Group A6- Deliverable C

The Life-Proof Hearing Aid

Submitted by

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GNG2101

Date: 27/09/20

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Introduction

Having established the design criteria and narrowing them down into seven sections, the next step was to ideate a product which could meet these necessities. Each team member was tasked with developing three potential solutions to the client's problems, with the overall goal of best satisfying each design criteria defined in the previous deliverable, deliverable B. All twelve proposed solutions are described in detail in this document. In order to quality check the solutions, each team member's design concepts were peer reviewed on how well they catered to the agreed upon design criteria and target specifications. Coming to a consensus, the team chose one concept to pursue as it best addressed the problem statement which is, a need exists for the development of a low profile addition to [redacted] Cochlear implant that is comfortable, durable, and does not hinder the device's existing features. The following report examines the user needs and what criteria those translate to, the proposed solutions, and finally the design concept our team will be moving forward with including a detailed feasibility study of it.

Table of Contents

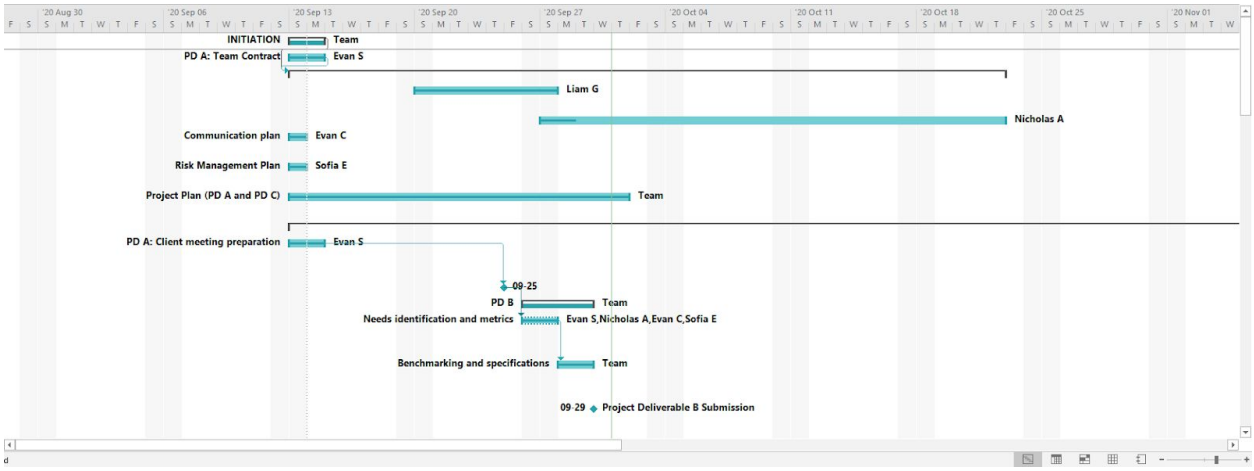
1 Project Plan

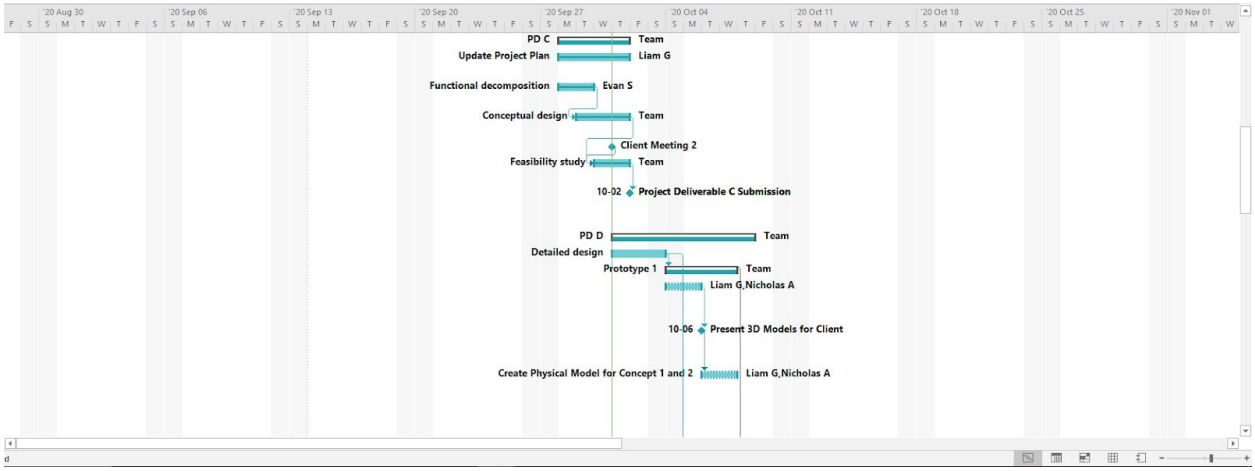
Updates to the Project Plan have been made to better represent the coming weeks and the sub-tasks associated with the next deliverable. Accurate dates for previous sub-tasks and deliverables have been set and all dependencies for these tasks have been applied. In the coming weeks, we will continue to adjust the project plan as tasks become more clear, which will give us a more accurate and realistic time scale for the project. Below are sample photos of the project plan, but they only encompass a small portion of the whole thing. We have submitted the MS Project file for our project plan with this document so that the full plan may be viewed at once.

GANTT CHART

	Task Mode	Name	Resource Names	Duration	Baseline Estimated Start	Baseline Estimated Finish	Start	Finish	Predecessors	% Complete
1		**INITIATION**	**Team**	**2 days**	**Sun 20-09-13**	**Mon 20-09-14**	**Sun 20-09-13**	**Mon 20-09-1**		**100%**
2		PD A: Team Contra	Evan S	2 days	Sun 20-09-13	Mon 20-09-14	Sun 20-09-13	Mon 20-09-1		100%
3		**PLANNING**	**Team**	**29 days**	**NA**	**NA**	**Sun 20-09-13**	**Thu 20-10-22**	**1,2**	**59%**
4		Setting project scope and goals	Liam G	7 days	Sun 20-09-20	Sun 20-09-27	Sun 20-09-20	Sun 20-09-27		100%
5		Budget	Nicholas A	20 days	Sun 20-09-27	Sun 20-10-04	Sun 20-09-27	Thu 20-10-22		10%
6		Communication plan	Evan C	1 day	Sun 20-09-13	Sun 20-09-13	Sun 20-09-13	Sun 20-09-13		100%
7		Risk Management Plan	Sofia E	1 day	Sun 20-09-13	Sun 20-09-13	Sun 20-09-13	Sun 20-09-13		100%
8		Project Plan (PD A and PD C)	Team	15 days	Sun 20-09-13	Thu 20-10-01	Sun 20-09-13	Thu 20-10-01		100%
9		**EXECUTION**	**Team**	**59 days?**	**Sun 20-09-13**	**Thu 20-12-03**	**Sun 20-09-13**	**Thu 20-12-03**		**14%**
10		PD A: Client meeting preparation	Evan S	2 days	Sun 20-09-13	Mon 20-09-14	Sun 20-09-13	Mon 20-09-14		100%
11		Client Meeting 1		0 days	NA	NA	Fri 20-09-25	Fri 20-09-25	10	100%
12		PD B	**Team**	**3 days**	**Thu 20-09-17**	**Thu 20-09-24**	**Sat 20-09-26**	**Tue 20-09-29**		**100%**
13		Needs identification and metrics	Evan S, Nicholas A, Evan C,Sofia E	2 days	Thu 20-09-17	Thu 20-09-24	Sat 20-09-26	Sun 20-09-27	11	100%
14		Benchmarking and specifications	Team	2 days	Thu 20-09-17	Thu 20-09-24	Mon 20-09-28	Tue 20-09-29	13	100%
15		Project Deliverable B Submission		0 days	NA	NA	Tue 20-09-29	Tue 20-09-29		100%

Ready New Tasks : Manually Scheduled

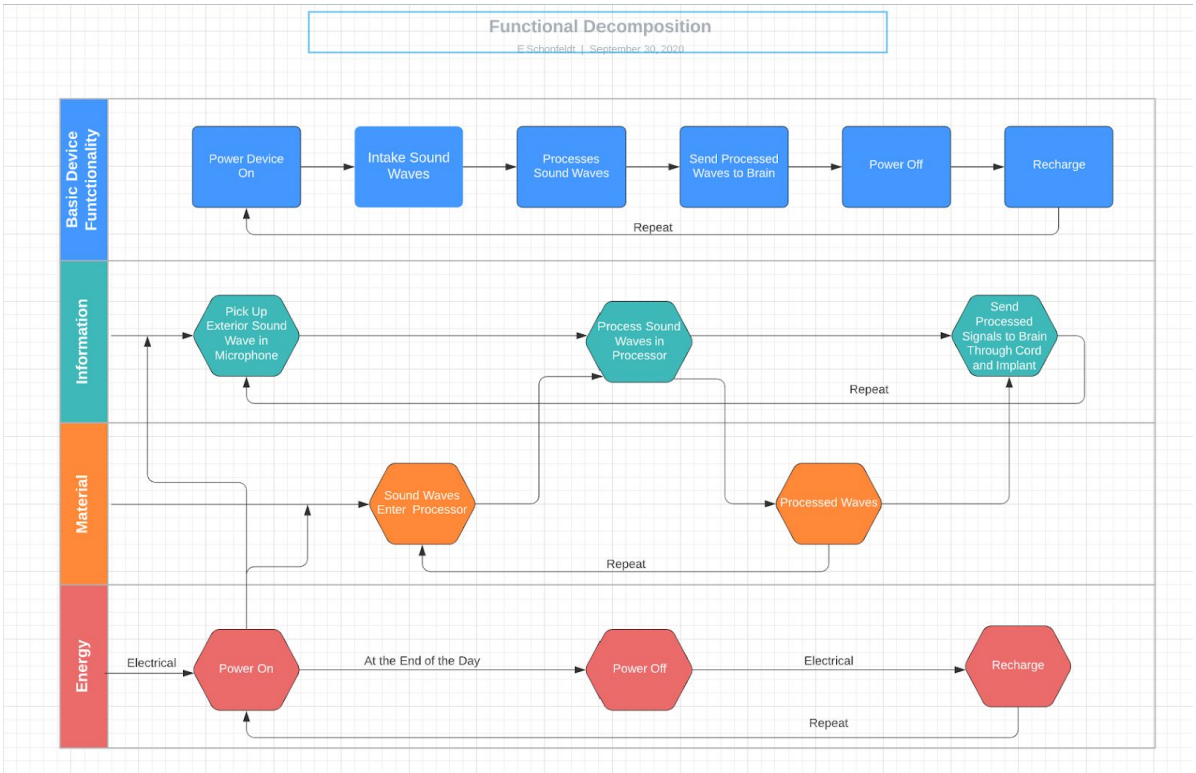


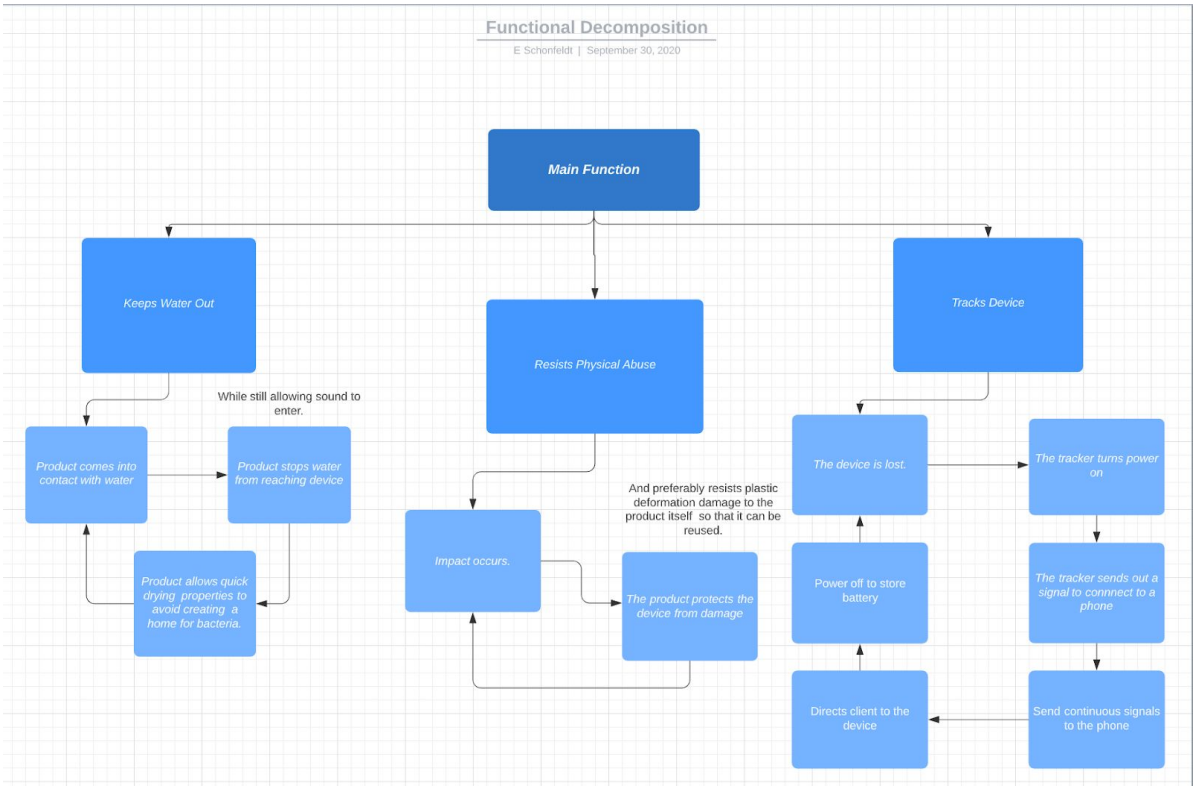


2 Functional Decomposition

The functional decomposition of [redacted] existing hearing aid is detailed below in Figure 1. This decomposition flowchart highlights the main components of [redacted] device. As this device allows her to hear, any product we create must not hinder the device's ability to complete those basic tasks.

The second diagram in figure 2 details a basic functional breakdown of our ideal product according to our most important functional design criteria. The most important subsystem boundary we have found to date is in the waterproofing function of the product as sound must still be able to enter clearly while simultaneously keeping water out.





3 Individual Concepts and Analysis

Team Member A: Evan Charkowy

Concept 1: Modular Case

A case consisting of a durable seal tight plastic, silicone, or metal frame. This would go around the existing cochlear device, these pieces would be put around the initial five pieces individually but have a seal between each to make the device waterproof, dust proof, and bite proof. This case can be taken apart to allow certain pieces to remain on the device, this way target pieces that are affected most by dropping could remain on, where a waterproof complete case is not needed. This case would also contain a separate piece of thin titanium or other metal strip that would be coated in a braided carbon fibre cable, with magnets on both so that the pieces may stay together easier if knocked off. This piece would be detachable by a small holding clamp to get rid of as the user ages and no longer needs it. Could consist of an attached chip to allow for better locating Via Bluetooth or GPS.

Concept 2: New Case Design

By examining and reverse engineering, or by taking apart an existing device inside pieces could be reformatted into a better case made of a lightweight metal. This can be done by ordering specific pieces that are necessary for the cochlear device and compacting them in a way to allow the piece to be thinner, without hindering any existing functionality. This case can be reformatted to be automatically waterproof and consist of a water pushing mechanism that allows the device to go underwater and pushes the water out when prompted, such to not damage the mic. Another option for this could be a separate cover that could be closed around the mic that doesn't hinder sound, but is water impermeable. Both a longer lasting battery and upgraded bluetooth components can be implemented and replace the existing ones to allow for less charging, and better location if lost.

Concept 3: Comfortable N7 Off The Ear

By reconstructing the device and taking it apart in a similar fashion to "Concept 2" The device could be reformatted into a new case that would connect to the magnet, but no longer sit on the ear. The device could be outstretched and thin, lining the back of her skull (either vertically or horizontally) This would still allow for the magnet to be connected but would be more comfortable and easier to move with. If placed vertically this could provide better cover behind the ear and allow for the device to be only one piece. The material would have to be lined with a thin gel like material to mould to the shape of the skull to avoid discomfort, but also would prevent the need for wires to hinder and be bitten. This longer and thinner piece allows for the possibility of wireless charging, GPS or better bluetooth to be installed. This means that the only thing being in danger for water would be the mic, but like Concept 2 this could easily be prevented with either cover, or water pushing mechanism. For ease of looks the hair would naturally cover this piece when grown out, since it is mostly behind the ear allowing it not to stick out like the wires currently do. (This would also have lining inside to make sure the components are not damaged when dropped)

Analysis (Connection to Design Criteria and Target Specifications):

The concepts that Evan developed covered many of the design criteria that the team listed as being important to the clients. The concepts focus mainly on better tracking, resistance to water and physical damage, and keeping a low profile therefore hitting on the points that came directly from the problem statement. These concepts took into consideration the more heavily weighted design criteria.

Concept 1 featured a design similar to ideas which other team members had. The feature which makes this concept stand out is the magnets between pieces. This would hold the pieces together and make it harder for Freyja to take the device apart and lose individual pieces. This feature, while interesting, would need to be monitored to observe the effect of the magnet on the existing device magnet (which secures the device to her head) as well as on the sound processor. This concept would be a more reusable case than the one she currently has. Additional bulk, material

choices, and level of comfort would need to be taken into account as well as sound quality to the processor when in the case if this concept was chosen to go forward.

Concept 2 described remaking the exterior of Freyja's existing device. This concept allows for a lower profile product with more flexibility on design while still checking off important design criteria such as waterproofing and not hindering the existing features. The only concern associated with this concept is the feasibility and budget. Aside from the materials to test and make the product, the Cochlear Implant devices are expensive. As we cannot take hers apart, we would need to find an alternative test product. This would quickly become out of our budget if we are not able to find sponsors or exterior help. The second factor would be the deadline. We may have some difficulties with developing the casing that does all that we need it to as well as allowing the device to work as normal within the time limit we have.

Concept 3 has strong features such as better mobility for Freyja and being far less noticeable by others on top of touching on functional requirements such as water resistance and opportunity for a more advanced tracking system. This concept is creative but feasibility may again be a concern as there are many parts to the concept. The other concern for this device is the weight. This concept goes with the idea that the magnet that holds the device to her head would support the weight of the device. This could be a health issue as using a high magnetic setting or using the magnet to hold weight can cause deterioration (and in severe cases infection) of the skin which exposes the interior magnet resulting in further surgery. To avoid this, some form of support for the device could be needed possibly in combination with a very lightweight design should this design be chosen to go forward.

Team Member B: Sofia Ershova

Concept 1: Bluetooth Tracking Device

A small tracking chip that could be placed either directly on the device or inside of it. The chip can work with either BLE for short range or GPS for long range. If the device is lost within a known short range, it will be prompted to send out BLE signals, which can be picked up by an existing application. This can prompt a visual and possibly auditory signal that can help locate the device. Since BLE is better suited for short range, if the device is not within that proximity it switches to GPS tracking to help locate it. Since the chip is small enough to be put on the device, it will not be as obvious when present.

Concept 2: Play It Ear

(futuristic and crazy and not really possible totally beyond the scope of not only this project but possibly even current technology but it's an idea)

An implant inside the ear that completely replaces the device. Essentially works as a replacement ear, taking in auditory stimuli and translating them into signals that the brain can process and interpret. Since it is a small device that goes inside the ear, it will not be visible from the outside and will be protected for the elements the same way a normal ear is.

Concept 3: Cuben Fiber Case

A cover made out of cuben fiber. Cuben fiber is a very strong, lightweight and waterproof material. Originally used in sails for America's Cup racing boats, it is currently used in various applications that require high-strength, durable material, primarily in outdoor gear, fishing lines and nets, military, law enforcement and the maritime industry. Fifteen times stronger than steel and is resistant to UV rays and chemicals. A cover or sleeve for the device would be made of this material, with a rubber ring at the bottom to provide a snug fit and to stop water or dust from getting inside.

https://www.outdoors.org/articles/amc-outdoors/what-is-cuben-fiber-an-incredibly-light-strong-waterproof-and-outrageously-expensive-outdoor-fabric

https://www.hyperlitemountaingear.com/pages/hyperlite-technology

Analysis (Connection to Design Criteria and Target Specifications):

The concepts which Sofia presented give rise to key features which are feasible to incorporate into a final design. To begin, the solution in Sofia's concept 1 fully solves the need of a greater tracking range for the device. This is an important feature to solve because of the high cost of the device, and major consequence of losing it. However, the concept does not fully solve the needs of the client, those being durability and waterproofing. Although, the concept has features which may be easily implemented in another design as the tech is already available and thoroughly tested. Sofia's concept 2 seeks to create an alternative device to the sound processor, which is an in-ear sound processing device which transfers an input signal of sound through a microphone, to a signal that can be processed by the cochlea and sent to the brain. This design is quite interesting and would completely solve all of the client's needs, however, the technology is new and our team may not be able to feasibly create a product such as this one. However, features like the in-ear design may be implemented and connected to the headpiece of the client's cochlear implant. Sofia's final concept is an interesting take on the waterproof case design for the device. Sofia proposes to use a material called Cuben Fiber, which is strong, durable, lightweight and waterproof. A Cuben Fiber casing would be ideal for this application because it is a fabric-like material which would leave a comfortable finish to the Cochlear Implant, while also solving the need for the device to be resilient. The material would likely not hinder the ability to pick up sounds, but might hinder the ability to be tracked via Bluetooth. The downside to this design is the extremely high cost for Cuben Fiber. To summarize, Sofia's concepts offer

features which could be easily implemented into other designs and which solve the individual needs of the client quite well.

Team Member C: Liam Genik

Concept 1: Upgraded Waterproof Battery Case

Similar to the pre-existing casing provided with the N7, however, this design is made to be more durable and resilient. The casing can be made with a strong plastic to both protect the battery case from wear and physical abuse and keep the module protected from water. The waterproof case would ideally be used most of the time so that in the event that Freyja spontaneously introduces the device to a harmful environment like a shower or a pool, there will not be any worry of catastrophic damage to the device. The casing would use a membrane near the microphone which would not allow water in, yet allow sound through, keeping the device functional yet waterproof. The point where the device may enter the case would be closed with a water-tight O-Ring, which is difficult to open easily. The case would ideally be comfortable so that Freyja does not feel the need to take the device off after long-term use.

Concept 2: Waterproof Extension Module

The device would feature an extended cable from the headpiece to the microphone/battery case. The extended cable will be used to place the microphone in a waterproof protective case, which is equipped with a trackable Bluetooth module. The protective case serves as a new housing for the microphone/battery pack which can be clipped to clothing or to a belt, etc. The device would be large enough to house the device, yet keep it in position so that it does not move around while inside the protective case. The case would be childproof, so that Freyja cannot open it when the device is placed inside. The case would also have an air-tight seal using an O-ring to keep water and dust out of the case. The case would make it easier to track the device as well, since there would be two tracking platforms, the one integrated in the N7, and the one set up in the protective casing. The tracking module in the case could be made to be more reliable, as it will have more room to fit a larger Bluetooth module inside. The case also has the possibility of having its use extended to being a portable charging unit for the device, similar to a wireless earbud case.

Concept 3: Retrofitting the N7 to be waterproof

Using concepts and designs for products like the Advanced Bionics Neptune Sound Processor, we can adopt ideas for retrofitting Freyja's existing device to be waterproof. To illustrate this, air-tight O-rings and a locking mechanism may be added to the door where the batteries are inserted. In addition, an addition of a water impermeable membrane where the microphone is may keep the water out of the device while letting sound in. The device can be fitted with these sorts of membranes in areas where water can enter the housing. This would eliminate the need for an addition to the N7, and reduce the number of parts that Freyja's parents need to keep track of. It would also not inhibit the existing features of the device, as this solution is more of a remodel than an addition.

Analysis (Connection to Design Criteria and Target Specifications):

Concept 1: Tech for existing processor, waterproof membrane, sound not water. Membrane needs to be researched more.

This currently meets the majority of the design material. It covers the possibility of the device becoming waterproof in a way that wouldn't hinder functionality as well as keeping it durable and able to withstand potential physical damage. This matches similar designs throughout the group and is the most feasible solution to the problem while still keeping cost and our overall knowledge of the device in mind.

Concept 2: External case. Added features inside.

Drawbacks: longer wire, clip has to be strong and has to be balanced for weight so no attention is drawn. Unsure whether the wire would connect to the device or case.

Pro: Could have an armband or such to make it less noticeable.

This overall design is feasible and could potentially be possible making. With the device's dual bluetooth system it would allow there to be more of a chance that the device would be found if potentially lost, and with quicker results. Not only this but the wire and clip would prevent the device from getting lost most of the time in the first place, which is definitely a feature we need. The design would just potentially not be that comfortable for a two year old, and while childproof, still needs to be less noticeable which could be a problem if she doesn't happen to wear a belt or have anywhere to clip it onto, like in the pool. This problem could however be potentially fixed with added accessories.

Concept 3: Overall very cool and feasible design similar to others eliminates the need for adding bulk to the design. This solution is possible however we would need to get a hold of an existing device to remodel it without damaging any of the pieces inside. Other than this the solutions meet the majority of the criteria. It becomes waterproof, does not allow for extra bulk, and allows the parents a little more ease of mind when it comes to worrying about whether the device will be damaged or lost. This also allows for the potential to replace existing pieces for better ones and even making the device itself a little slimmer.

Team Member D: Nicholas Anderson

Concept 1: Trackable Battery Module

Instead of taking apart the device and finding a way to insert a tracking device that provides more range and accuracy than what is currently offered on the N7, one method of solving this problem would be to have the battery modules be slightly longer and feature a compartment within each one that has a some sort of small chip which use Bluetooth Low Energy technology to connect to the phone. It is important that this chip has an increased connectivity range greater than 10 meters. Furthermore, seeing as the tracking portion of the N7 will be in the battery modules, it would make sense for the chip to run off of its own separate

power supply so as to still function even if the sound processor is out of battery. A much less feasible plan would be to have the chip also include a cellular component so that the user would always see the N7's location no matter how far they are from the device.

Concept 2: N(7)ecklace

This will be the most costly design, however it is important to dream big. I propose that instead of the N7 resembling the traditional sound processor and sitting on the ear, the N7 taken apart and redesigned as a necklace. This new casing would be much more comfortable as the weight would be equally distributed and not lopsided like when it is just resting on one side of the head. Furthermore, this would allow for a new casing to be built which would be waterproof. It is important to note that a separate waterproof case would need to be designed for the coil section of the device, which would run up the back of her neck to her implant (well hidden by hair). In addition, the case could be designed with new materials which are more durable, however being a necklace it is already so much less likely to fall when compared to the traditional cochlear implant sound processor. A larger device could also potentially offer space for larger/more batteries significantly increasing the longevity of the battery life. This type of design for portable speakers has already been put to market in the product Bose Soundwear. https://www.amazon.ca/Soundwear-Companion-Wireless-Wearable-Speaker/dp/B0748KDJPS

Concept 3: Blue Light Blocking Glasses

Like the previous concept, this idea is also a redesign in the hopes of having a more comfortable and low profile product. I propose that the N7 internals be placed in blue light blocking sunglasses. Blue light has been found to be harmful to individuals eyes and with children being introduced to screens at younger ages, this is a significant issue. Furthermore, glasses are very common and thus low profile in that nothing would stand out. The frames can be made of a waterproof and of a durable material that can withstand drops. If this solution were to be pursued, the coil and magnet portion of the N7 would need to be made waterproof as well. The device will be more comfortable than the N7 as the weight of the product will be equally distributed on the head unlike the N7. It is important to note that the lenses of the glasses could be prescription if the need arose, however Freyja currently does not need prescription glasses. Bose already has audio sunglasses available for purchase named the Bose Frames Tenor and Soprano which are proof of concept. Our device would likely be more bulky as there are more complex components. Finally, a eyewear strap could be added to the glasses so as to help the device not get lost/dropped as easily.
https://www.bose.ca/en_ca/products/frames/bose-frames-tenor.html#v=bose_frames_tenor_black_row

Analysis (Connection to Design Criteria and Target Specifications):

Nicholas' concepts all contribute to solving at least one client's needs. Concept 1, while not sufficiently addressing any other client needs, proposes a solution for the need to improve tracking of the device. Since Bluetooth Low Energy (BLE) is technology that already exists and is in use, it is something that can already technically be done. The cellular component to further increase tracking for longer ranges is also a good feature to have. Some drawbacks to this design include a concern with potentially adding bulkiness to the device, as it was proposed to extend the battery modules in order to fit the tracking device. Additionally, it was proposed to have the chip run on a separate battery so that it can function even if the main device runs out of power. While this is a practical idea from the point of view of being able to find the device easier if it was lost, there are some drawbacks with either needing to replace the battery if it is not rechargeable or needing to charge it separately, which may take up more time and/or effort. The second concept of the necklace would offer more comfort and durability, as it would be something that would sit on the neck and redesigning the device would allow us to protect it with more durable and waterproof materials. The redesigning can also allow for a larger battery, which can increase the battery life of the device, improving upon the already existing battery. However, depending on how the design is made, it may not offer the amount of discreteness that the client desires from the product. There was also no proposal for a better tracking device, however this is not a big issue as that could be easily implemented and the design lessens the likelihood that the device would be lost in the first place. The final concept proposed by Nicholas is to redesign the device into a pair of glasses. This would contribute to making the device more discreet, as glasses are something that many people have and would appear inconspicuous from an outsider's point of view. It can also be practical from other viewpoints as they can double as prescription glasses, if the need arose, or as blue light blocking glasses. Bose already has something like this on the market, which proves that this could be possible. Some issues with this design could be added bulkiness, as it must incorporate all of the current existing hearing device components, which could be difficult to design into something that is light and comfortable. Overall, Nicholas' concepts are very creative and all have features that we could pull from into our final design.

Team Member E: Evan Schonfeldt

Concept 1: A Special Casing

This product would be a soft casing which would be molded to her device so that it fits tightly and perfectly over the device. There would be a very thin, completely waterproof skin as the interior layer of the case. The exterior case would be made of a rubbery material which would resist plastic deformation (possibly made from the same material as earbud sleeves such as silicon or rubber for example) and finished so that the exterior is soft, and custom fit to her

ear/head. The silicon exterior would be made with honeycomb shaped structures between two thin layers of the material to help with resistance to shock. The connection points between device parts would have waterproof seals and silicon folds/custom molding to help hold the pieces in place. This product is meant to be placed onto the device and remain on until it needs to be replaced or is no longer necessary.

Concept 2 A Tracking Wire and Application

The product consists of a thin wire shaped object which is secured to the device using a clear tape like patch that is water resistant and uses water resistant adhesive. The wire would send out a tracking signal which could be tracked with a custom phone application that is more accurate than the current application being used. The application would also be able to direct the client to where the device is as opposed to saying whether or not they have gone in the right direction once they have already done it. The device would constantly (and automatically) be synching to the application to avoid any confusion. The power source for the wire would be drawn from the device battery itself ensuring that as long as the device was charged, the wire would be too.

Concept 3 Replacement Body

This product replaces the plastic exterior of Freyja's existing device. The exterior would be made from a more waterproof material and would be custom made to not only replicate the existing device shape but fit her ear and head better. This would eliminate any excess bulk and would help conceal the device as it could be molded to conform to her head and ear. A chip would be inserted into the layers of the case to send out a tracking signal which could be connected and tracked via phone application already on the market. The gaps in the casing would be filled with completely waterproof but openable seals. The connection points of the device would have ports where the other device part casings would screw into place helping to keep the device together.

Analysis (Connection to Design Criteria and Target Specifications):

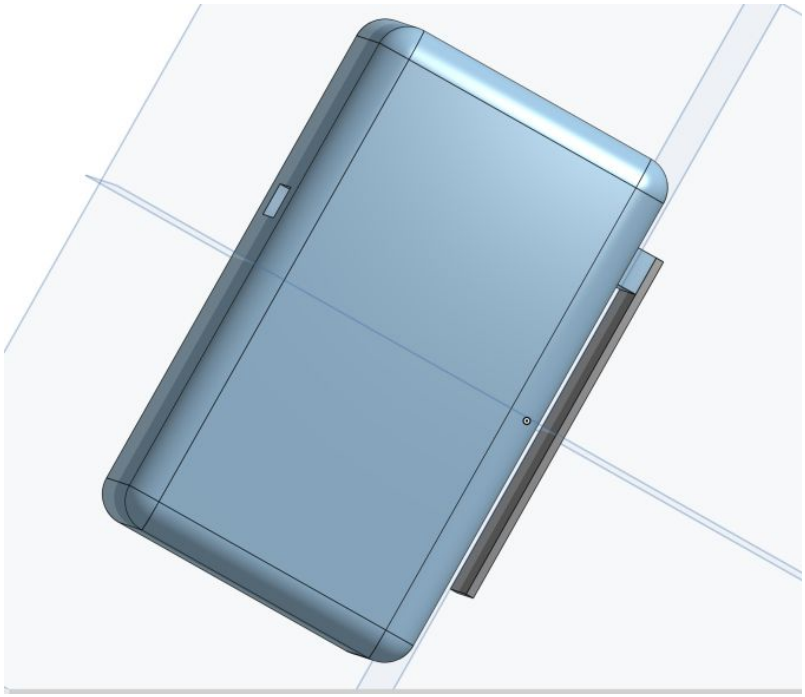
Evan's concepts do an effective job at satisfying some of the pressing design criteria which have been established to design a better product for the client. To begin, concept 1, which is a case, is very promising as it features the product being waterproof which is a heavily weighted design criteria. Furthermore, the material of the proposed case will be that of something similar to the gel tips in earphones (probably silicone) so as to resist physical abuse like biting which Freyja has already been seen to do. To make the device able to withstand large drops, the exterior of the case would have a honeycomb structure for added support. Lastly, the case satisfies the need for a more comfortable product as it will be molded to Freyja's current sound processor. However, it is important to note that this design concept does not attempt to solve the issue of inaccurate tracking of the device.

Evan's concept 2 aims at solving the problem of inaccurate tracking of the sound processor through the addition of a thin wire shaped bluetooth receiver with a range and accuracy far superior than the current method of tracking. It would be attached to the sound processor by a water proof tape, therefore making the receiver waterproof. Tracking the sound processor is very important as it is a significantly expensive device, and this design concept does a great job at solving this problem assuming the technology is available. However, this design concept falls short when it comes to addressing any of the other design criteria.

Evan's concept 3 proposes retrofitting Freyja's current sound processor so as to make it waterproof, more comfortable and have more accurate tracking. The internals of the N7 would be placed in a new case which is waterproof. In addition, similar to the first concept the new body of the device would be molded to the user' ear and head making it more comfortable. Moreover, a tracking chip, which offers greater range and accuracy, could be added to the new casing. Lastly, this design also includes all the components of the product being fastened together so as to avoid losing small individual parts. This is one of the more promising design concepts proposed in this report with it just falling short when it comes to the durability of the product as no improvements are described in regards to this design criteria.

4 The Chosen Concept (Solution)

The design that we chose to go with, based on feedback from the customer and our own concept analysis, is a small, hard case into which we will fit the components of the device. The customer gave positive feedback to both final concepts that we presented to them, so our final design incorporates elements from both ideas. The case itself will be made out of a hard, durable material, with a childproof lock to prevent Freyja from easily accessing it. The case will be lined with a waterproof material to protect the device from water damage even if it were to become submerged in water. It will feature a clip that will allow the device to be clipped on to her clothing or an accessory, preventing easy loss and contributing to discreteness and comfort. The clip will be strong enough to allow mobility without causing discomfort or fear of it coming off at any point. It will also feature a tracking chip that can connect to an existing application, allowing for more accurate tracking should the device get lost. It can also allow for a soft material (such as silicone) casing to be added, which can allow for customization of the aesthetic and possibly contributing further to making the device look inconspicuous on Freyja's body.



5 Solution Analysis

This design combines some of the most prominent concepts that have been discussed in our concept generation. Redesigning the casing was a recurring theme in our concepts, as the device is now, it is not protected from physical damage or water, and it is bulky. The customer also expressed a need for better tracking of the device, and as such, solutions for this problem were also heavily present in our individual concepts. Our solution to the current problem provided to us fits the desired design criteria in several ways. Our solution consists of an external case that holds the original Nucleus 7 device in place and allows for improvements and features that would not yet be possible without the case. The features that it satisfies are waterproofing, durability/physical damage resistance, childproofing, better bluetooth range, and better mobility and discreteness for the user. The customer stressed that those were some of the most important features of the design. However, it does not come without its concerns. Depending on the material we use, the final product may turn out to be heavier than expected, which will take away from the comfort and discreteness aspect of the design. Another important concern is the length of the wire of the device that will be made available to us. If it is too short, it may limit where the device can be placed on the body to the back of the shirt, a hat or a headband. Overall, our design combines our individual concepts in a way that maximizes the needs it is able to meet and satisfactory to the customer.

6 Feasibility

During our concept analysis we chose designs that were the most feasible. When considering our final design concept however, we realized there are still quite a few risks and uncertainties associated with various features. Most can be handled with careful planning and strategy. A point form list of possible risks and uncertainties has been included below. Following this list, there is a description of how each risk will affect our planning and design according to the TELOS method of feasibility analysis and how we intend to minimize it.

Risks:

- If we don't make it completely waterproof then it could damage the device.
- Our product interferes with the device which would impact Freyja and become useless.
- The material we wish to use (which will have all of the features we need it to) will not be available to us.
- We will need to order products which may take longer than expected due to Covid-19.

Uncertainties:

- How well will the device pick up sound in the case?
- How will we adjust our product to ensure proper sound quality should it be poor?
- We are unsure of what material best suits the needs of the client at this time as there are pros and cons to a variety.
- How will the product hold up in inclimate weather (very cold weather for instance)?
- Do they have a cable long enough to make our product useful for Freyja?
- How will we know if the device is working properly for Freyja?
- How will we get to see her interact with the product and if we can not accomplish interaction, how do we know what works and what does not?

Technical: Our product is technically quite simple, yet there are multiple parts of the design that need to be integrated to make the whole product function as intended. This being said, it is quite possible to implement all of the necessary features into a compact and lightweight design. To begin, the tracking technology can be implemented by adding a third-party Bluetooth or GPS tracking chip into the free space of the case. The chip would therefore come with an existing app that is capable of accurately tracking the case. This would mean that the client would have two forms of tracking software available, the one provided by Cochlear, and the one that comes with our case design. The cable would also need to be considered, because the length of it will determine where the device would be clipped and secured in place. The case itself would be relatively simple to produce, as there are many lightweight, cheap plastic materials that are durable and waterproof making them viable candidates for the case. There is also the possibility of 3D printing the exterior of the case which would make production even simpler. The most crucial aspect of the design is keeping it waterproof yet allowing sound to pass through, which may be

achieved using waterproof membranes at points on the case where the microphone from the N7 may be situated. This may be difficult but is possible if the membrane can be attached securely.

Economic-

Our product features relatively low technology, low manufacturing cost to begin with as it is a simple shape and design without many intricate features. The most pressing economic feasibility issue to be concerned with is the cost of the materials. Using good quality materials is important as this will make a large impact on how durable and waterproof the device can be made. As these are the main goals with this product, it is imperative we choose the proper materials to ensure the best quality that we can produce and have the product fulfill its purpose. It is also important to choose the proper materials in order to ensure safety to Freyja's device as it is expensive and a key piece of her life. These materials can quickly become expensive and increasingly so with the more testing we wish to do. Luckily, we have been able to find some high quality materials for relatively low prices in bulk that offer the opportunity for a free sample before ordering. As an alternative, we have been researching some less expensive options. Technology associated with bluetooth and tracking features of our product can also become expensive quickly. We have been researching and benchmarking existing tracking devices and have incorporated this into our planning with different alternatives. As we are designing this case to be a permanent solution instead of a product that would need to be constantly replaced, the cost of manufacturing is relatively low compared to the sleeves that she currently uses. We are hoping to secure some exterior funding or assistance from third parties which we have connected with to supplement our project budget.

Legal

Our product would be constructing a protective case to hold a current cochlear device being the Nucleus 7. Upon the research for this topic it has been discovered that a very similar device made and produced by Cochlear already exists meeting some of the requirements that the functionality of our case would provide, which is currently patented by Cochlear as of July. However, this is just for the pieces for the inside of the regular N7 reformatted, so making an external case that puts the original N7 in it would not be an issue as there were no patents for this online that could be found. For the device's warranty, it was found that in the user guide they state that any modifications made to the device would void the warranty and resolve Cochlear of any damage to the device. It is also found that using any external devices that were not originally compatible with the Cochlear device family, would also render this warranty useless. Luckily this problem can be dealt with, since we are not making any internal or external modifications to the device itself we would not have to worry about it. As for the compatibility devices we would however have to contact Cochlear to have them approve us to make a compatible device to ensure that if anything were to happen to the device, due to an error made by our case that Freyja's family would not be liable or have to worry about getting the device fixed.

Operational-

Analyzing the chosen design concept through operational viewpoint truly illustrates the benefits of the design. The solution of developing a portable waterproof Nucleus 7 case which locks is brilliant in that it requires nothing overly complex. Similar to most modern truly wireless earphones, our plan is to construct a durable plastic case which, inside of the main body, has a mould of the N7 device for insertion. Connected to the main body of the case via a hinge will be the cap of the case. It is important to note that o-rings will be attached to the portion of the body and cap which come into contact when the case is fully closed so as to not let any water in. In addition to this, once closed, there will be a child proof

locking mechanism to hinder [redacted] from removing the sound processor from the case. Furthermore, the cap of the case will be grated so as to let sound enter the top of the case where the two microphones of the Nucleus 7 will be located. In order to make this waterproof, a water impermeable membrane layer will coat the inside portion of the cap. Moreover, as a means of addressing the inefficient tracking method currently offered by Cochlear, an external bluetooth tracking device will be added to the case as they are relatively cheap, small and offer much more accurate tracking. The case size could easily be altered to make space for this bluetooth device and there are numerous free mobile apps which can track any bluetooth device well. Lastly, the most challenging portion of this design will be to replace the magnet coil with a longer option while also not allowing the section where it needs to connect to the sound processor to compromise the case with openings for water. A solution to this will most likely be similar to that for the microphones where a water impermeable membrane will line the connection point.

Schedule

The scheduling of this project is entirely possible, and is solely dependent on our team to have it finished on time. The project deliverables that are to be submitted each by a certain date for a grade are a skeleton schedule to keep us on track with the project. We have already had restrictions and delays upon our original meetings but this should not be an issue for us as currently, the team is fully back on schedule according to the GNG 2101 process. Upon the making of this device all that is left for us to do is design prototypes and respond to customer feedback. With 3 months left in this course it should be entirely possible, the only consideration that might delay us is being able to have the product made and testing materials, as this requires us to be present and could potentially be an issue if the current pandemic situation continues to falter. We have been given a reasonable timeframe to complete this project and we must put our organizational and time management skills to good use to make sure we meet all our deadlines.

7 Conclusions and Outlook for the Future

In summary, twelve design concepts were generated by our team, with every proposal attempting to solve some or all of our client's needs. These concepts were described in detail and judged using the design criteria established in deliverable B. While most designs were promising, it was unanimously agreed upon that the best proposal to pursue would be that of a waterproof case for the Nucleus 7 which also locks so Freyja is unable to access it, thus protecting it from any of the common abuse children inflict on everyday items. Following this further, many group members proposed the use of a bluetooth tracking device which is more accurate than what is currently used by the N7 and it was decided that this should be added to previously mentioned case concept. After the design concept was pitched to the client and they approved the idea, a feasibility study was performed on the design concept which the team would like to pursue. This study showcased how the task of bringing this product to reality is not insurmountable in any way.