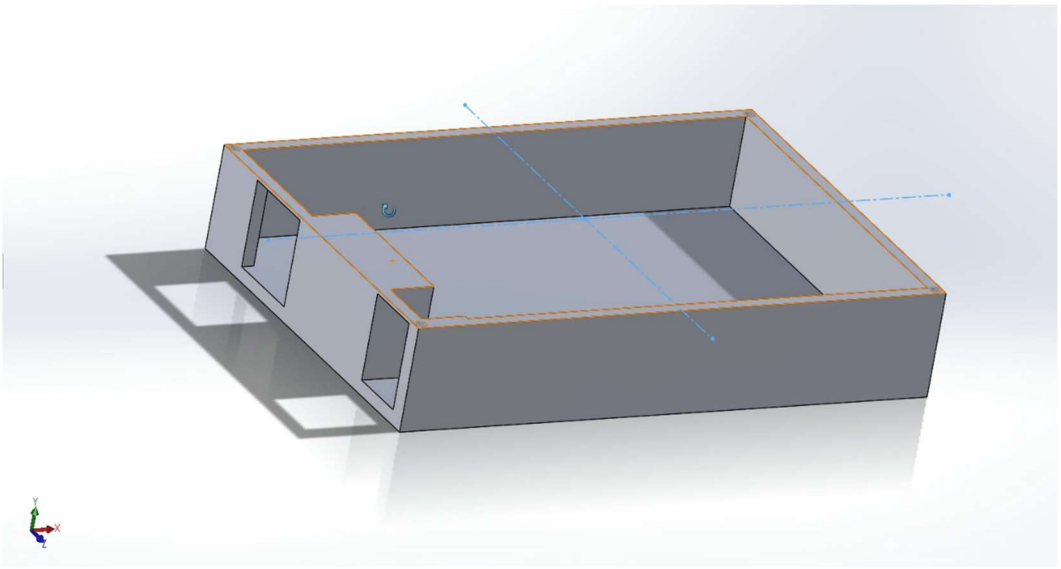

Figure 9: Second perspective view of Arduino case module

Weight Analysis of Arduino Case Module			
Lucas Siviero			

Constants		Amount	
g =	9.81	-	
Mass (kg)		-	
DHT22	0.0024	2	
LSM6DS3	0.0007	1	
M3	0.384	7	
M3.5	0.514	7	
Total Mass (M3)		2.6935	**Note the mass of the screws are approximated**
Total Mass (M3.5)		3.6035	

Material	MDF	PLA	Acrylic
Density (g/cm^3)	0.8	1.024	1.19

Component	Top Case	Bottom Case
Volume (cm^3)	10.881	23.352

Mass Using MDF		
Component	Top Case	Bottom Case
Mass(kg)	0.0087048	0.0186816

Mass Using PLA			**Note this assumes the PLA is 10-30% filled**
Component	Top Case	Bottom Case	**Filament diameter 1.75 mm**
Mass(kg)	0.011142144	0.023912448	

Mass using Acrylic			
Component	Top Case	Bottom Case	**Assumes that all screws used are either M3 or M3.5.**
Mass(kg)	0.01294839	0.02778888	

Material	Total Mass (M3)	Total Mass (M3.5)
MDF	2.7208864	3.6308864
PLA	2.728554592	3.638554592
Acrylic	2.73423727	3.64423727

Figure 10: Material analysis of Arduino case module

3.5 Physical Model Tests and Results

The physical model testing method is to use cardboard and extra electronic components to give a more concrete visual model of a complete system and to ensure all parts connected will receive power. The model itself is low fidelity, so it assumes the point of attachments to the drone will work with the length of wires used in the model, but that may not end up being the case. This is a low cost experimental-physical model that simply acts as a better visual aid for all the subsystems put together. The results from building the model have shown that the DHT22 sensors needed inside do in fact require two 10Kohm resistors to function properly. Figure 8 shows this circuit using the resistors previously mentioned. Figures 9 and 10 show screenshots of the physical model itself to demonstrate proof of concept in terms of power functionality as well as a preliminary circuit diagram that should function with the DHT22's circuit requirements obtained from the data sheet. This model as per the objective is complete, the next physical model will be ongoing into phase 2 of prototyping, but it depends on when the components come in the mail.

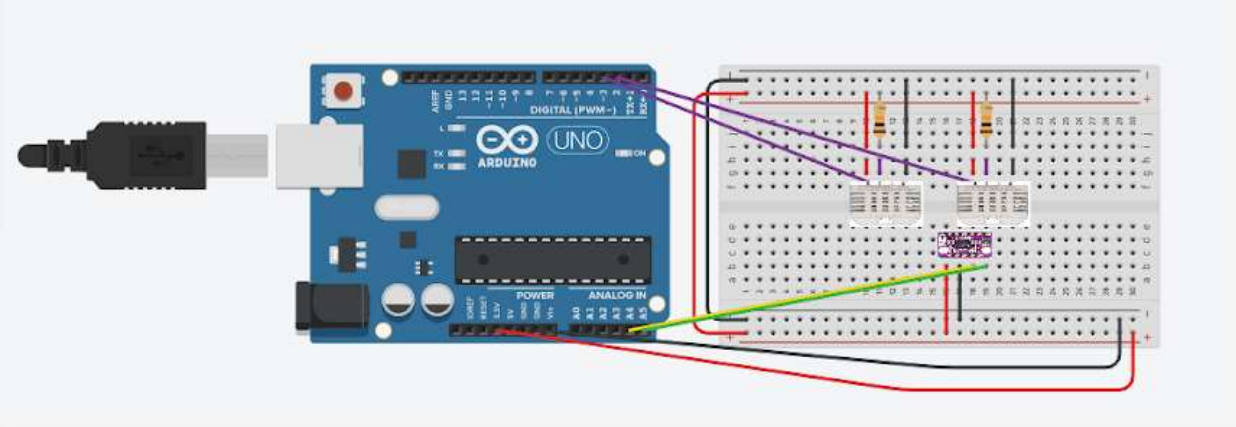

Figure 11 Circuit Diagram on Tinker Cad (Red = 3.3V, Black = GND, Green = LSM6DS3 SDA, Yellow = LSM6DS3 SCL, Purple = DHT22 Signal)

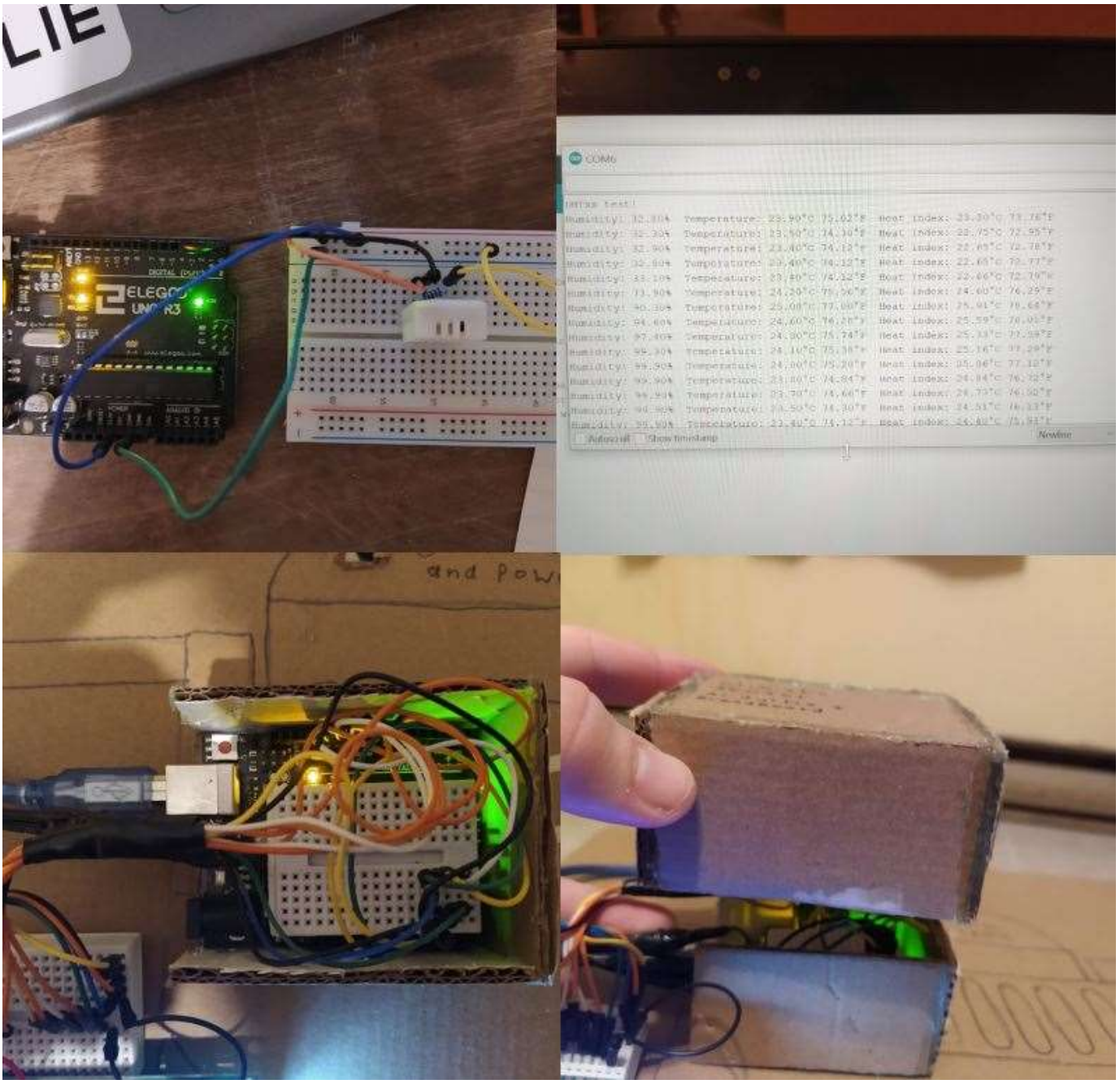

Figure 12: DHT22 Wired to Arduino (Top left), Serial monitor output of sensor testing with steam (Top right), Testing placement of breadboard on top of Arduino (Bottom left), Testing sliding mating and fitting contents (Bottom right)

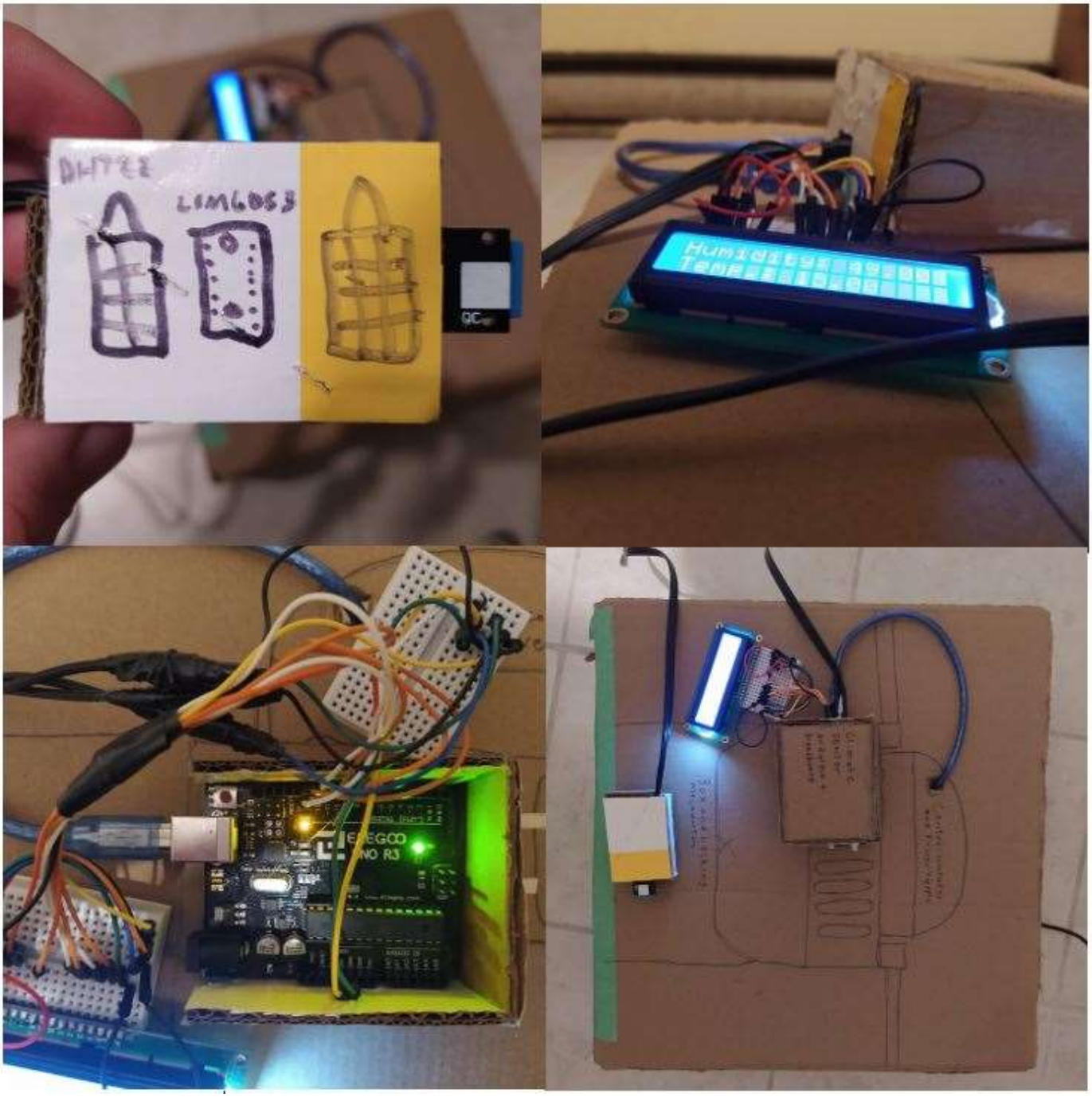

Figure 13: Illustration of Sensor Probe (Top left), Testing Serial Output from DHT22 (Output to LCD Instead of Raspberry Pi) (Top right), Testing Global Circuit with Power Supply, Output, Breadboard and Sensor Probe (Bottom left), Testing Mating of Case to Grills of Drone, Case to Through Wire and Global Conceptual Design Illustration (Bottom right)

4.0 Wrike Snapshot

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=SviBnsqUyW7OygvrZSMLMAgla6KovjzH%7CIE2DGNRVGQZTMLSTGE3A

5.0 Conclusion

Through the completion of the first phase of prototyping, the group will come to better understand the components that will be used in the climate sensor/shake alarm. The basic functions of each component will be coded and tested to ensure it produces the desired results. Furthermore, the casing that will be used for each subsystem will be completed and ready to be laser cut. Each member of the team will contribute to this round of prototyping, ensuring that the group has an equal division of labour and responsibilities.

In future phases of prototyping, the group will look to assemble the circuit entirely, and test the module working together. It will be important in this phase of prototyping to be able to ensure that the client's needs are met with the module that is created. In this respect, constant communication with JAMZ Delivery will ensure that they are always at the forefront of our priorities.