GNG2101

DELIVERABLE D

Submitted by

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Introduction

Deliverable D covers the development and analysis of the first prototype, a project cost estimate (BOM) as well as obtaining customer feedback and comments for the concepts developed in deliverable C. It was following the meeting with the client that several needs were identified. From these needs, design criteria were defined, then a global solution was determined. From this solution, three different prototypes will be produced. For this deliverable, we are looking at the first prototype which must be made from inexpensive materials and components and which focuses more on creating a basic proof of concept. Firstly, the customer's feedback will be presented following the concepts developed in deliverable C and a sketch based on customer feedback. Secondly the presentation of the prototype will be discussed. Thirdly, the analysis and tests carried out on the first prototype will be discussed and then end with a preliminary bill of materials and parts

1. Client feedback

1.1. Summary of client feedback

During the second client meeting, we shared our most recent ideas for the prototype with our client in order to get her opinion and suggestions on how we could improve the design to best fit her preferences. Earlier on in the day, we came up with the idea of using a magnetic charger which we brought up to her in the meeting. We were glad to learn that she really appreciated the idea of the hearing aid being rechargeable, as she mentioned previously that batteries were expensive and their life time was very short, and thought that having the charger be magnetic would be much easier.

She also agreed with our idea of waterproofing the electronics and microphone however brought up that she will not actually be using the hearing aid to swim and that her only trouble was wearing them in the rain. Nevertheless, we will still be including this in our design to ensure that the hearing aid is more than capable of remaining functional in rainy conditions as well as when immersed in water; this way if she were to change her mind or possibly drop the hearing aid into water, it would still work.

Besides this, the client had no further suggestions or issues with our current ideas.

1.2 Detailed design

Due to the positive feedback from our client, we have decided to stick with our current design with a few updated features:

Our design idea is to purchase an over-the-ear hearing aid that is rechargeable with a Micro USB cable and to modify it to produce a hearing aid that is waterproof, thus, functional when immersed in water. We will do this by waterproofing the electronics, microphone and charging port separately.

To waterproof the charging port, we will use a magnetic charger with a removable charging head, as shown in Figure 1.1, that we will purchase online. We will then plug the charging head in and seal it using either silicon glue or superglue so that it remains in place to block off the charging port and stop water from entering. The hearing aid will then be recharged just by attacking the magnetic cable to the end of the charging head.

Figure 1.1: Magnetic charger with removable charging heads

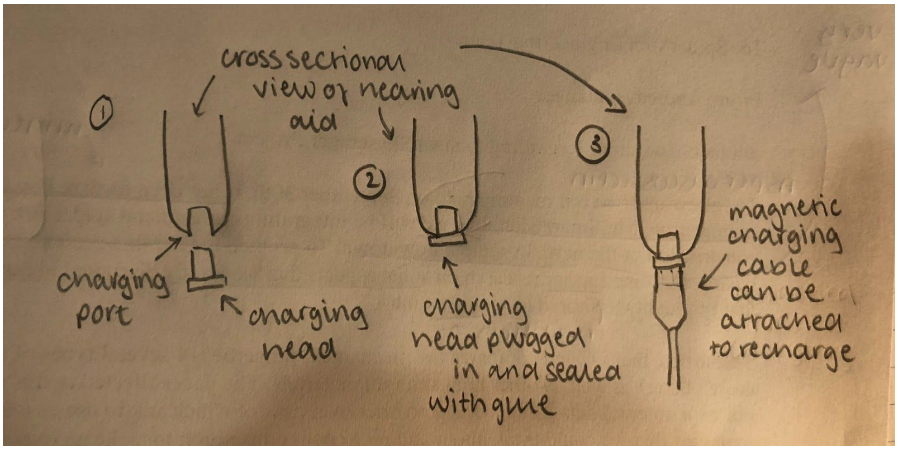

Figure 1.2: Diagram to show the application of the magnetic charger

This method of charging will ensure that the charging port is sealed at all times and has been tested already by Kerollos with a similar charger (further explanation in section 2.2.5).

To waterproof the electronics, we will disassemble the casing on the hearing aid and cover all the electronics, except for the microphone which will be covered by a different material, in clear nail polish. We will then put the casing back on. This will allow the nail polish to act as a second

barrier of waterproofing in case any water were to enter the hearing aid and come into contact with the electronics.

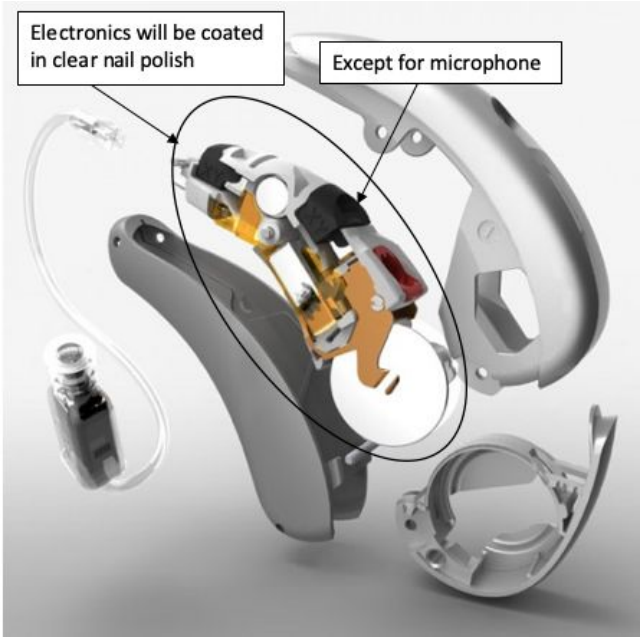

Figure 1.3: Exploded View of a Hearing Aid to show electronics inside

The last step will be to waterproof the microphones. This will be done with some sort of waterproof fabric to enable sound to still be heard whilst providing protection against water. The fabric mentioned has not yet been tested however will be before implementing it into the next prototype. We will cover the microphones by cutting a small section of this fabric and, using either silicon or super glue, stick it around the microphone.

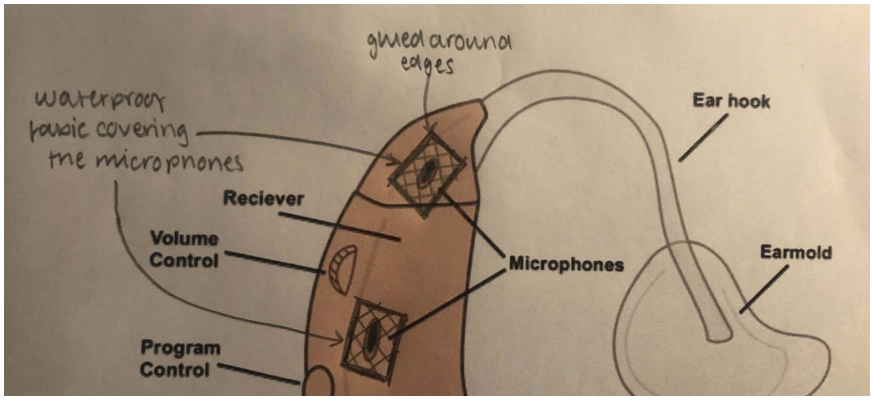

Figure 1.4: Diagram to show placement of waterproof fabric

1.3 Critical subsystem

The most critical subsystem in our design is the microphone. It is the key to how hearing aids work and it is important that our design protects it from getting water damaged. To make the microphone waterproof, a type of waterproof fabric will be fitted on top of the microphone part of the hearing aid so that no water can get in. However, the material covering the microphone must also be able to allow sound to travel through it so the fabric used cannot be too thick. The microphone is also the most important subsystem since the client specified that she needs the hearing aids to have a properly working microphone.

2. Prototype I

2.1 Development of prototype I

For the development of the first prototype, we decided to test some subsystems. We therefore used objects found at home to create different prototypes for our tests. So here a list of different materials that we used to test the assumption described in the previous section:

- Headphones
- Clear nail polish
- Magnetic charger
- Shower curtains
- Microphone
- Plastic wrap
- Superglue
- Electrical tape

2.2. Test plan

2.2.1 Objectives

The purpose of this first prototype was to give us a better understanding of the problem and to get user feedback, which helps reduce the risks associated with a particular aspect of the concept. This prototype also helps us to measure the performance of our solution and to better understand its functionalities in real time, which means that it can always be improved and perfected to arrive at the best final solution while saving money and time in the long run. More specifically, the objective of this first prototype is to test the waterproofing effectiveness of materials to decide which one we will use for waterproofing the hearing aids. To test the different materials, such as nail polish, plastic wrap and a shower curtain, we will use headphones and microphone. We will cover the headphones or the microphone with these different materials and check if they still work when submerging them in water. We will also be testing the magnetic charger under the water.

2.2.2 Test criteria

- The test criteria for success is the headphones work when submerged in the water
- The test criteria for success is the microphone works when submerged in the water

- The test criteria for success is the charging port is sealing when it's submerged in water
- The test criteria for failure is the headphones do not work when submerged in the water
- The test criteria for failure is the microphone doesn't work when submerged in the water
- The test criteria for failure is the charging port isn't sealing when it's submerged in the water

2.2.3 Prototype type

Our type of prototype is physical and focused. The physical side allows us to better communicate information among ourselves and also to the client. We can also better anticipate or improve until the final product since the prototype is tangible. The focus side allows us to focus more on the critical subsystem (ie. waterproofing electronic components) and perform several rigorous tests to improve as much as possible until the final product.

2.2.4 Test dates

We have planned about one hour for each test that we will start before the second client meeting to make sure to consider the client feedback. The test needs to be done before october 6th if we want to discuss the result with the client.

2.2.5 Test results

<u>Test 1:</u> Nail polish

For the first test we applied several layers of clear nail polish on the headphones(*figure 2.1 and 2.2)*. Once dry, we tested the headphones in the bath by connecting them to a phone. Once our head was in the water, we played the music on the phone to confirm whether we heard it or not so whether the headphones worked or not. After a 30 minutes underwater, it was noticed that the headphones still worked and the music could be heard well. So it is possible to see that the nail polish makes the headphones waterproof. Also the headphones remained in good condition and still working after the test. Moreover, the headphones remained very comfortable to wear after the addition of the layers of nail polish. This test is shown in *figure 2.3*.

Figure 2.1

Figure 2.2

Figure 2.3

This test was also done on a small LED circuit in which the entire circuit was coated in clear nail polish as seen in *figure 3*. The circuit was then placed underwater and remained there for 30 minutes. After this test concluded the circuit still functioned and the LEDs lit up as seen in *figure 4*.

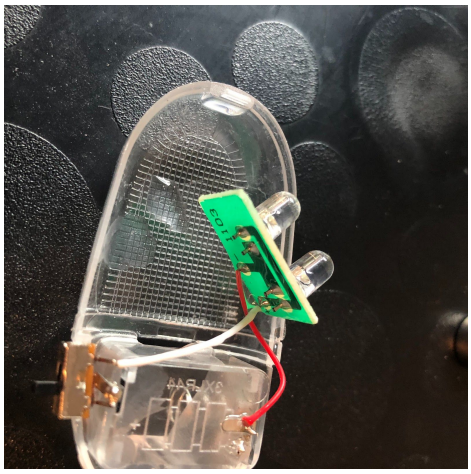

Figure 3

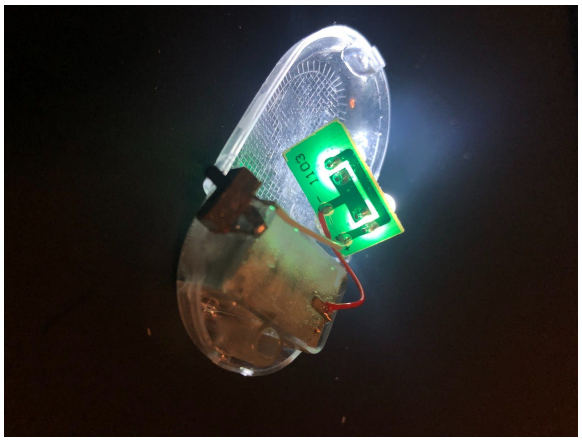

Figure 4

<u>Test 2:</u> Shower curtains

We repeat the same test but this time we use a microphone and cover with a piece of shower curtain and shrink wrap it around the microphone of the headset. Although the vinyl shower curtain formed around the microphone it kept tearing open at the sharp corners of the microphone. So the result was not really conclusive. We can therefore eliminate this option for the design of our product since it was not completely waterproof.

<u>Test 3:</u> Plastic wrap

We repeat the same experiment as the shower curtain but using plastic wrap. Unlike the shower curtain the plastic wrap did not tear at the sharp corners of the microphone. The plastic wrap formed a perfect seal around the microphone (*figure 5)* and lasted for the entire duration it was in the water for (*figure 6*). So the test was conclusive.

Figure 5

Figure 6

<u>Test 4:</u> Magnetic Charger

To test the seal around the magnetic charger and the charging port we used a magnetic micro-USB charger which was inserted into a power bank and sealed around it with superglue (*figure 7*). Note: all other seams and ports of the power pank were covered with electrical tape. The power bank was then placed in water and moved around to simulate swimming for 10 minutes then it was left in the water for an additional 20 minutes (*figure 8*). After the test was conducted the power bank still worked and no water entered the device. So the test proved that we can seal the charging port in this fashion. Also this test meets the client's need for rechargeable hearing aids.

Figure 7

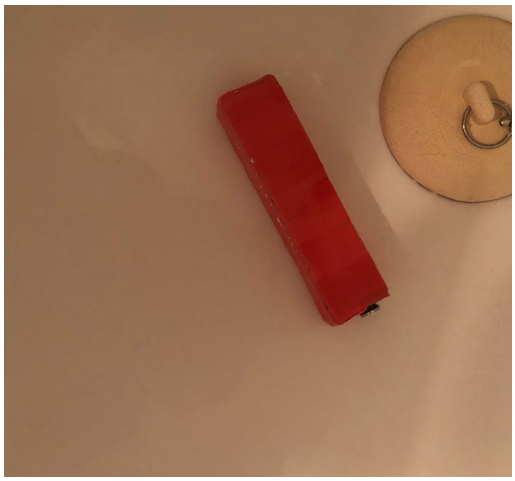

Figure 8

Table 1: Summary of the test result

Materials	Expected result	Actual result
Nail polish	Headphones work	Headphones work
Shower curtains	Headphones work	Microphone doesn't work
Plastic wrap	Microphone works	Microphone works
Magnetic Charger	Seals charging port	Seals charging port

3. Bill of Materials

Another important step to the project management is estimating the costs. The next section will present a table of the bill of materials for our project.

Table 2: Bill of materials

Item number	Part name	Description	Quantity	Unit cost	Extended cost
1	Hearing aid	Digital hearing amplifier	2	$29.99	$59.98
2	Polish	Clear nail polish	1	$2.47	$2.47
3	Charger	Magnetic micro-usb charger	1	$9.90	$9.90
4	Silicon glue	Transparent caulking	1	$2.17	$2.17
5	Waterproof fabric	Black neoprene fabric 56x18"	1	$16.99	$0.85
				Total	$75.37

Conclusion

To conclude, it was seen in this deliverable that following the feedback given by the customer in relation to the solution of deliverable C, it was possible to design the first prototype. The tests and the bill of material were also discussed. In addition, after conducting all the tests, we can conclude that our target specifications are feasible since the materials used meet the required IP code rating and the hearing aid that will be used is rechargeable and has a high quality microphone and speaker.