Project Deliverable H:
Prototype III and Customer Feedback

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Group 10

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March 28, 2021

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1.0 Introduction

This document describes the current development of the JAMZ drone's climate sensor prototype as well as the plan for testing the third prototype. This document supports the following objectives:

- Identify existing project information and research
- List the recommended testing requirements and objectives
- Recommend and describe the testing strategies to be used
- Incorporation of feedback from previous prototypes
- Prototype development and analysis
- Identify the required resources and estimates of the prototype testing efforts
- Analyze customer feedback and comments on the prototype

1.1 Task Plan Update

No new tasks have been added to the Wrike task plan since the last team deliverable. All team members have achieved task deadlines and milestones for this deliverable and are on track for completion of the prototype before Design Day on April 8, 2021.

Link to Wrike Project Timeline Snapshot:
https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=OhtwOpjqceZrWUYNaQMIKKRkVBZjad29%7CIE2DGNBVGEYTELSTGE3A

2.0 Prototype Testing Plan

Table 1. Prototype testing plan and objectives for the third climate sensor prototype.

Test ID	Test Objective (Why)	Description of Prototype used and of Basic Test Method (What)	Description of Results to be Recorded and how these results will be used (How)	Estimated Test duration and planned start date (When)
1	Correct average test	• Analytical	• Verify that the code reads and outputs the average of both sensors	Time: 2 min When: 2021-03-26
2	Uno relay test (flag code test)	• Analytical	• See how the arduino Nano relays information to the Uno (numerical values or bool)	Time: 5 min When: 2021-03-26
3	Box size test	• Experimental	• Verify that all 3D printed boxes fit their respective system.	Time: 5 min When: 2021-03-23
4	Two Coffee two sensor test	• Experimental	• Verify that the combination of all our subsystems are working and that the relay data is accurate (compared to meat sensor)	Time: 15min When 2021-03-27
5	Heater enable/disable test	• Analytical	• See the variation in temperature readings caused by the Si7021's heater function	Time: 10min When: 2021-03-26

3.0 Feedback from Previous Prototypes

The most critical subsystem for the success of the climate sensor module is the temperature and humidity sensor. The analysis of the multiple tests run on the sensors prove the subsystem to be successful; all prototyping tests display accurate data output by the sensor. Based on the data generated from previous prototypes, customer feedback was collected, as well as feedback from Professor Knox during our project presentation.

This prototype is constructed with two sensors, the arduino Nano, the arduino Uno (which simulates the Raspberry Pi), and a multiplexer. On our previous graphs, we were able to see a variation of about 3 degrees Celsius once the Si7021's heater function was enabled. As such, we researched this function: the function is used to defog the temperature sensor when the humidity gets too high, thus producing heat to clear the accumulated water vapor. Here in Canada, such humidity values are extremely rare, thus for this prototype we decided to disable it on both sensors. We also received as feedback that JAMZ would prefer to receive flag feedback and not constant data. In other words, they only want to know when the food is no longer in good condition. They want this type of relay, because sending constant data to the Raspberry Pi uses a lot of memory, thus taking away from other modules on the drone. To implement this feature, we used flag code (bool variable called flag), which only sends data to the linked micro computer if and only if the food is in bad conditions. Also, based on previous feedback, coffee was chosen as our testing object for this prototype.

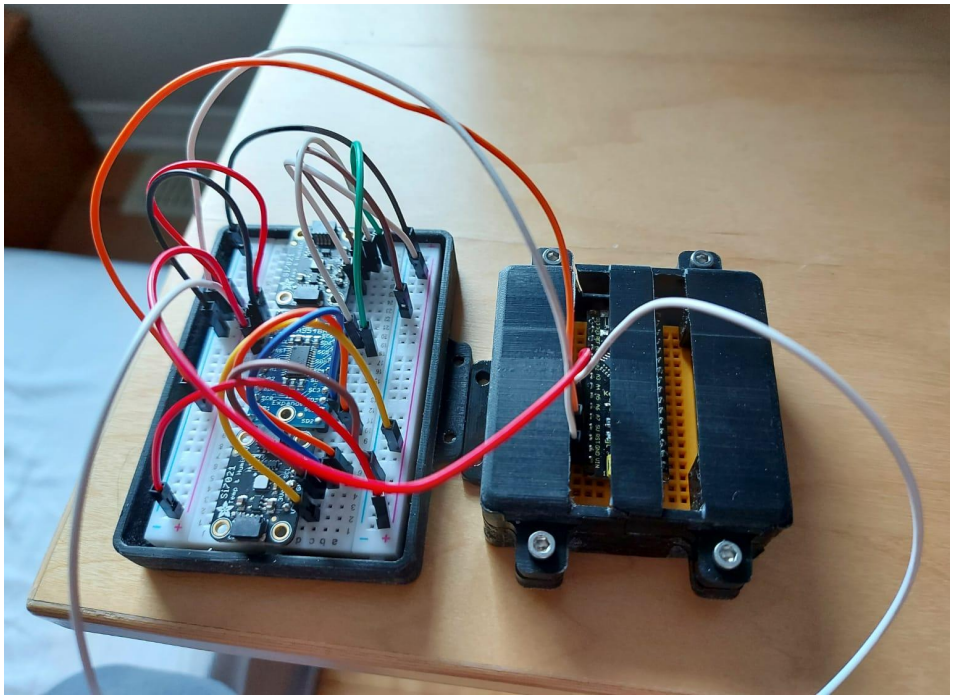
Now that the prototype II has proven that both sensors work and are reliable, we decided to relay back the average of both sensors instead of comparing each other to see if their data is synonymous (with a light variation accepted). A safety net in the code will also be implemented, which means if ever one of the sensors relay data that is very far from the regression tendency, that value will be disregarded and the sensors will have to be checked. Additionally, the housing for the arduino nano was 3D printed and enclosed on the component providing a safety casing and a more professional look.

4.0 Prototype III

Prototype III major components consist of an Arduino Nano microcontroller, an Arduino Uno microcontroller (to simulate the Raspberry Pi), two Si7021 temperature and humidity sensors, as well as a multiplexer to switch data inputs. An addition from Prototype II to Prototype III is a 3D printed enclosure to secure the component assembly. The code has also been updated to supply flag data to the Raspberry Pi based on the average readings of both sensors, in contrast to sending constant data based on alternating individual sensors. These components make up the most critical subsystem: the temperature and humidity sensor. The

subsystem's main objective is to monitor the package's temperature and humidity, check if the food conditions are good, and if they are not good, notify the drone operator.

Figure 1. Climate sensor prototype III assembled inside its 3D printed enclosure.



4.1 Prototype Simple Analysis

Based off of the client meets and the feedback received, an improved prototype three was developed . The following changes/improvements to the prototype include:

- We were told during one of the client meets that sending the temperature reading every second to the drone operator is not needed. So we developed a range of temperatures that if the sensors give a reading outside of that range then the drone operator will receive that information. This can conclude that the package may be compromised. This was implemented into the code in order to satisfy the client's needs.

- After showing the client our CAD models of our protective casings they agreed and liked what we had presented to them. Therefore we went ahead and printed the cases.

- We also have finished the physical development of our system. All the electrical components have been assembled and are working properly.

They have also been put into their respective 3D printed casings. Essentially marking the end to any physical development of our system.

- Another piece of feedback we received from professor Knox was that in our testing phase we should consider worse case scenarios of types of foods/drinks being shipped. We had originally planned all of our testing around burgers and getting the heat loss etc. After taking into consideration what the professor said we believed that programming our code to fit the needs of shipping coffee would bring much better insight on what our temperature range should be. Since the internal temperature of coffee is so large monitoring the temperature loss would be a lot easier.

Overall, prototype three has been developed significantly from taking the feedback from prototype two into consideration in order to generate a product more in line with the client and users needs.

4.2 Prototype Stopping Criteria

Prototyping in theory should never stop. A product is never flawless. However, due to time constraints, prototyping must be stopped a day before the deliverable is due to allow for time to analyse prototype test data and understand the customer feedback to prepare changes for the next prototype.

4.3 Prototype Test

Prototype III will focus on the ability of the two temperature sensors to read precise data in reference to one another. As well as for the code to output the average of the two temperature sensor's data. To test this subsystem we ran a simulation with two coffees. The data output of both sensors were collected as well as the average of the two sensor's data by the code. With the collected data two graphs were generated: one plotting the average of the two sensors as well as the individual data points of the sensors and the other is the average humidity as well as the individual data points of the sensors. The two graphs were later utilized to collect customer feedback. One parent of each team member was asked to rate the similarity of data between the three slopes in each graph in reference to one another. The rate is based on a scale of 0-5, 0 being no relation, while 5 is congruent.

4.4 Prototype Test Results

The following test was performed with prototype III, consisting of the two Si7021 sensors attached to the multiplexer and Arduino Nano, assembled inside the 3D printed enclosure. The sensor system was then placed inside a closed box containing hot coffee. This test measured the difference between the temperature and humidity readings coming from sensor 1 and sensor 2 and the outputted average values being output from the Arduino, to see if the values agree.

Figure 2. Prototype III inside a box for the two coffee test.

Figure 3. Plot of the temperature readings for sensor 1, sensor 2, and average temperature during the two coffee test.

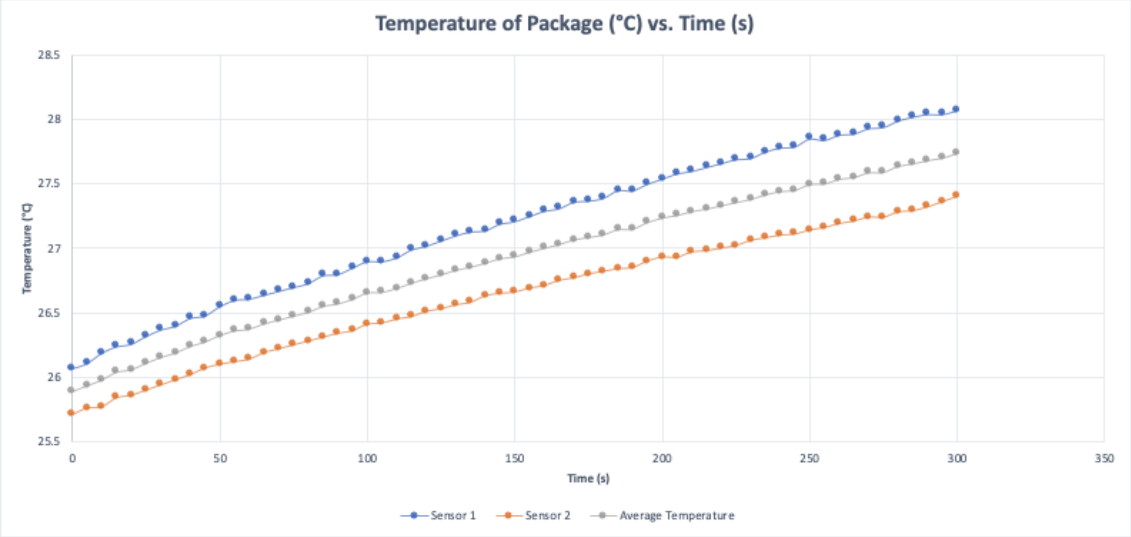
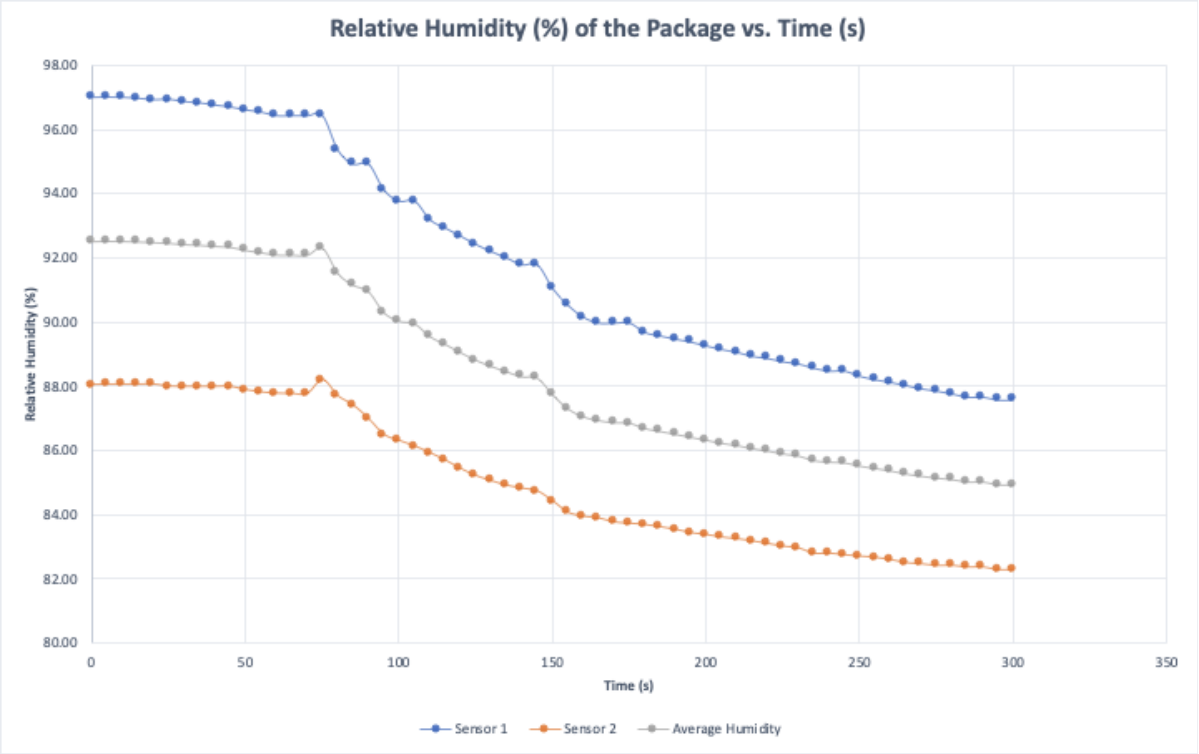


Figure 4. Plot of the humidity readings for sensor 1, sensor 2, and average humidity during the two coffee test.



5.0 Customer Feedback

The collected data was shown to team member's parents to get input on if the data we received from our tests is accurate enough for the client's uses. They were asked to rate what they saw on a scale of 0-5; 0 being the no relation between the two sets of data while 5 being a directly proportional relationship between the data sets. A summary of this feedback is shown in the table below.

Table 2. Summary of customer feedback on the prototype testing data.

Team Member's Parents	**Feedback on the Similarity Between the 2 Sensors**	**Feedback on the Average of the 2 Sensors**
Supathira's Parents	5- "Both sensors are outputting **similar** data to one another. They seem to **mimic** one another for **every concavity.**"	5- "The average taken by the code of the temperature and humidity seems to be **reliable** since the data points of the average **fall in between** the data points of both sensors."
Alison's Parents	5- "Both graphs show that the sensors are outputting **accurate** and almost **similar** data"	4- "The temperature and humidity readings look to be falling within the **required constraints**."
Gabriel's Parents	4- "The readings look different but **over time** they move by the **same amount**"	5- "The average value looks like it would be **more accurate** than just one sensor"
Benjamin's Parents	4- "Both sensors seem to **fluctuate** along the same lines and **tend** towards the same answer, yet they seem to keep the same beginning **difference** in both the humidity and temperature graphs".	4- " The average **effectively** represents the combination of both sensors".
Evan's Parents	4- " The two sensors seem to have relatively the **same slope** and look	4- "Again the average of the two sensors seem to **depict the same data**,

	almost **identical**."	and look to have the **same slope and shape** of the sensor's trend line."

6.0 Analysis of Feedback

Based on the customer's feedback and the analysis of the prototype test results, several areas in need of improvement were identified for the development of a more comprehensive prototype.

In prototype II sensor one was checked for accuracy by comparing the data output with a meat sensor's output. The conclusion being sensor 1 relays accurate information about the climate of the box. In Figure 3 it is visible that sensor 2 is also relaying similar data to sensor 1. From this we can conclude that sensor 2 is also relaying accurate information. As well as the integration of two sensors recording similar information will increase the precision of our module when determining the climate of the package.

The analysis of the average value test results show that over time the difference of the values of sensor 1 and sensor 2 decreases. This means that the average value can be seen as more representational to the actual temperature and humidity of the package. Therefore using the average readings from two sensors rather than one to calculate the package's overall condition is more reliable than the readings of only one sensor.

The Uno relay test showed that the Arduino Nano was able to successfully send a signal that was received by the Arduino Uno. This test simulates the transfer of data from the Arduino Nano in the climate sensor system to the Raspberry Pi onboard JAMZ's drone.

The analysis of the two coffee test results show that the temperature measured in the package goes up over time, and the humidity measured goes down over time. This information can be used to better understand what the flagging code should be set to when determining if the conditions in the package are good or bad. The sensors also tend to agree with the temperature and humidity changing and so an average value can be used to gain a better representation of package conditions.

From the analysis of the box size test results, it was shown that the 3D printed enclosure was sized correctly such that it was successfully able to fit all components of the sensor assembly. There was also no excess room for the components to move around the enclosure.

From the analysis of the prototype test data as well as the feedback received on the prototype, the concepts analysed will be changed in order to better meet the needs of the client and their customers.

7.0 Conclusions and Recommendations for Future Work

In this deliverable, the current state of development for the third prototype was discussed. By developing a test plan for the prototype and considering future customer feedback, a better understanding of how to further improve the prototype can be achieved. Future work will consist of development of a more comprehensive prototype that will be presented on Design Day to demonstrate the final capabilities of the prototype.