University of Ottawa | Université d'Ottawa
GNG 1103 | Winter 2021

GNG 1103 [G]

Engineering Design

Course Professor: **Rubina Lakhani**

Deliverable H - Prototype III and Customer Feedback

Prepared by Group: # 4

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Introduction

In this project, the team will test the previous prototype again, find defects and make appropriate adjustments. They will also acquire more detailed information from the tests, and then implement this newfound information, as well as the customer service feedback we have gathered in the past two weeks into the third prototype. Later, we will show the physical prototype of the adjusted prototype and discuss it's brand new and complete features. The prototype will minimize the occurrence of risks and uncertainties to make it reach the test goal and meet our needs. This will be our final prototype that we present on design day.

1.0 Updated Test Plan Outline

Our second model has allowed us to conduct several important tests at medium-fidelity which enable us to determine where the flaws in our design are located, as well as what our design has done well up to this point in the process. From our previous model, we learned a critical detail that has affected our test plan: the complexity of implementing the folding aspect of our design was more significant than anticipated. The model we constructed was not able to fold to our intended specifications after a variety of attempted tests. As a consequence, we have elected to drop the folding aspect of the design, in favour of a simpler model which will have the same effectiveness. This is a minor loss, as including the folding aspect would have produced the same overall storage volume, but in a different shape.

In this final prototype, we will essentially be extending the second prototype to fit the needs and specifications outlined in our design process. In particular, the main aspect which will be added to this final design is the water drainage system, by means of drilling holes through the mat and studs such that water produced from melted snow and ice is able to drain from the upper surface of the mat to the sidewalk below it. The water will then be able to be channelled away through grooves in the bottom of the mat, all of which will prevent the buildup of water on the mat, and improve overall traction. The other feature that we are looking to incorporate into this prototype is the aspect of automation. This will be done through the use of a smart plug, which can be linked to an iPhone or Android app, and allows for the remote activation of the mats by workers.

As in deliverable G, the next pages will be devoted to the test plan table, which outlines the tests that will be performed in order to validate our prototype and ensure that we have a design that is presentable to the client. Note that some tests are to be repeated, due to their lack of completion during the previous prototyping phase
/required retesting due to changes made to the prototype.

Table 1. Test plan for prototype 3

Test ID	***Test Objective***	***Description of Prototype used and of Basic Test Method***	***Description of Results to be Recorded and how these results will be used***	***Estimated Test duration and planned start date***
1	Weight supported	This test is to take place with the updated physical model, as the studs have been updated with drainage holes and it will be a requirement to test the weight supported by the design yet again.	The testing procedure will follow that shown in row 4 of the test plan table in deliverable G: “Multiple masses of varying weight will be placed on top of a panel to test its strength. Each time weight is added, the total mass supported should be recorded. Once the prototype appears to display visible stress, make a note of where the safe operating weight limit was reached, and halt testing.”	Testing of this property will begin as soon as the drainage holes have been added to the studs, which aims to be completed by March 26th. The testing should not take longer than one day to find a maximum weight supported.
2	Water drainage test	This test should be completed using the high-fidelity physical model. The test should confirm that water	To verify the completion of the test, the testing individual should make note of the amount of time it	This test, as with the weight-supported test, can only be completed once the holes have

		can effectively drain out from the surface of the mat to the underside, and then make its way out from the underside of the mat.	takes for a certain specified volume of water (for example, 100 mL) to drain through one of the holes. Ideally, this time will be under 10 seconds. When this has been achieved for each of the drainage holes on the product, the test is deemed completed.	been produced. Thus, the test should begin following the weight-supported test and will take 1-2 days (depending on complications). Note that the weight supported test can be performed again following this test to evaluate the impact of water contact on the maximum weight supported.
3	Water resistance/ damage test	This test should not necessarily be completed on the physical model, as the materials used to construct the model would likely be effective enough. However, for the most accurate results, the physical model should be used. The goal of the test is to analyze whether any damage is done to the product by the	The result recorded should be whether any visible/noticeable damage occurs in the product. This can appear in the form of softening of the material, reduced structural integrity of the product, damage to the electronic systems, etc. If any damage is noticed, the team should be notified, and a discussion will ensue in order to	This would be one of the longer tests to carry out, as completing it with the physical model is somewhat of a risk under our constraints: we only have one model, and so if it is damaged we will have little to show the client. Thus, the test will be more theoretical in nature. We will still be able to test

		continuous presence of water.	rectify the issue. If a test passes with no notable water damage over the specified time period, the test can be deemed complete.	the individual materials of the prototype, which can begin on March 25th, lasting for 1-2 days, since the materials will need longer exposure times. Edit: The tests have been postponed to the week of March 29th, as the weather over the testing period prevented us from adequately waterproofing the prototype, which would defeat the purpose of our test.
4	Water blockage/freezing test	This test is targeted towards testing whether water if trapped, will freeze inside the drainage holes, and prevent the water from draining. This should be performed on the physical model if possible since it will demonstrate	Similar to the previous test, this test will be performed (outdoors, in cold weather or indoors, in a large freezer) by pouring a specified volume of water onto the mat. The volume must be enough that the drainage holes fill	This test will be difficult to enact, as the freezing temperatures have largely come and gone. We also do not have access to a large freezer, since the product is too large to store in a conventional freezer. Thus,

		whether our prototype will function under the winter conditions for which it will spend the majority of its useful life.	at least partially. The mat will then be left in the cold, and activated, for a period of 3 hours. The test will be deemed completed if there is no blockage due to freezing.	there is no specific time frame for this test, and it may need to be performed next winter, barring access to a large freezer.
5	Automation/ remote activation tests	As discussed in deliverable G, we will be using a Smart plugin combination with a mobile app to automate our product. We had initially planned to test this with the medium-fidelity model, however, due to the circumstances under which we are completing this product, we will only be able to test it with the high fidelity model.	The test plan will follow the reasoning outlined in deliverable G: "The only result necessary for recording is whether the smart plug will be able to effectively regulate power input from the junction box when connected to the mats, which would thus make the test a success, and provides a stopping criteria."	This phase of testing can only begin upon acquisition of the Smart plug. The plug is set to be delivered on Friday, March 26th. Thus, testing will begin as soon as the plug can be combined with the junction box, which may take up to two days.
6	Basic + Extensive melting tests	This test will allow us to determine if the product will function as intended. The goal of the test will be to melt a significant	The test will aim to record the amount of time taken to completely melt one standard ice cube (for the basic test). Ideally, this	This test will begin the week of March 29th, and take up to 3 days to test to completion. The power supply has

		amount of ice and snow using the fully assembled high-fidelity prototype.	will take less than 5 minutes. Once this goal time is achieved three times consecutively by the product, the mechanism will be deemed functional, and the test will be completed. For the advanced test, the goal will be to melt a full sheet of snow, which will provide an accurate indication as to whether	arrived as of March 26th, and thus the testing will be carried out during the following week in preparation for Design Day.
7	Hinges and latching functionality	This test will be performed on the physical model if/when the latching mechanism is built. The goal of the test is to ensure that the latching mechanism functions, and that it cannot be easily broken open by force.	To perform the test, the latching mechanism will be opened and shut repetitively, with varying degrees of force. This will ensure that the latching mechanism is functioning effectively. Next, we will test the strength of the latching mechanism by using tools meant to damage or pry off the latch (for example, a	These trials will be conducted during the week of March 29th, and should only take one day to complete. The trials should be done with care, however, since we cannot afford to damage the model prior to its presentation

			crowbar) to ensure that the latch cannot be broken by force. Once we reach a sufficient degree of force (the latch cannot be broken by human force), the test will be concluded.	

2.0 Physical Prototype

The main focus of this prototype was to clean up the physical functionality by adding more structure and improving its functionality. Firstly, to better support and increase the maximum weight of the modules, the column size was increased to have a side length of 5cm (2in). It was also necessary to increase the size so that drainage holes can be made without compromising the weight limit of the heating mat. The new columns can be seen as outlined in Figure 5. After this alteration was completed, it was tested using the method stated in the test plan outline. There does appear to be a minor but insignificant dip in the top cover, however, this is due to the columns being slightly shorter than the case border. Although there is a small deformation in the prototype, this is a mostly elastic deformation as it returns to its original shape. Disregarding the imperfection, the model was still successfully able to withstand an impressive amount of weight, holding over 400lbs (roughly 181.4 kg).

The next modification made was to add hinges to the top cover to make the internals accessible to maintenance crew members. To install the hinge, a small incision had to be made on the inner corner of the mat to allow the hinge to be flush with the top of the casing. Before making the cut on the prototype, a test was performed on spare material to test fit the component. Figure 1 shows this test and how the hinge settles into the mat, while figures 2 and 3 show where the part can be located on the mat, in the open and closed positions respectively. Since the top cover and hinge extrudes out of the case slightly, this may be a possible reason for the gap that was previously mentioned. For the final product, a similar but shallower incision will be made around the border of the mat so that the entire top of the product will be perfectly flush. After installing the hinge, an issue that occurred was that the weight of the top cover, if fully flipped open, could potentially cause unnecessary strain on the bolt holding the hinge to the frame.

For the final product, a rotating arm will be installed so that it will be able to hold open the cover while maintenance is being conducted. This mechanism will work similarly to the arm that is used to hold open the hood of a car when the engine is being inspected.

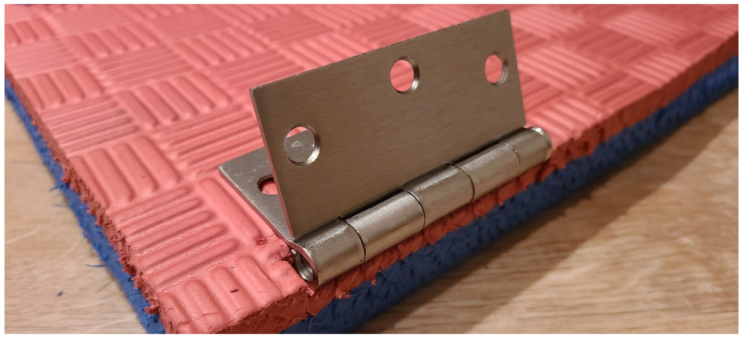

Figure 1: Test fitting for the hinges

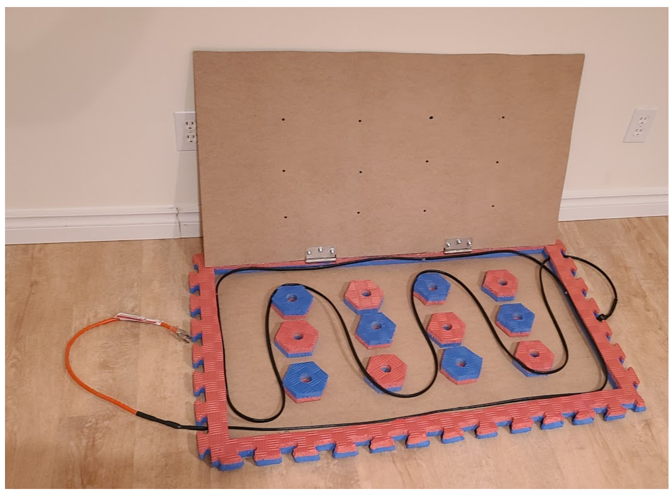

Figure 2: The prototype with the hinges installed

After the cover was installed, holes were drilled through the entire module, centred roughly through each column. Due to human error, the holes are not perfectly centred (as illustrated in figure 4), however, the overall purpose of the holes will not be affected. After the initial pilot hole was made, the top cover had holes drilled to be ¼ of an inch with a counterbore to allow melted snow and ice to funnel through the top and fall through the columns (figure 3). The column holes are made larger (1 inch) to avoid contact with the water to minimize any potential corrosion over time (figure 4). Unfortunately, due to weather conflicts, a previously obtained polyurethane wood finish was not able to be used on the wood components due to health and safety hazards due to a lack of open space to use it. This finish would allow the wood to be waterproof and increase its weather resistance to ensure longevity, so the testing of the columns must be delayed. However, it can be inferred that the space between the columns and the top of the casing will present an issue, so it should be solved before further testing the prototype's resistance to water to obtain more reliable results.

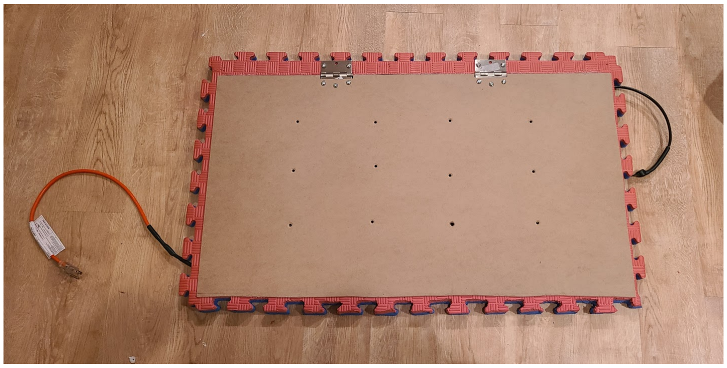

Figure 3: Top of the prototype

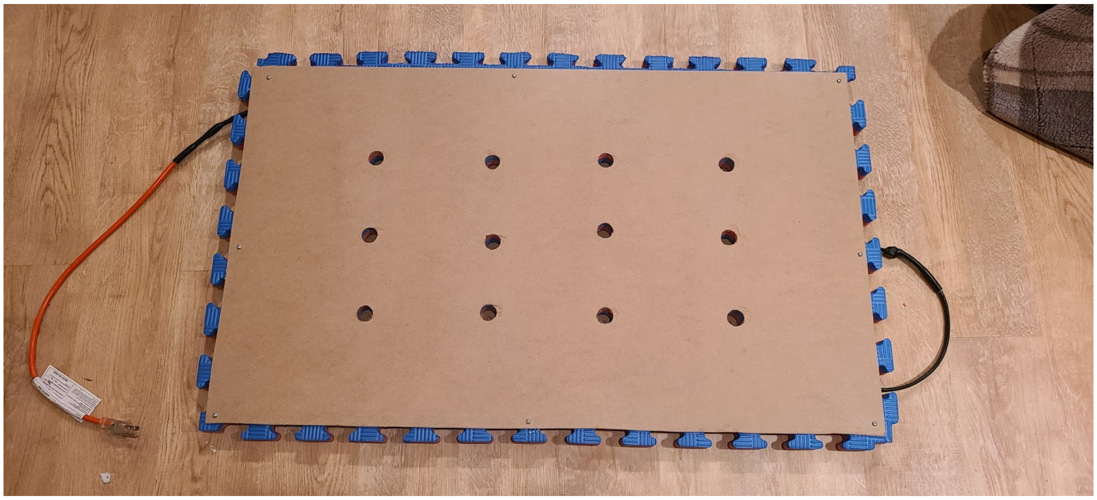

Figure 4: Bottom of the prototype

The final modification made to the prototype was the reorganization of the heated electrical wire. In the previous model, the wire was only located around the columns causing the majority of the heat to be created in the middle of the module. This would lead to less heat energy being transferred to the perimeter of the mat, and inefficiently melting the snow. With the new layout illustrated in figure 5, the wire is more evenly dispersed to optimize the heat transfer to the snow. Unfortunately, since the winter season has come and gone, the prototype has no way of testing how efficiently the heat would transfer to the ice and snow on top of the module without a simulated environment (which would be out of the product's budget).

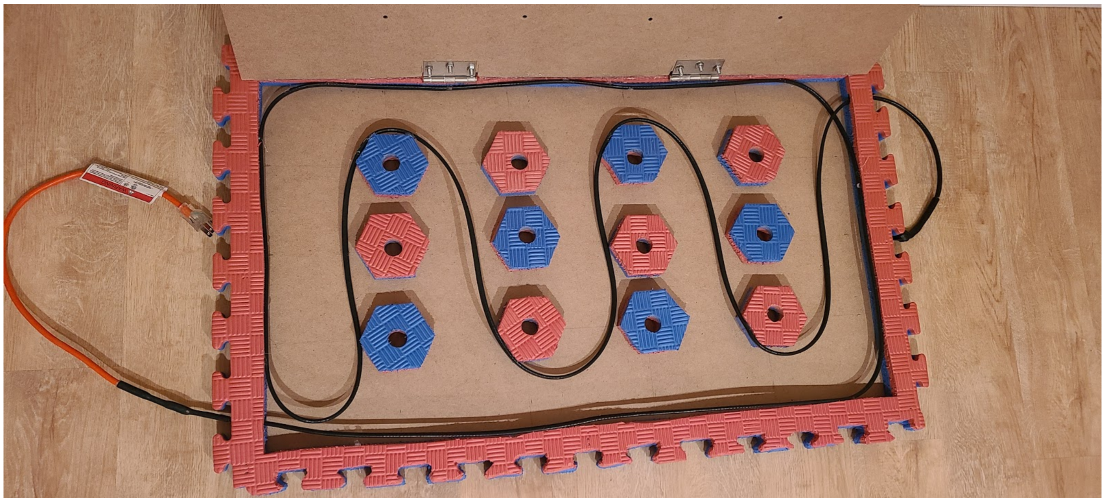

Figure 5: Internal components of the prototype

The final component of the prototype is the Smart Socket SP10 by TECKIN (figure 6). This device plugs into a wall outlet and acts as a wireless switch to any wired device via a mobile phone. This socket is being utilized to replicate the junction box discussed in previous deliverables. TECKIN's product, through the mobile application, would also simulate different options available to the user, such as setting a timer for when a device would be in use, or setting a timer for how long it will supply power (figure 7).

Figure 6: Smart Socket SP10 by TECKIN

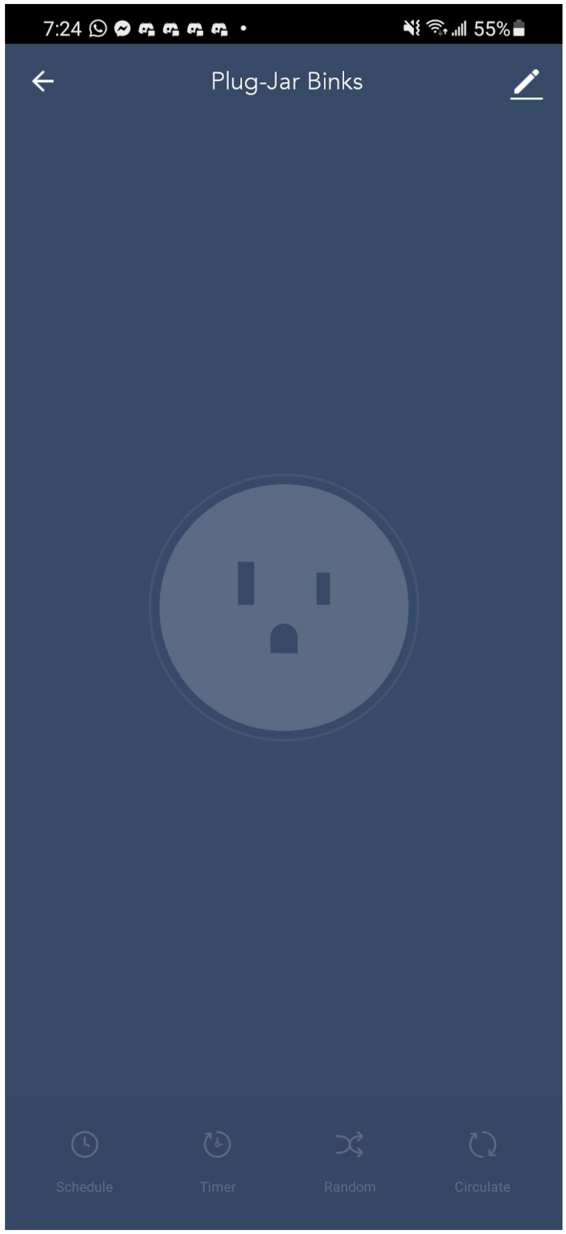

Figure 7: Mobile Application used to control the SP10

4.0 Digital Prototype

The main purpose of having the digital model was to give a safe environment where the model can be adjusted without wasting real material and costing us much. With every physical prototype, we also made a digital version, this helped us gain a better understanding of what different sets of dimensions would do to the look and feel of the model. Other than the ability to test different dimensions these digital models also gave our customer another version of the product to look at. The digital version allows the customer to understand the precise dimensions as well as the general proportions of the designs different features such as the dovetails and internal supports. The previous prototypes had a 3D digital model but for the third iteration we created a 2D model, this helps give a better understanding of the dimensions of the design while the 3D model gave us a better understanding of what the design would look like in real life. The main reason for the switch to 2D being that the physical model now accomplishes the job of the 3D model more effectively.

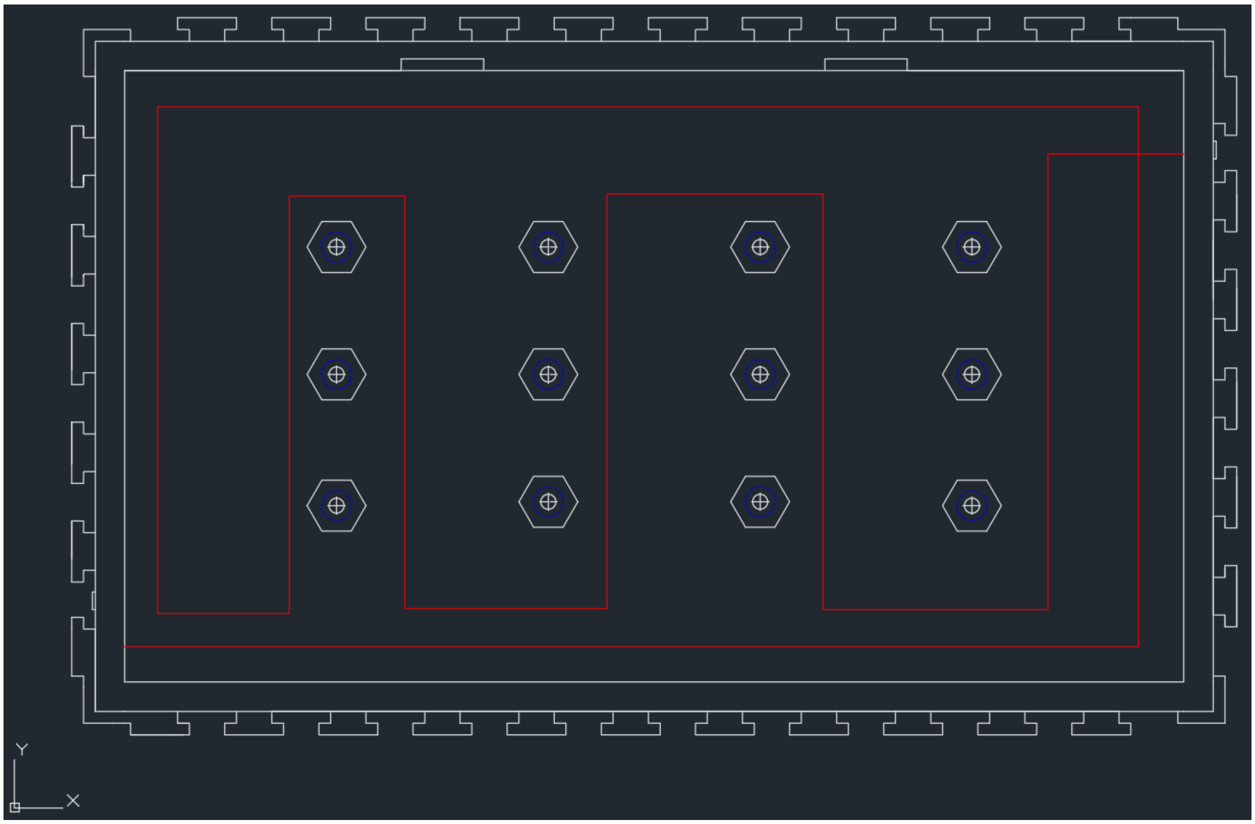

Figure 8: 2D drawing of the top of the model (thickness of 1¼in)

In this digital rendition, the different coloured lines are there to make it easier for the customer to distinguish between the actual case (white), the wiring (red) and what is not visible from the top of the design (blue dotted line).

5.0 Wrike Snapshot

Note: Please copy and paste the entire link to view the snapshot. Just clicking on the snapshot below won't work because it's cutting off half the url. To avoid this as mentioned, please copy the entire link below and paste it into a new tab to view the snapshot.

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=Ldr55IYAiYcpNE0EwAd7JWusuNrQPdaK%7CIE2DGNBUG44DMLSTGE3A

Conclusion

In this deliverable, we created our third prototype which will be our fully functional version of our solution. This doesn't mean it's the version we would sell, since we did have to take some shortcuts and use cheaper material due to the $100 budget, but it is the version we will pitch on design day and our final prototype for this project. Firstly, we outlined our test plan for this prototype and then continued building the prototype from our medium fidelity prototype with the newest subsystem being created which was the automation with the smart plug. Then the prototype was tested for the properties outlined in our plan to verify that all components work and that we wouldn't need to make adjustments before design day. Overall, we ended this deliverable with a comprehensive prototype in hand that functions fully.