Introduction:
In this deliverable, our team has designed our first prototype for the climate sensor add-on. For our prototype, the main goal was to create a proof of concept, so it was relatively simple. Our team made a physical and digital version. For the physical version, it was made out of random scraps around the house, so the quality is not perfect, however, it does show proof of our concepts. For the digital version, our team used the software Onshape to create the prototype. Moreover, our team finalized the code so that it will be ready for testing and feedback. Once again, since it is only the first prototype our team designed very simple models so that our concepts can be easily visualized.

For this project, multiple prototypes need to be made and each must be tested and analyzed to gather relevant feedback. Our team has prepared a test plan with multiple test objectives that will evaluate the performance of all the critical components of our add-on. This test plan will provide the “why”, “what”, “how” and “when” of each test. Each test objective is provided with a brief description of what is being tested and what method will be used to perform the test. Moreover, it will also provide the reader with a description of how the results will be measured and gathered, as well as the estimated time it will take to complete each test. Lastly, the test plan will provide an analysis of the results. With all of this information, our team hopes to gather relevant information on how to improve our prototype, so that it will allow us to make a final functional prototype.

Physical Prototype:
For this deliverable, we created a physical prototype using scraps around the house. The main goal of this prototype is to show a proof of concept and is not meant to be fully functional in any way. In this prototype, the sensor is protected from the outside environment and exposed to the inside of the containing box. This was designed so that the sensor would only be gathering data for the temperature and humidity of the contents inside of the box. We were not certain about the dimensions of the containing box, so we picked a big enough box that would be able to contain a decent amount of food. The box’s dimensions are 12 in x 10.5 in x 10 in. The lid of the box contains an opening for the sensor attachment. In the figures below, all the important components of this physical prototype will be shown.

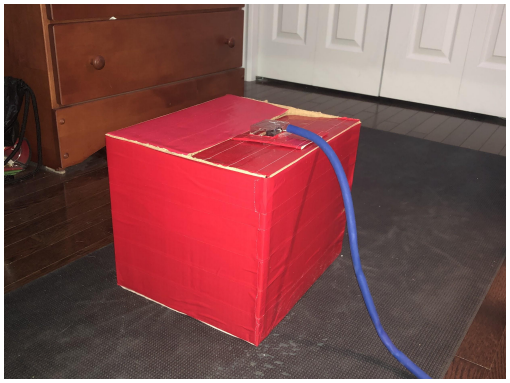

Figure 1. Closed box containing the sensor on the lid. (blue cord is representative of wires)

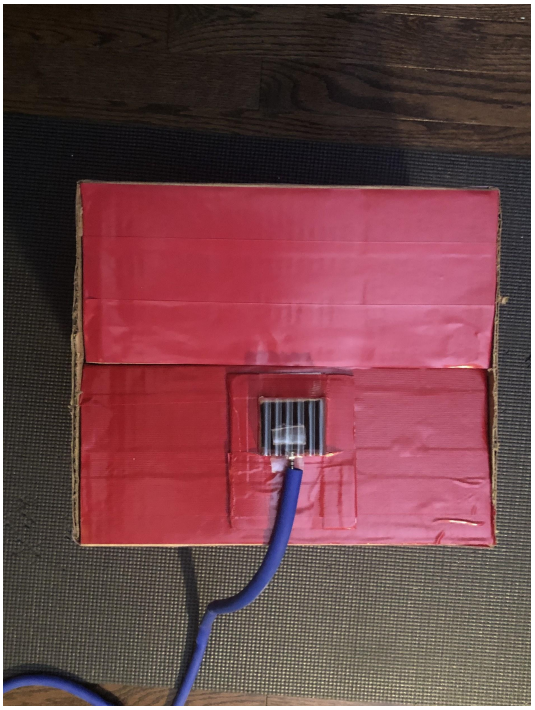

Figure 2. Top view of the physical prototype

Figure 3. Side view of the physical prototype

Figure 5. Inside view of the physical prototype

As shown in the figures above, the physical prototype is not close to being complete. However, it does show our vision of how we think it will look like once it's completed. Since everything was made out of cardboard and plastic, every piece was put together using different types of tape. Obviously, in the future we will be using stronger materials that will most likely require screws and more permanent attachments methods. Moreover, the covering of the sensor shown in the figures above is just a simple piece of plastic. We have not decided on what material to use to cover the sensor as of this moment, but hopefully this will be decided by the next prototype. We must also consider what materials JAMZ will be using for their box so we can replicate it and use it when testing our sensor (improve fidelity of the tests). In sum, this prototype is not fully functional because we do not have the parts to make it functional yet. However, we are hoping that we will have all of our required materials by this week so we can start testing our prototype and making an actual functional prototype for the next deliverable.

Onshape Sensor Case Prototype:

In order to create a visual of our sensors case we decided to use Onshape. In this prototype we ensured that the sensor itself is not closed off or covered from the inner environment of the food delivery box. The idea behind this prototype was to cover the sensor chip in a way a phone case would work. We designed the case to surround only the edges of the chip to ensure data would not be skewed due to the covering of the sensor itself. We also decided to include small holes on each of the corners to support the attachment prototype, which will allow for the casing to be securely screwed in.

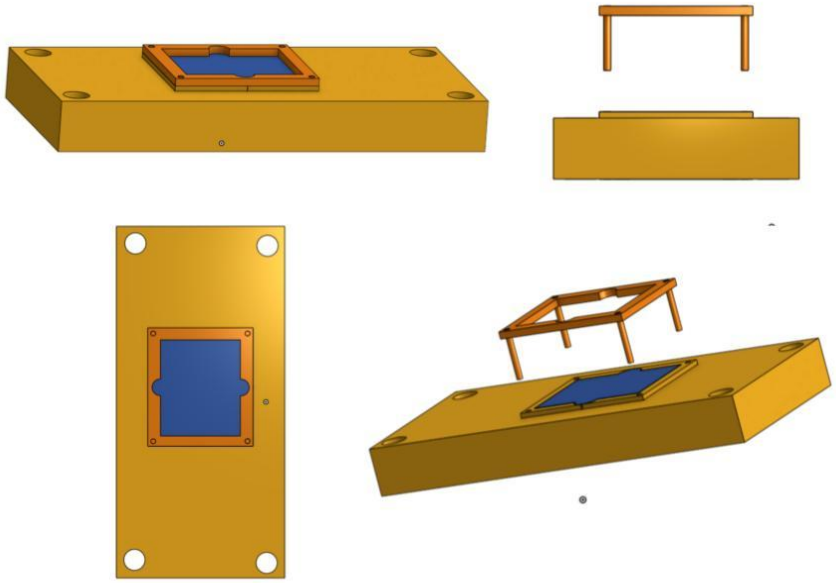

Figure 6. Onshape Sensor Case Prototype Different Views

The blue portion of Figure 1 acts as a generic version of the climate sensor, the orange portions refer to the actual casing. For access to the interactive CAD model please click HERE

A downside to this type of casing and positioning is that unfortunately the pins will also be exposed to the inner environment of the food delivery box. Although we will attempt to keep the wiring as short and condense as possible, this could still increase the risk of possible damage or malfunction, if wire damage occurs.

Onshape Sensor Attachment Prototype:

To create a visual prototype of the Attachment of the Sensor, we decided to use OnShape. In this prototype, the objective was to ensure that the Sensor Electrical Components, being the arduino, and its casing fits in its designated area within the “Sensor Mount” component of the drone. The Sensor mount component is orange and the casing is in blue, as shown in Figure 7. A strong adhesive would likely be used to secure the casing to the Sensor Mount during installation.

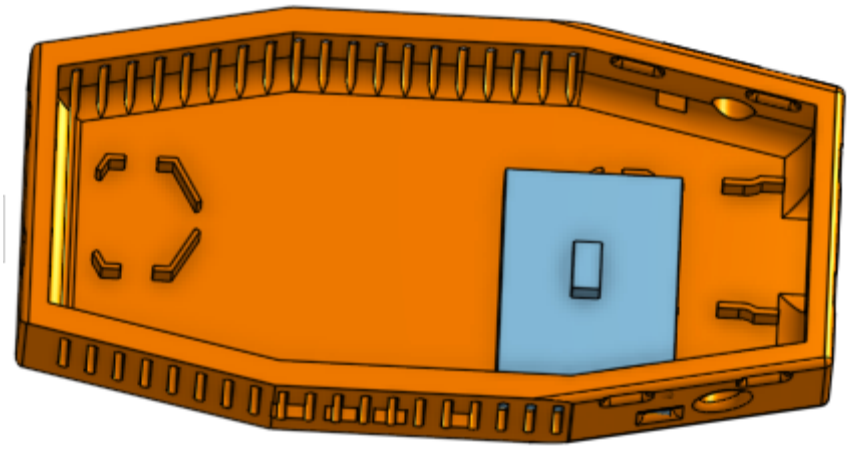

Figure 7. Onshape Sensor Case Attachment

For access to the interactive CAD model please click HERE

A downside to this kind of attachment is that it is not centered in its position due to some issues in OnShape. However, this could easily be changed during installation since there is visible room for changes.

Test Plan I:

Table 1: Climate Sensor Test Plan

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)	Analysis
1 (Code)	To ensure proper and accurate function of code with sensor.	Numerical and physical prototype. Test speed of data and response time reliability	Plug in sensor and change the temperature and humidity of the surrounding environment $0 (use materials we already have)	ASAP (once materials are approved and have arrived)	As soon as the AHT20 has been delivered, the code will be tested. We will gather data on the response time of the code, and how reliable and

					consistent the system will be able to print data.
2 (Wire connection)	To ensure nothing will come loose or disconnect during a delivery.	Physical prototype. Test the physical connection of the wires. Test for any kind of flight path and disruptions that may occur.	Plug wires into all other necessary components and move/shake the prototype as if to simulate a rough flight. $0 (use the materials we already have)	Any time, the sooner the better	Even with assuming stronger materials are being used, the wire connection is still too loose. The wires will disconnect from the Arduino causing the entire system to no longer work. A more secure way to keep the wires attached will be needed to ensure the functionality of this system. Attaching the wires to the sides of the case for the Arduino should help with this issue.
3 (Sensor protection)	To ensure durability and protection to the sensor.	Numerical prototype. Test the strength of the casing. Test how casing reacts under different environments.	Use found numerical strengths and dimensions of casing material in order to determine max forces.	ASAP (once materials are approved)	Assumptions based off of models and research: - $V=29cm^3$ - $SA=130cm^2$ - $\rho=1.08g/cm^3$ - $M=V\rho=30.6g$ - Tensile strength=40MPa - Can withstand up to $T=225^oC$ From this information we can see that this case will be able to adequately protect the sensor during any delivery. The case surrounds the sensor to protect it from all sides possible without interfering with the function of the sensor.

4 (Sensor Attachment)	To ensure the sensor does not disconnect during delivery	Numerical prototype. Test the strength and fitting of the attachment style under different environments.	Use the strength and dimensions of the sensor attachment in order to determine max forces and optimal placement.	Anytime, the sooner the better	Assuming there is a secure spot in the microcontroller compartment on the drone for the Arduino to go, the attachment to the drone will be strong enough to hold during any flight. The sensor fits well in the assigned space within the “Sensor Mount”. A stronger form (or an additional form) of adhesion may be needed between certain components in further testing.

Basic Code:
The code attached below is untested because the electronic components have not arrived. As soon as the AHT20 sensor and the needed wires are in our team’s possession, the code will be tested with the test plan above. The code compiles properly and the functions used have been cross-checked using the following links:
Link to Key Functions
Link to AHT20 Library
Link to AHT20 Class Reference

```
#include <Adafruit_AHTX0.h>

Adafruit_AHTX0 AHT;

/*
 * Start with a Baud rate of 9600
 */
void setup()
{
  Serial.begin(9600);
}

void loop()
{
  /*
```

```
   * This comment is taken from learn.adafruit.com:
   * sensors_event_t - This type is used to encapsulate a specific sensor reading, called an
'event',
   * and contains a data from the sensor from a specific moment in time.
   * Create a temperature and humidity value
   */
  sensors_event_t tempValue, humValue;
  /*
   * getEvent: Gets the temperature as a standard sensor event
   */
  AHT.getEvent(&tempValue, &humValue);
  /*
   * Print the temperature and humidity values in one row
   * Wait 2000 milliseconds or the desired amount and print the next set of values in the next row
   */
  Serial.print("Temperature: ");
  Serial.print(tempValue.temperature);
  Serial.print("°C\t");
  Serial.print("Humidity: ");
  Serial.print(humValue.relative_humidity);
  Serial.println("%");

  delay(2000);
}
```

Conclusion:

In conclusion, in order to best test our design we made different prototypes to tackle each portion of the concept. For general understanding and proof of concept we created a physical prototype out of random materials. Next, we create CAD prototypes of the casing and attachment portion of the concept in order to visually see how they would look and function in 3D. This also permitted us to finalize dimensions and proceed with tests and analysis. We also finalized our code in preparation for testing.

In order to generate a sufficient amount of useful feedback we conducted several tests and analysis on our prototypes. In order to do so, we created specific test plans to touch on the “why”, “what”, “how” and “when”.

Wrike Planning for Next Deliverable: