# Deliverable F

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# Introduction

Due to the increasing need for students to have access to technology, people with impairments that limit their motor skills are put into a more difficult situation. Our team has taken on the task of designing a camera cover. The user will be a 12-13 year old boy named Oliver who uses an eye-gaze camera to verbally communicate through a Tobi I12+ device as it reads his eye movements. The user also has to rely on other devices for school work and electronic communication, as well as a power wheelchair. The program he uses requires the software to track the movement of a dot on his forehead in which the camera will pinpoint the position, translating it to words, then sentences. Furthermore, Tobi I12+'s eye gaze light interferes with other devices he uses. The team was able to extract valuable information from the client, allowing us to design a potential solution to the problem.

This document provides information on the third client meeting, improvements done based on the feedback received from the client, and a detailed description of the development and testing process of the second prototype.

# Prototype 2

For this deliverable, we decided to build two prototypes that would go hand in hand with each other. The goal was to 3-D print a larger, properly scaled cover for the camera and to simultaneously begin working on the circuit for the wireless transmission from the button to the servo-motor actuator. This process is described below.

## Big Red MK 2

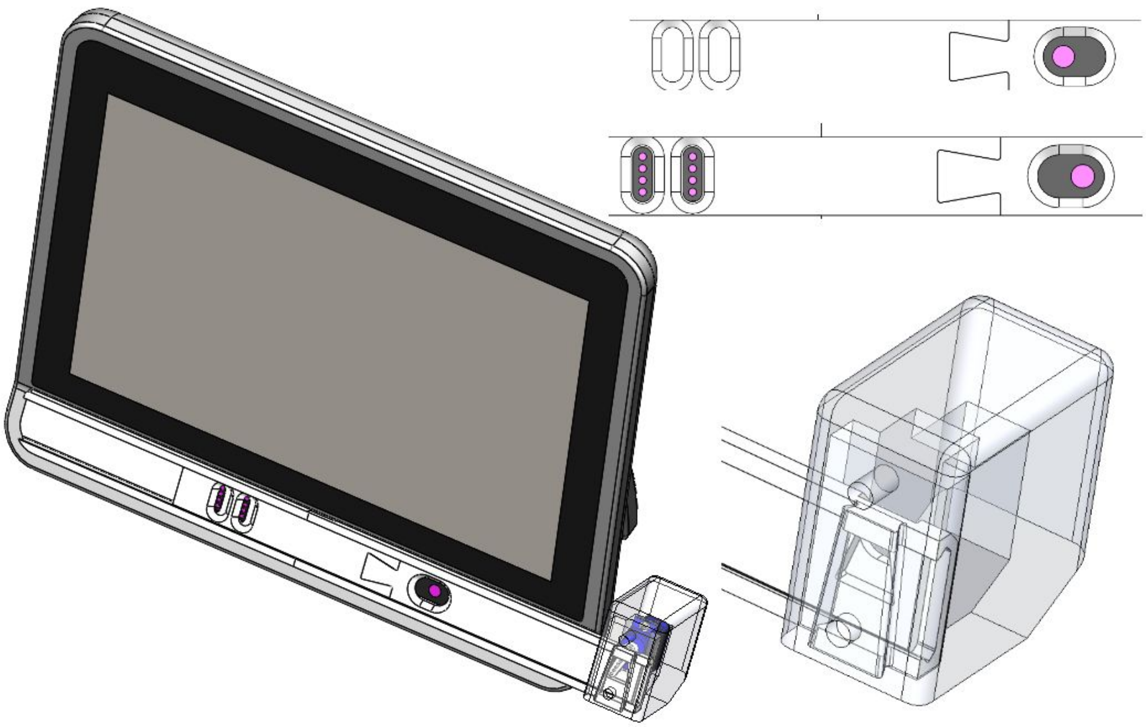

Figure 1 - CAD design

Figure 2 - Cover closed

Figure 3 - Front of servo mount

Figure 4 - Back of servo mount

Figure 5 - Separate parts of cover

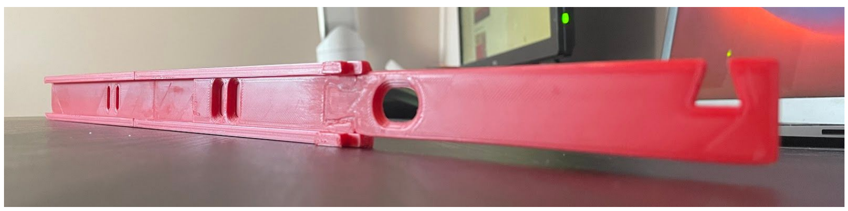

Figure 6 - Separate parts sliding together

Figure 7 - Separate parts together

For the original Big Red prototype, the main goal was to have a physical representation of what had come of our conceptual evaluation and refinement process, as well as doing some simple tests. For Big Red MK 2, we plan to develop this design into a proper prototype that could fit the servo-motor and be properly tested against more of our design criteria.

The first step in this process was to alter the CAD and make improvements based on the information obtained from the client. We received many measurements and photos of the Tobi I12+ device which allowed us to improve and optimize our design based on what we understand to be the dimensions of the Tobi I12+. The new dimensions we received include the width and height of the device as well as the locations of the cameras with respect to the width and each other. We were able to take these dimensions and estimate unknown dimensions and turn them into a more to scale model than our first big red prototype. After making the CAD model, we created a 100% scale 3-D printed prototype which should fit perfectly onto a Tobi I12+.

For this prototype, we were not able to determine all of the dimensions required for our original clip-mount design (specifically the curvature of the rear of the Tobi and the angle of the front where the cover would mount). Because of this, we decided to switch from a clip mount to a removable adhesive mount using 3M Command adhesive strips. These strips attach to surfaces with adhesive and connect together with rigid-Velcro. This velcro will allow the cover to be removed and replaced repeatedly after applying the strips. Each 75mm strip is rated to carry 1.8kg (loaded in shear).

We will be testing our new prototype against our old target specifications from PD-B as well as other tests that we believed to be useful before constructing our final product. These tests are all listed below:

Table 1 - Analysis of expected and experimental results for the Big Red MK 2 tests

| Tests | Expected Results | Actual Results | Discrepancies |
|---|---|---|---|
| Fit on Tobi I12+ (Y/N) | Yes | Yes | No discrepancies |
| Dimensions (mm,mm,mm) | 324 x 28 x 10.6 | 322 x 28 x 10 | Discrepancies from within the slicing software and sanding of the 3D model resulted in slight differences in dimensions from our expected result. |
| Weight (g) | 50 | 44 | Changes in weight may come from estimations of the slicing software being slightly off compared to the real 3D model |
| Cover slides smoothly (Y/N) | Yes | Yes | No discrepancies |
| Drop height (m) | >0.3 | >1 | Based on the increased infill in the 3D print, the model is much stronger than it was before which increased the durability. |

| | | | |
|---|---|---|---|
| Cover area (cm^2) | 31-22x6-1 | 32.2 x 2.9 | No discrepancies |
| Tape Adhesion - 20mm x 20mm strip (kg) | ~0.48<br>No adhesive failure | 0.37<br>No adhesive failure | Very small discrepancy. This is likely due to peeling caused by the small strip length. See below. |

The tape adhesion test was performed to determine if the adhesive strips would adhere properly to 3D printed PLA. Three 20mm x 20mm segments of tape were cut from a pair of 3M Command mounting strips. Dust was blown off the parts with compressed air to ensure a clean surface for testing. The surface was intentionally not cleaned with alcohol as recommended to simulate a non-ideal mounting scenario that could occur during mounting to the Tobi.

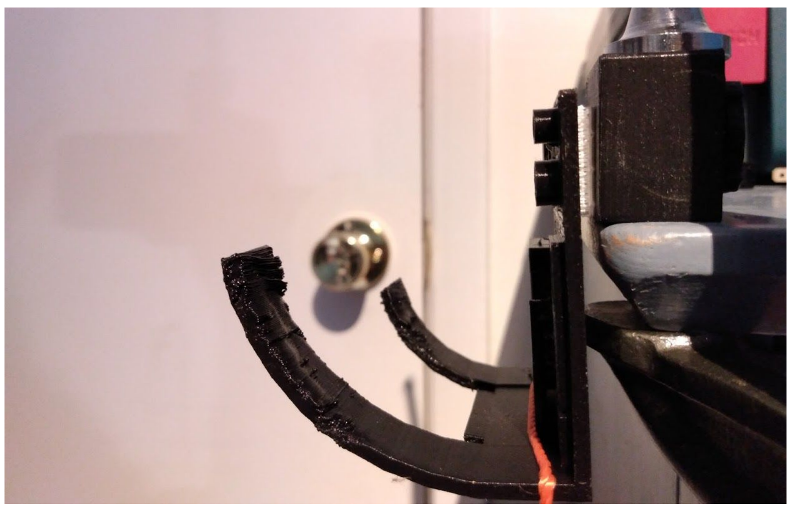

Figure 8 - Tape adhesion test

Table 2 - Results of tape adhesion test

| Trial | Supported Weight (kg) |
|---|---|
| 1 | 0.3 |
| 2 | 0.4 |
| 3 | 0.4 |
| Avg. | 0.37 |

These results are slightly lower than the expected value of 0.48kg (1.8kg capacity x 20mm/75mm). This is probably due to the velcro peeling from the top instead of resisting only shear. The clamp was positioned to prevent tilting, but did not work effectively. To compensate for this tilting and peeling in our final prototype, we will increase the strip length and use two strips on each end of the cover. This should prevent peeling and twisting. In this configuration, the cover will need to be pulled off axially which will require significantly more force.

Most importantly, the adhesive did not fail in any of the tests and showed no signs of weakening. This demonstrates that the adhesive is suitable for mounting the PLA sliding cover.

## Zip Zap MK 1

The goal of this prototype was to build and test a functional circuit that would be very similar to the one that will be present in our final prototype. This circuit consisted of an Arduino, a breadboard, a transmitter-receiver pair, a small button, a micro servo-motor, and a MOSFET to switch the servo off when not in use. The main goal of this prototype was to test the components that we had purchased and ensure that wireless communication between the button and the cover would be possible. The software that was used was the Arduino IDE and servo library.

The separation between the team members meant the process of building the circuit had to physically be done by one person. To assist them, other members of the team joined a live video call to work together to assemble the circuit. Additional complications were encountered due to the fact that the microcontroller that is going to be used in our final product can only be powered by a USB micro B. This was not available to the team member physically constructing the prototype at the time so an Arduino UNO was used instead. This should cause no complications in the future as the other microcontroller is Arduino compatible and has IO pins compatible with our current design..

The first test was to determine if the arduino could toggle the servo between two positions and power down the servo when not in use with the mosfet. The servo ground was connected through the N-channel mosfet and the arduino controlled the servo signal and the mosfet gate. This allowed the servo to be powered off between moves.

The second test was to test that the Arduino could activate the transmitter and send a proper signal to the receiver. Simulations on tinkercad.com were performed to define how the circuit should be mounted and a physical version of it was developed to properly test the components that were purchased. This was done by putting both the transmitter and receiver on the same breadboard and using a switch to activate the transmitter temporarily. This would then send a signal to the nearby receiver and it would send a signal to the Arduino where a built-in LED would visually show the signal.

The third test was to see if the transmitter could activate a servo motor to the desired angle. This was hoped to be accomplished by connecting the servo to the breadboard and using the servo library. The circuit would send the servo commands when the arduino received a signal from the transmitter. Due to the distance between team members, work schedules and electrical issues, the team ended up running out of time for perfecting this task. Improvements will be made such as attaching the longer-range antennas, which was not completed for this prototype due to a lack of soldering equipment.

The design of these systems will be refined for in the next prototype.

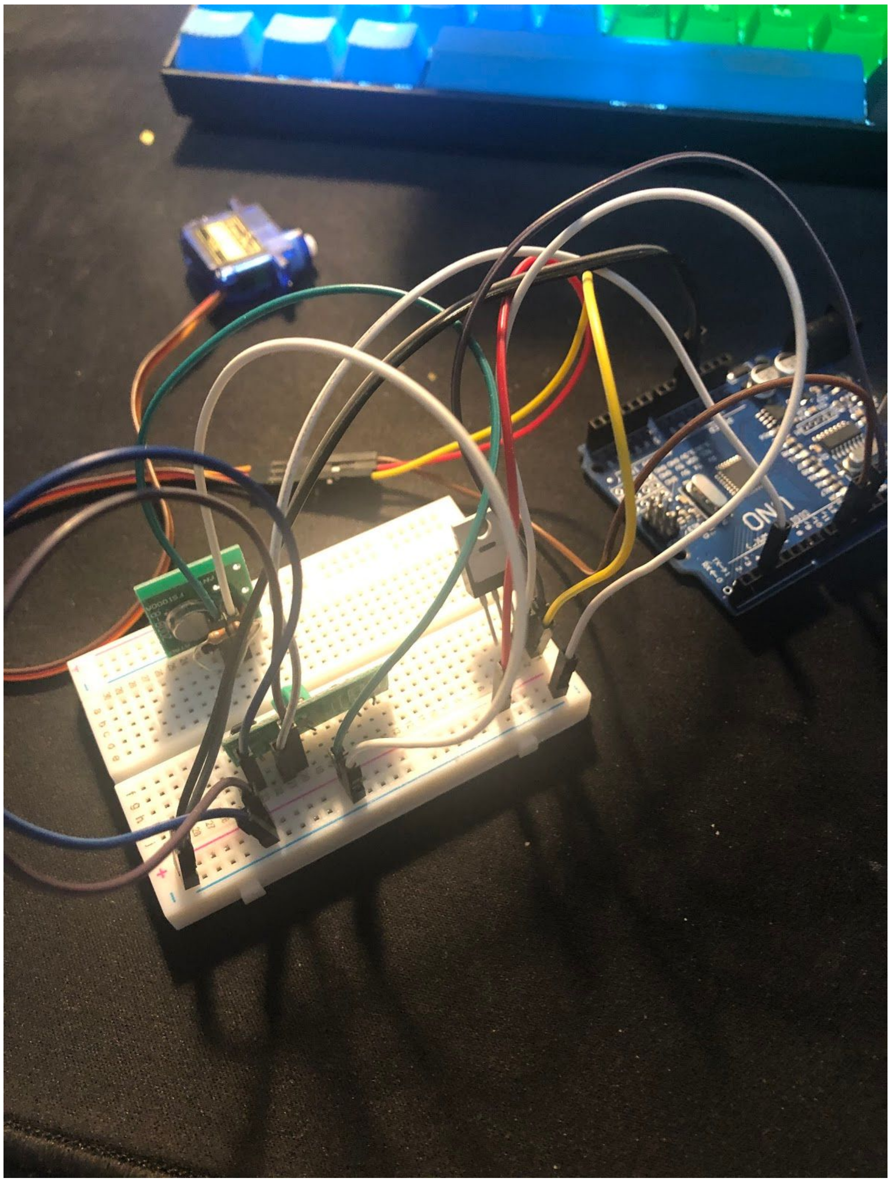

Figure 9 - Prototype circuit

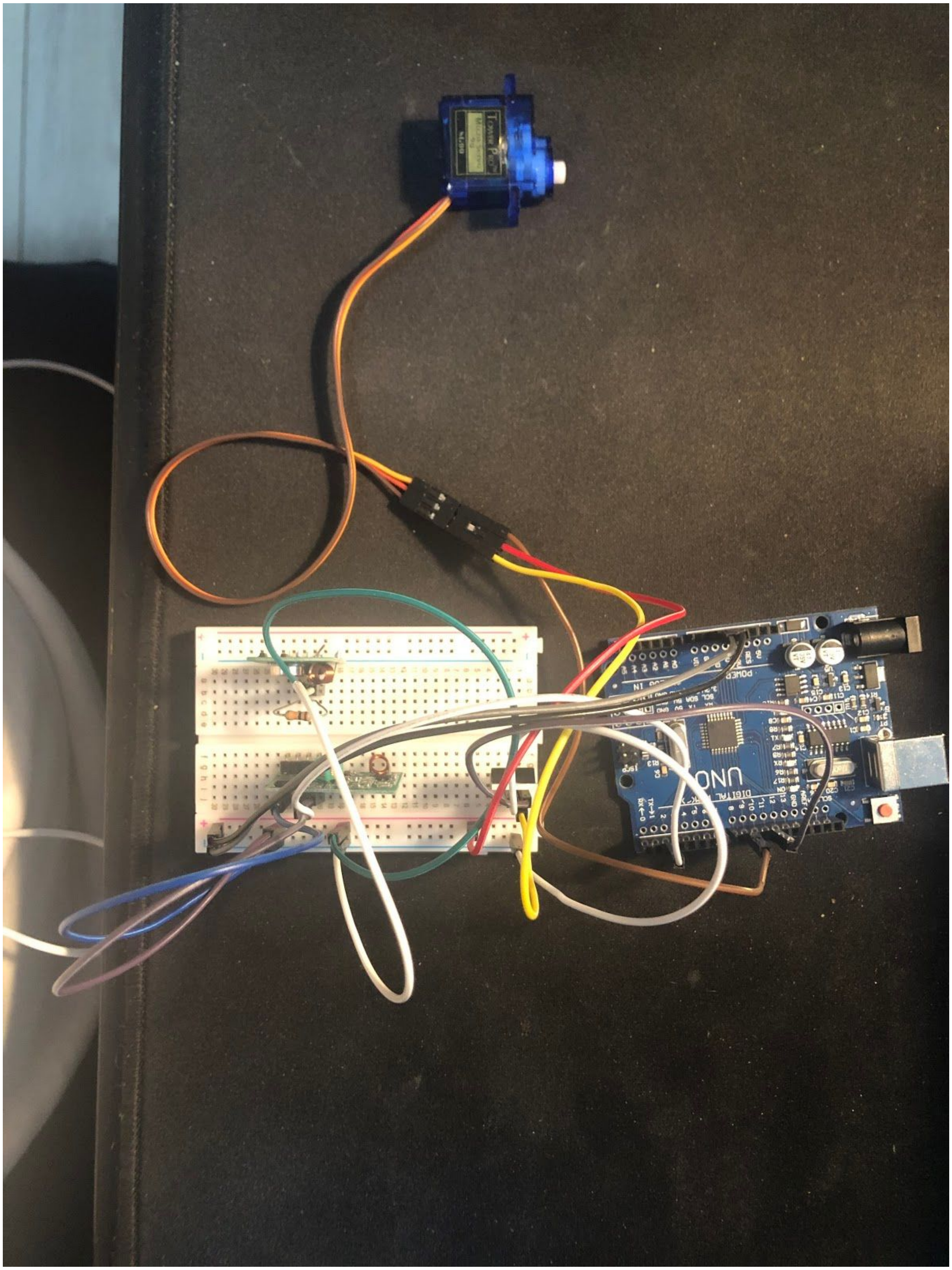

Figure 10 - Prototype circuit 2

Table 3 - Analysis of expected and experimental results for the Zip Zap MK 1 tests

| Tests | Expected results | Actual Results | Discrepancies |
|---|---|---|---|
| Activation Time (s) | <2 | <2 | No discrepancies<br><br>The servo and MOSFET perform as expected. |
| Wireless connection (Y/N) | Yes | Yes | No discrepancies<br><br>However the wireless connection has only been tested at a short range. Longer range testing will be completed once the long-range antennas are soldered to the modules. |
| Button can move Servo to the desired position | Yes | No | Due to minor problems with the electrical components, we have not managed to make this work yet. |

# Client Meet 3 Feedback

We presented our new updated design to the client who seemed to be impressed with it. We discussed the idea of using the existing arm as a stand or paddle which we could dangle another button off of and the client seemed to like it. An important point made by the client is to assure that the position of the button is right so that Oliver can activate it easily. Power was a concern since Oliver would return to school soon and our device should avoid using much of the battery, mainly from the Tobi I12+. Therefore, the components used for the project were chosen so they would draw only a small amount of power from the chair and, since the Tobi I12+'s battery could be more affected, the option of an external battery to power the servo motor is being considered. More tests on this subject will be performed once our electrical components are constructed. Another important factor that was pointed at the meeting was the wiring. There cannot be any wires hanging from the button, arm, or on the back of the chair since Oliver may swing his arms around or grab onto them making this a big problem. Electrical tape is considered as a solution to wrap the wires around the arm we construct and the existing one on the wheelchair.

Oliver and his mother will provide us more pictures of the existing upper arm on his right side that will be used to show us the dimensions of the arm. A project of a clamp to which we can attach our arm and button will be done based on the information obtained from the pictures. They said they will send us the photos as soon as possible so we can start prototyping this portion of the project. Amita mentioned that she had another Tobi I12+ at CHEO which we could go over and see when she is available. This could give us more accurate dimensions as to how large the Tobi I12+ is.

# Project Plan Update

The next step for our project is to develop a potential business model and an economics report. The business model should be made to commercialize the final version of the eye gaze camera cover, which is a refined version of the second prototype that is presented in this document. The economics report will contain the possible costs, a 3-year income statement and the break-even point for our simulated company. The following link: https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=NpQ5XMnYzB1r7r1DQT2wHQDFMiPWvTi7%7CIE2DGNJSGE2TCLSTGE3A

# Conclusion

Based on the feedback that was acquired during the 3rd client meeting we were able to get more specific information on the Tobi I12+ and wheelchair battery life. We decided that drawing battery from the wheelchair will not be an issue as long as the wires do not become an issue to Oliver's day-to-day actions. We will be securing the wired tightly around the arm of the chair using some type of discrete tape or zip ties. In regards to the servo power, we will test the battery consumption with the new prototype and will be also creating an option in which the servo is battery powered for when Oliver is in need of the Tobi I12+ for longer periods of time to not drain the battery.  The button which is connected to the arm will be attached to the pre-existing arm that is available and will be angled correctly for his head position. We are waiting to receive a few images to then be able to create the clamp prototype.

The physical prototype Big Red was modified and improved to form BIG RED MK 2 in which is designed with more specific dimensions to fit the servo- motor better. Due to the additional client information provided, we were able to make the prototype more accurate. With the help of a CAD model the 3-D printed prototype should fit perfectly onto the Tobi I12+. The constraints from the first prototype were then tested again using the new and improved prototype. The physical prototype BIG RED MK 2 should be accurate in dimensions and should be to scale with the Tobi I12+.

With the information that was provided during the client meet and the components we purchased we were able to create a working prototype of the electrical component ensuring that the wireless communication between the button and cover was functional. Some issues arose due to the fact that the team is unable to meet together and therefore there were certain components that were unavailable to the member who possesses the electrical components. For this prototype, the Arduino UNO was used instead of the Adafruit Trinket as that was not available to the team member at this time. The prototype was tested against the constraints that were decided earlier on. The electrical prototype ZIP ZAP MK 1 is a similar functional electrical prototype to what we want for our final prototype.