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IGNIS – Fire Safety Device for D/deaf Individuals

By

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IGNIS





TAbstract:

‘Ignis’ is a personal fire-safety device for Deaf and hard of hearing individuals that detects active nearby fire/smoke alarms and alerts the user through visual and sensory components. D/deaf people are at an increased risk during a fire; cultural issues including lack of education increase this risk. Furthermore, existing products on the market cannot effectively protect those who travel with profound hearing loss, as most systems are designed for a single location.

Ignis uses a bandpass filter to isolate the approximate frequencies of British fire/smoke alarms above a specific decibel level. The device responds to these frequencies immediately and continues throughout the alarm’s duration; this alerts the user by flashing and vibrating using high intensity LEDs and a vibration motor, in an identical pattern to the fire/smoke alarm’s tone.

A detailed design process was used to reach the final design. This report covers the progression from a technical concept to a final design and prototype, including iterative research, concept design, CAD, and test rigging.

Acknowledgements:

I am incredibly grateful for the following individuals for their advice, support, and guidance throughout this final year project.

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Chapter One – Introduction and Context

1.1 Background and Problem:

This project aims to provide a solution and address the cultural issues that surrounds a lack of affordable and effective fire-safety precautions for deaf and hard-of-hearing (D/deaf) individuals in the United Kingdom.

Statistics (2021/22) show there are over twelve million people living with ‘greater hearing loss’ making it the second most common disability in the UK. Despite this, it’s considered that fire safety overlooked among D/deaf individuals as “they do not receive the same media, educational, or industry attention as the hearing population” (Preventionweb, 1999).

Whilst fire-safety regulations have improved in recent years, alongside the introduction of BS-EN54-23:2010 and later regulations (i.e. The Fire Safety (England) Regulations 2022, Building Safety Act 2022 and extended guidance on the 1st Oct 2023), there remains a lack of “effective” and “suitable” alarming devices that suit a range of situations for vulnerable groups (S2 Fire Solutions, 2017).

1.2 Market:

The D/deaf population in the UK that are “profoundly hard of hearing” is approximately 900,000 (Hearing Link, 2024). Assuming an obtainable market size is between 3-5% of the total market size; this would be 27,000-45,000 individuals per year. Following research, however, it’s apparent D/deaf communities are closely-knit and rely less on media, which is likely to influence sales.

Across the UK, 188,000 people use British sign language (BSL). Of this submarket, 65% of individuals are unable to speak; a large percentage also cannot read (Wilson, MW et al. 2019) which is a contributing reason for small communities.

The D/deaf population also has a high percentage of individuals with ‘secondary’ conditions, including ASD and ADHD (National Deaf Children’s Society, 2024S). Additionally, D/deaf adults frequently have a lower income than average due to a reduced employment rate (65%) (Hearing Link, 2024).

Nonetheless, there is a record of “unsatisfactory” medical attention for D/deaf individuals in the United Kingdom. The proportion of audiologists to members of the public is 1 per 16,805 people; with an NHS project demonstrating that a further 1700 audiologists would be required (Hear4U,2024).

As many as 6.3% of adults aged over 70 have severe hearing loss (Hear4U, 2024). As the UK’s population is aging, it’s predicted that the population over the age of 80 will double over the next 10 years (Centre for Aging Better, 2023), increasing the D/deaf population.

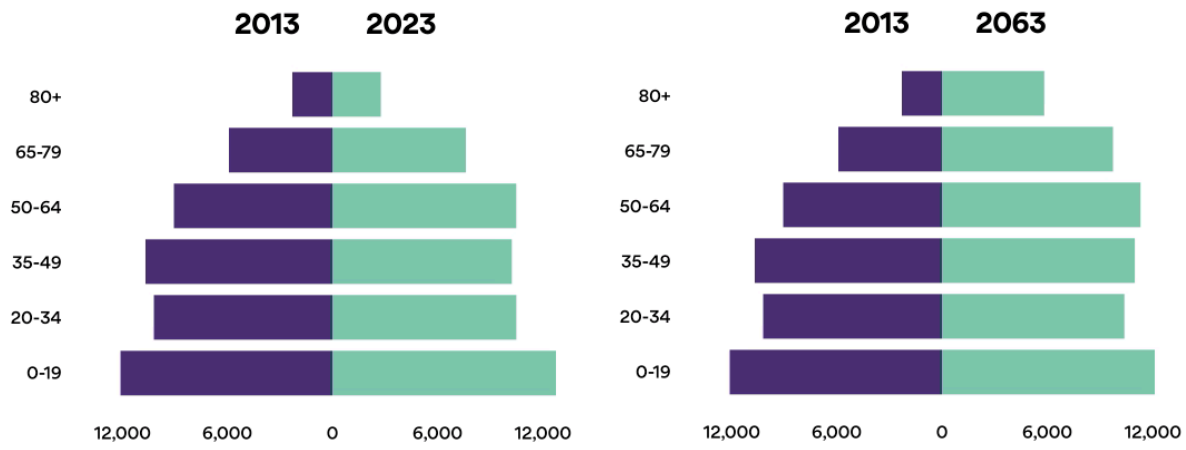


Figure 1 - Population statistics (Centre for Aging Better, 2023)

Whilst the D/deaf population is commonly associated with being elderly, a large proportion of the working population also have hearing loss. This demographic is already “marginalised” (Green, W.S; Jordan, P.W., 1999); which is likely to worsen as the population ages.

1.3 Existing Products/Methods:

To avoid discriminating against disabled people, regulation BS-EN54-23:2010 requires compliant visual alarming devices (VADs) to be installed in public buildings where D/deaf people are “likely” to be alone (S2 Fire Solutions, 2017). There are still associated risks with these devices, however.

According to the FIA, existing products, such as pagers and vibrating pads can be used in place of a VAD. Building regulations (ADB) state that “areas where persons with impaired hearing are likely to be on their own, ‘pagers’ are more appropriate” (S2 Fire Solutions, 2017). There are also known issues with these devices, however, such as their convenience for travel.

Alternatively, methods such as the ‘buddy system’/PEEPs are used. Whilst they mitigate the risk of injury, they’re also reliant on circumstance; the ‘buddy’ is assumed to always be nearby and PEEPs doesn’t necessarily consider the measures needed to alert the person (Alerter Group, N.D).

Existing “specialised detection and alarm devices” on the market are “prohibitively expensive”, with a “dearth of information” on how to obtain them (Preventionweb, 1999). As a result, smartphone applications are a popular alternative to assistive devices (RNID, 2014). Despite this, further research revealed examples of software issues with ‘sound recognition’ on smart devices (Apple Community, 2020).

Further research revealed popular brands of vibrating bed alarm are frequently referenced amongst D/deaf communities; however, they are not portable and are primarily designed for home use. Although vibrating alarms are often necessary, the market is antiquated; with popular designs remaining unchanged for years.

Hearing aids, however, have changed significantly over recent years. The appearance and quality of these products are exceptional and follow modern trends, providing colour options, custom ear moulding, ITE/ITC devices, and smart device connectivity (Help in Hearing, 2016; Hear4U, 2023; RNID, N.D.; Hearingaid, 2024), inspiring the design of Ignis.



Figure 2 - Phonak Virto P-Titanium (Preston Hearing Centre, 2024)

During the proposal stage, a product matrix (figure 4) was used to find common/desirable features amongst competitor products. Additionally, a 'SWOT' analysis was conducted to understand the advantages/disadvantages of existing products (Appendix A).

No.	Features/Function \ Make and model	Deafgard	Roger Pen	Phonak PartnerMic	Auzen Line Excellence	Phonak Virto P-titanium	Phonak Audeo Paradise	Vibratime	Apple watch (Series 9)	Dorgard	Safe Awake	FixFire Pager system	Hush-Pro 92dB(A) Base Sounder	%
1	Detects sound frequency	x	x	x	x	x	x			x	x			67.00%
2	Activates based on frequency	x								x	x			25.00%
3	Alerts user (Fire/Smoke Alarm)	x			x	x	x	x	x		x	x	x	67.00%
4	Improves hearing		x	x	x	x	x							42.00%
5	Emits an audible tone				x	x	x				x	x	x	50.00%
6	Wearable technology				x	x	x	x	x			x		50.00%
7	Connects/"listens" to fire/smoke alarms directly	x							x	x	x	x	x	50.00%
8	Subtle/discreet		x			x		x						25.00%
9	Portable		x	x	x	x	x	x	x					58.00%
10	In constant use	x								x	x	x	x	42.00%
11	Sustainable/E-F design		x	x		x	x		x					42.00%
12	Quick Set-up/installation	x	x	x				x	x	x	x			58.00%
13	Personalised				x	x	x					x		33.00%
14	Repair/maintenance/return policy		x	x	x	x	x		x			x	x	67.00%
15	Warranty exceeding 2 years				x									8.00%
16	Designed for outside (& inside) use				x	x	x	x	x					42.00%
17	Designed for individual use	x			x	x	x	x	x		x			58.00%
18	No product 'tying'	x			x	x	x	x		x	x			58.00%
19	Inexpensive							x		x				17.00%

Figure 3 – Competitor Matrix (Author 2023)

1.4 Technical Challenges:

To compete with the existing products on the market, Ignis has been designed with BS-EN54-23:2010 as close guidance. As a result, the product is required to use red LEDs, capable of generating 0.4lux in an ambient light of 800lux.

Secondary research showed that existing products typically rely on visual and/or tactile methods of alerting the user. The product is required to have a vibration motor with an intensity strong enough to be felt through the casing of the device.

Fire alarms in the United Kingdom don't have a universal, regulated tone and frequency, making identifying an alarm challenging. Many of the frequencies for fire-alarms are between 800-970Hz or 2400-2800Hz, identifying this is also necessary (Eaton, N.D).

Ignis is also required to detect a fire/smoke alarm from a suitable distance. Research indicates that two detectors should be no further than 7.5-10m apart from one another (FireAngel, 2020; Channel, N.D). An average fire alarm is also required to produce a sound at 85 decibels from 3 meters (GOV.UK, 2012); the inverse square

law (University of Manchester, N.D.) shows a device capable of detecting a sound over 70dB is suitable.

Distance (m)	Sound Pressure Level
0	94.542dB
1	94.542dB (negligible)
2	88.542dB
3	85.542dB
4	83.042dB
5	81.042dB
6	79.342dB
7	77.842dB
8	76.442dB
9	75.142dB
10	73.942dB
11	72.792dB
12	71.692dB
13	70.642dB
14	69.642dB
15	68.692dB
16	67.792dB
17	66.942dB
18	66.142dB
19	65.392dB
20	64.692dB

Figure 4 - Inverse Square Law (Author 2023)

1.5 Humanistic Challenges:

As a result of D/deaf individuals being a vulnerable group, its important the following were addressed during the design process:

- Inclusive design
- Intuitive design
- Affordable design
- Long-lasting design
- Sustainable design

Initially, the inclusive design of Ignis was inspired by ‘Human Factors in Product Design’ by William S. Green and Patrick W. Jordan (1999). The author Roger Coleman, states “disability is the result of a mismatch between people and their surroundings”. Ignis aims to provide equal opportunities for the D/deaf community, reducing their dependence on public VADs.

The author also comments on designing for Deaf individuals to benefit those who are hard-of-hearing. Equally, Ignis considers the needs of ‘Deafblind’ people to improve the product’s functionality.

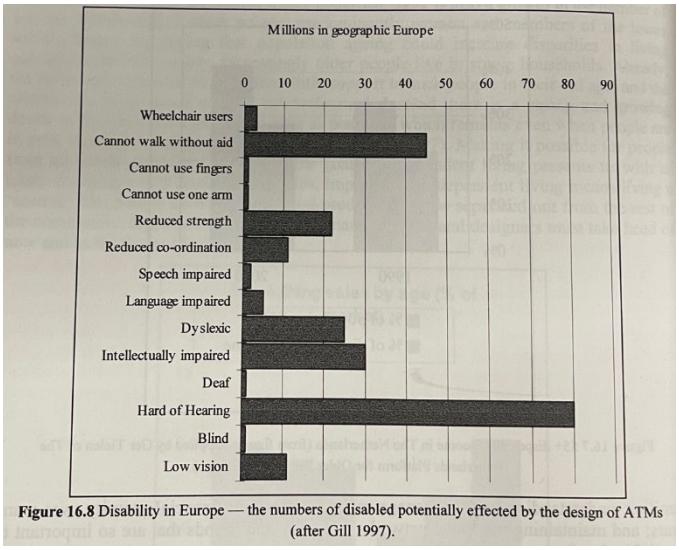


Figure 16.8 Disability in Europe — the numbers of disabled potentially effected by the design of ATMs (after Gill 1997).

Figure 5- Disability in Europe (Green, W.S; Jordan, P.W., 1999)

Patrick W. Jordan also reflects on the misconception that disabilities are “confined” to the elderly. The author states that young adults with disabilities are an “unattractive target group” as they are “marginal and provide little commercial benefit”. Despite this, inclusive design should be practiced; Ignis also aims to be attractive for younger demographics.

Jordan also states that products are often designed for disabled people with a medical or clinical aesthetic (Mullick and Steinfieldcited by Jordan,1999). As a result,

how the product communicates the user's disability was a key consideration for the project.

1.6 Sustainability Goals:

The following sustainability goals are central to 'Ignis' (Figure 6):

- Good health and well-being – Ignis aims to promote good health and well-being in vulnerable communities by alerting them to a potential fire.
- Quality education – Ignis aims to highlight the importance of fire-safety for D/deaf individuals.
- Sustainability cities and communities – By providing a personal fire-safety device, a D/deaf person can become less reliant on existing infrastructure.

Responsible consumption and production – The product has been designed as a permanent assistive device, without the need to be replaced. Ignis will use recyclable materials (i.e. Aluminium/ABS) and follow the WEEE directive. The BS8887 (MADE) directive has also been considered.



Figure 6 - UN Sustainability Goals (United Nations, 2023)

1.7 Solution:

Ignis (Figure 7) is a personal fire-safety device that encourages D/deaf individuals to gain independence when travelling alone. The product can identify the audio characteristics of a fire/smoke alarm and alerts the user through visual and tactile components.

Following British standard BSEN54-23:2010, Ignis has been designed to detect any fire/smoke alarm up to 13 meters away; with visual and tactile elements tested to ensure the device alerts the user.

Throughout concept generation and detail design, ergonomic and usability features have been considered to ensure the device is convenient. As such, Ignis is intended to travel with the user at all times.

This product also strives to challenge stigmas associated with products for elderly/vulnerable groups, using high-quality materials and a colourful design. Ignis has also been designed without obsolescence in mind; the analogue circuit doesn't require updates or 'down-time'.



Figure 7 – Product Render (Author, 2024)

1.8 – Intellectual Property Rights

Trademarks -

UK trademarks are supported by the Trademark Act (1994); however, EU trademarks must be registered separately if necessary. It is recommended, due to cost that a UK trademark is registered first (Appendix B). Although the trademark name ‘Ignis’ passes absolute grounds, recommendation suggests changing the name and logo. This is due to existing trademarks having similar aural and visual aspects within classes 9 and 10.

IGNIS

Figure 8 – Name/Logo (Author 2024)

IGNIS

Figure 9 – Competitor Brand (Appendix B)

Patents -

Although Ignis makes use of “old technology”, existing products on the market are sufficiently different. As such, Ignis is considered a novel invention. Subsequently, it is important to not disclose information, unless under a contractual agreement.

Following advice suggests, Ignis is also likely to pass “inventiveness” and industrial application. It’s also suggested that obtaining a trade secret would be ideal, avoiding the patent fees. Alternatively, charities may sponsor the product to obtain a patent.

Chapter Two – The Design Process

2.1 Overview

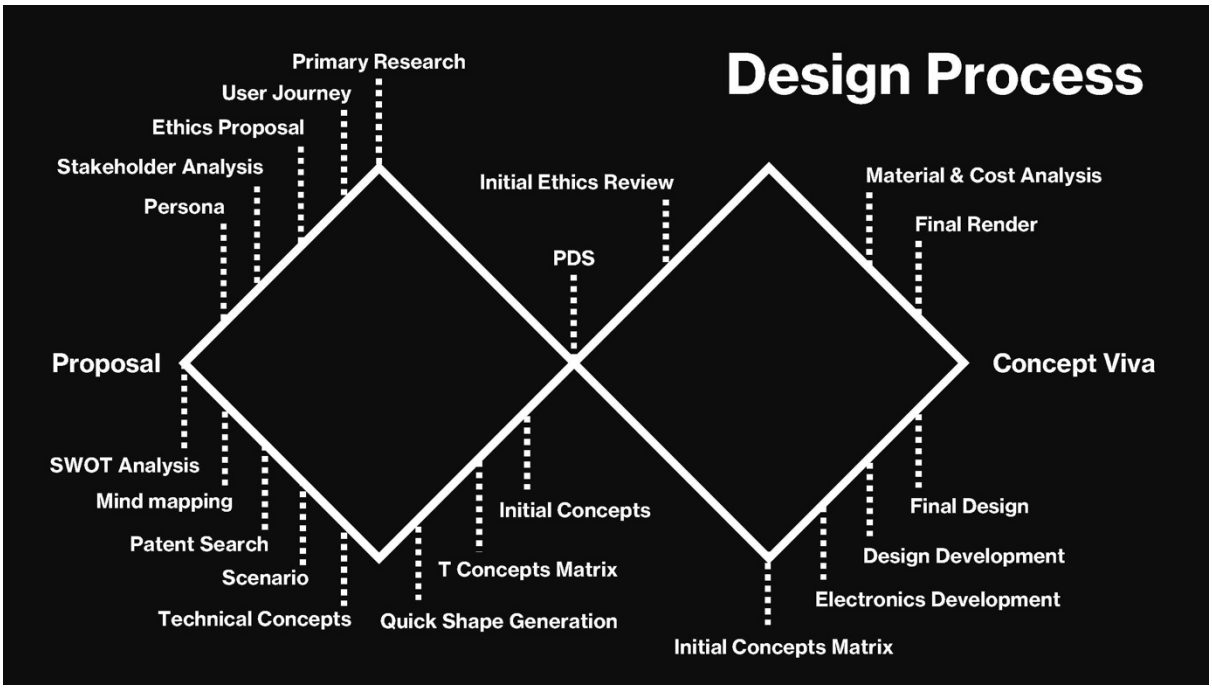


Figure 10 - Double Diamond (Design Council, N.D.)

This project took inspiration from the ‘Double Diamond’ design process (Design Council, N.D.); following the stages: ‘discover’, ‘define’, ‘develop’ and ‘deliver’. As a

result, the first stages of the project involved exploring the context and design problem through empathising with the target market.

As the project progressed, the design process was broken down into a Gantt chart (Appendix C) which highlighted aspects of the project that required further work. The design of Ignis was an iterative process, with new research into inclusive design, existing products, technical concepts, et cetera., altering concept generation/detailed design. As such, this time-plan changed as the project progressed.

All work, including research and concept generation/development was also recorded in a logbook with references, which has been valuable. As the project progressed, the ability to refer to previous data/technical concepts was often necessary.

During concept generation/development, CAD software was used to develop technical concepts, with iterations being stored in organised folders. This was key to visualising concept generations.

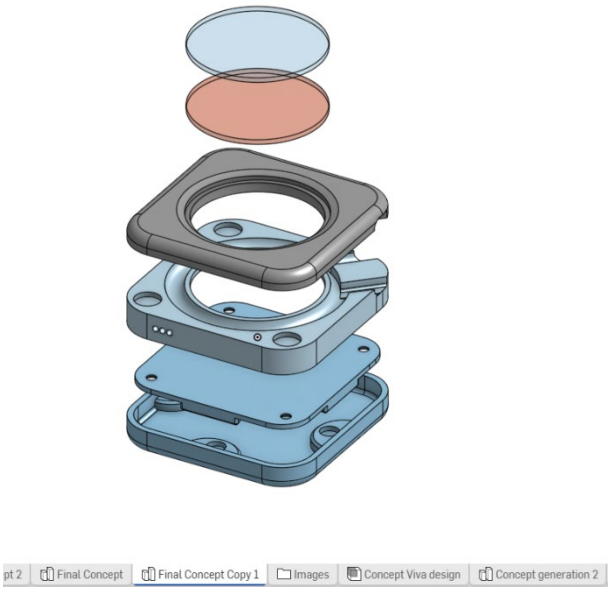


Figure 11 - Onshape Concepts (Author 2023)

2.2 Secondary Research:

Following research into the market/context during the proposal stage, further secondary research was required to gain a deeper understanding of the target market and the problem. At this stage, research gave insight into a wide variety of topics, including hearing loops/aids, funding for D/deaf individuals, healthcare, British standards, fire/smoke alarms and technical feasibility.

Following a set of technical concepts, it was realised that an electronic device would be the most effective method of alerting a D/deaf person. Research was later conducted into various methods of identifying the sound produced by a fire/smoke alarm, including the benefits of analogue filtering over digital sampling.

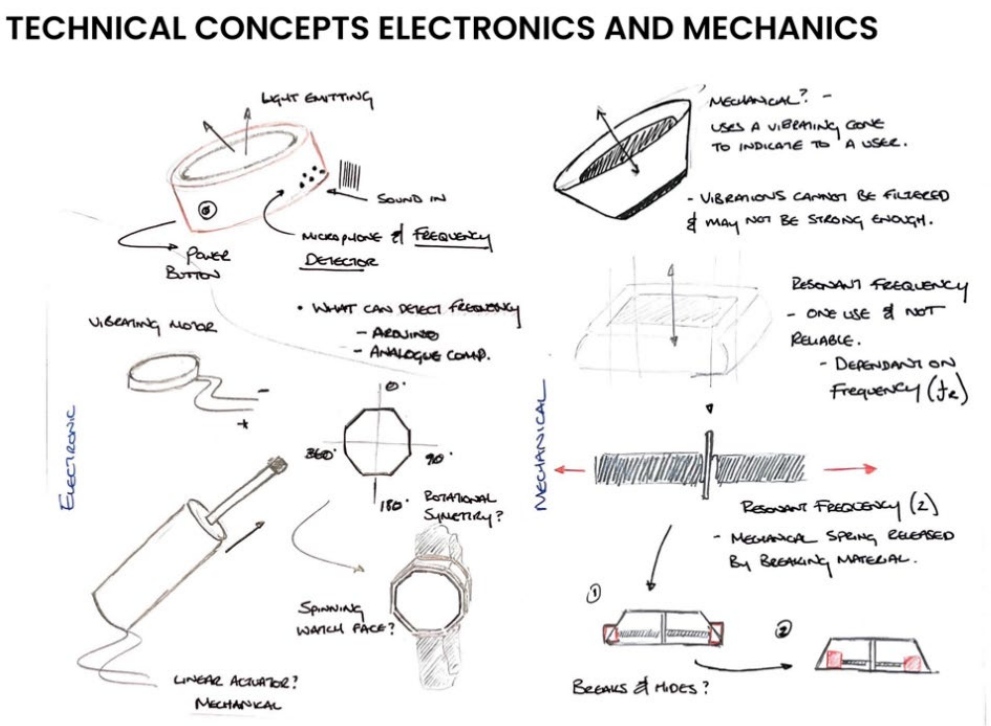


Figure 12 - Technical Concepts (Author 2023)

Following an increase of unsatisfactory VADs on the market, BS-EN53-23 was introduced to improve standards. This specification gave me an initial set of parameters to follow and led an initial PDS. This British standard also directed

further research, including the importance of colour theory in safety products and designing for marginal groups (i.e. epileptic users).

Through secondary research, it was possible to empathise with the target market; by searching online forums and support groups, it became clear how members of these communities felt isolated due to a lack of communication. D/deaf individuals frequently struggle with language as they're unable to learn phonetics at an early age; upon realising this, the "dearth" of information online became far more evident.

Secondary research continued throughout the project, giving insight into inclusive design, electronic design, design for manufacture, IP, standards, sustainability aesthetics et cetera.

2.3 Primary Research:

Following the approval of the ethics checklist and participation information/agreement forms (Appendix D), a questionnaire was produced and distributed to a local D/deaf community, alongside social-media communities to better understand their views of fire-safety (G1) (Appendix E).

Another questionnaire was created for members of a safe and well team at Dorset&Wiltshire Fire Service (G2) to understand their perspective on education and existing fire precautions for the D/deaf community. Both groups clarified that the device would be useful, despite acknowledging precautions already exist (Figure 13).

8 In your opinion, how would a portable assistive device aid the hard of hearing during everyday life?

Showing all 5 responses	
It would reduce the risk to the individual of not evacuating in a fire situation	1110588-1110570-118501683
It would support people away from their home/usual hardwired devices to evacuate should a fire occur. It may also support responsible persons under the fire safety order by providing a fire safety system to protect those especially at risk.	1110588-1110570-118507194
I can imagine that this type of device would be very empowering to an individual and would support them to and enable them to live independently. To move freely from private to domestic properties would be helpful.	1110588-1110570-118550886
freedom with the security of safety. from a children/young people's view - this would aid them to be able to participate in activities with their peers (such as sleepovers) with the additional safety mesaures to be alerted to a possible fire their hearing peers have in place. It think it would be an incrediable device	1110588-1110570-118652239
This would be an ideal solution, however, it depends on how the device is managed, does it have a British Standard or other form of best practice code, how often is it tested and maintained can without question the device be relied on to operate in all circumstances and instances, what type of fail-safe id there imbedded into the system.	1110588-1110570-118850727

Figure 13 - JISC Questionnaire (Author 2023)

Primary research also provided insight into the humanistic challenges of the project, including subtlety, appropriate pricing, use of existing products, funding, and questions regarding lifestyle. This research led to changes in the PDS (Appendix F) and concept designs.

During primary research, a ‘split-view’ regarding subtlety was found. This coincides with current trends in personalising hearing aids (Help in Hearing, 2016), where the younger generation frequently appeal to using bold colours. Ignis should build on existing trends and encourage D/deaf individuals to express themselves.

Questionnaire responses (G2) also suggested that the product should be designed for children, ultimately changing the aesthetics of a customisable ‘top casing’ and improving the product’s safety/usability features during detail design (Figures 14/15).

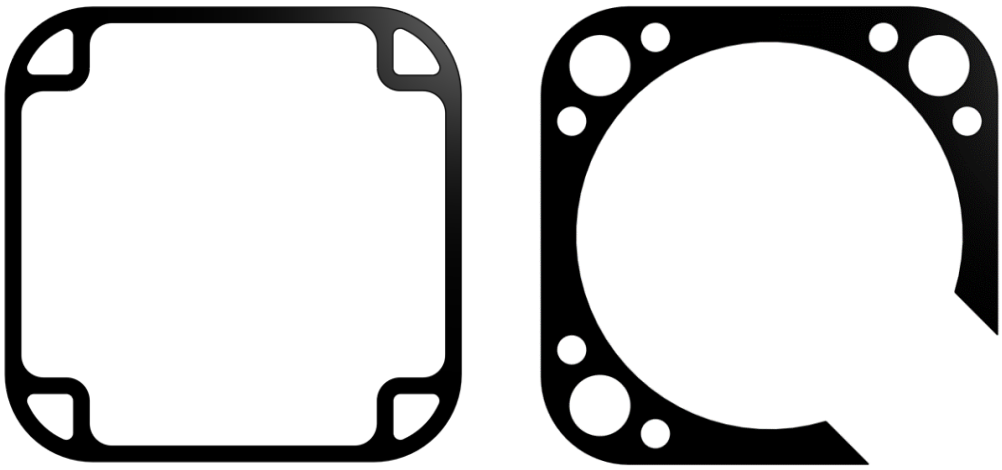


Figure 14 - Gaskets (Author, 2024)



Figure 15 – Aesthetic Design (Author 2024)

Participants also gave insight into personal experiences; of six participants, two felt their workplace didn't supply sufficient safety-provisions and training, validating a portable design. Most participants also stated they take part in activities that would make a wearable design inconvenient, changing designs during concept generation/development to include usability options.

2.4 Technical Concepts

Exploring technical concepts was necessary to widen the scope of the project before developing an idea further; it was equally important to fully understand the advantages/disadvantages of each concept.

A PDS was created following initial research, enabling technical concepts to be evaluated in a matrix analysis (Figure 16). It was considered an electronic circuit that identifies sound patterns or frequency would be the most technically feasible. Despite this, a wide range of technical concepts were generated (Appendix G).

Although this narrowed the variety of initial concepts, it ensured a reliable/feasible scope for the upcoming project.

	Electrical	Light emitting	Mechanical	Vibrations	Resonant Frequency (F0)	Electrical and Mechanical	Actuator	Vibrating Motor	LED & Actuator/Vibration Mot	Limited (physical) interaction	Motion sensor	Auto-turn off	Recharging/Powering	Mains power	Battery Power
Market															
1.1 - Market size		x					x	x	x		x	x		x	x
1.2 - Inclusive market							x	x	x		x	x		x	x
1.2.2/1.7 - Low income		x						x	x			x			x
1.2.3 - Inuitive UI for BSL users		x					x	x	x		x	x		x	x
1.3 - Design for individual/personal use		x		x	x		x	x	x		x	x		x	x
1.3.1 - Design for travel (portability)		x		x	x			x	x			x			x
1.8 - Low environmental impact		x		x	x			x	x		x	x			x
1.10 - Must compete with competitors									x		x	x		x	x
Function															
1.10/2.1 - 0.4 lux is required (BS-EN)		x							x		x	x		x	x
2.1.4 - Red light emitted		x							x		x	x		x	x
2.3.1 - Sensory aspect				x			x	x	x		x			x	x
2.5 - Strapped to bag/belt if removed		x		x	x		x	x	x		x	x			x
2.10 - Low consumption (LCA)		x		x	x		x	x	x			x			x
Aesthetics															
3.2 - Product should be visible for safety		x							x		x	x			x
3.3 - Must draw the users attention							x	x	x					x	x
3.5 - Inspiration from other products		x					x	x	x			x		x	x
3.5.1 - Users may wish to hide their hearing loss				x	x		x	x	x		x				x
Ergonomics															
4.1 - Ergonomic for men and women over 20		x		x	x		x	x	x		x	x			x
4.4 - Simple mechanism to attach to user		x		x	x		x	x	x		x	x			x
4.5 - Suitable weight to carry		x		x	x		x	x	x		x	x			x
4.6 - The product must not restrict the users movement		x		x	x		x	x	x		x	x			x
4.7 - Interactive elements clearly indicated and easily used		x		x	x		x	x	x					x	x
Materials, Standards & Manufacturing															
5.1 - Waterproof and UV resistant		x		x	x		x	x	x		x	x		x	x
5.3 - Should feel soft/comfortable		x		x	x		x	x	x		x	x			x
Percentage %		79		58	54		71	83	100		75	83		50	100

Figure 16 - Technical Concept Analysis (Author, 2024)

2.5 Product Design Specification

A PDS (Appendix F) was created and regularly updated, according to research, test-rigging and concept generation acting as a guide for further designs. As such, the products criteria changed according to the user's needs, which is reflected throughout the design process; many aspects of the PDS have also been removed or changed.

2.6 Persona & User Journey

A set of personas and a user journey were outlined during the initial stages of concept generation. This summarised previous research, specifically regarding lifestyle and existing products.



Figure 17 - Persona (Author, 2024)

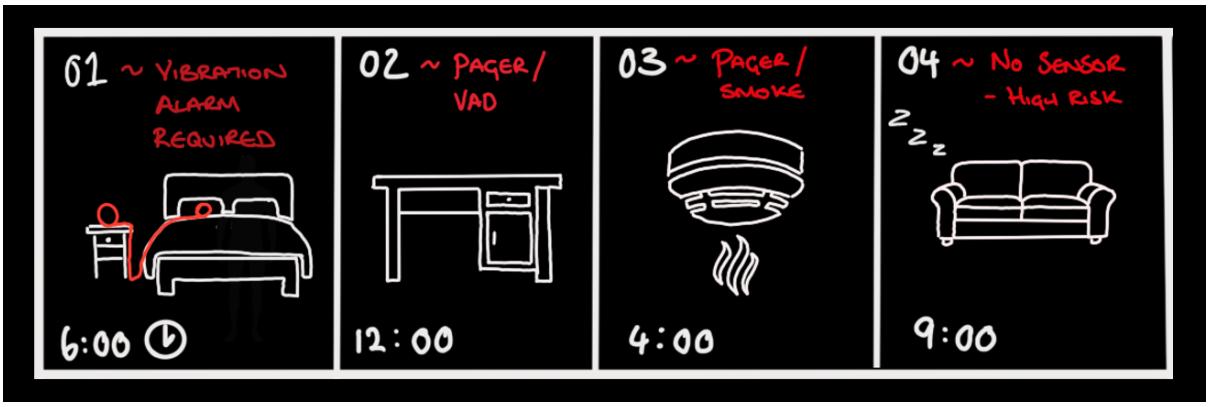


Figure 18 – User Journey (Author, 2024)

2.7 Concept Generation

At first, concept generation was quick and unprecise; each concept changed in shape, user interaction, ergonomics, and function. This allowed a broad variety of designs to be generated, whilst keeping the proposed technical concept as a common theme.

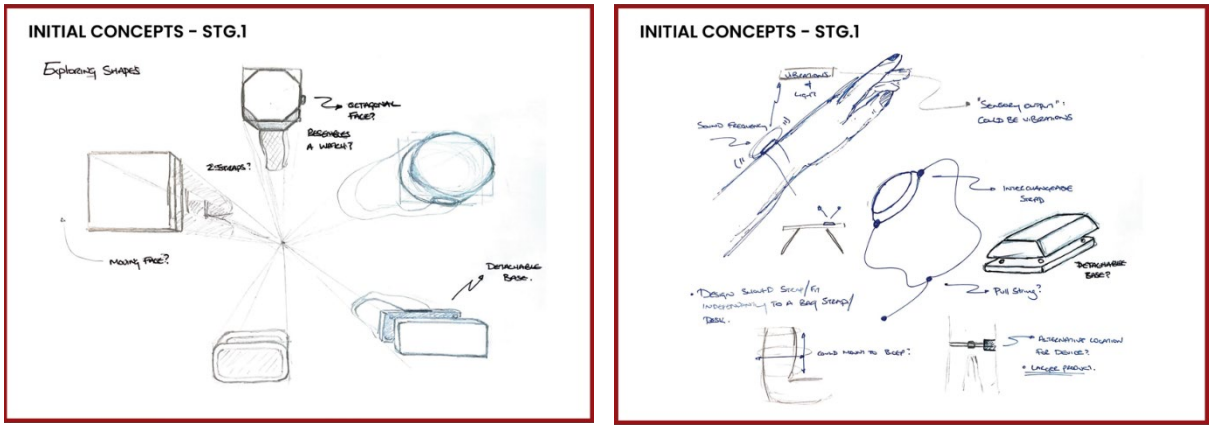


Figure 19 - Initial Concepts (Author, 2023)

Following the PDS review, a set of shape generations were created using random lines. Although this method didn't generate many concepts, considering the characteristics of shapes and what it communicated to the user was useful. Reflecting on initial concepts, the designs with sharp, geometric shapes were associated with eye-catching and unnerving, exciting design.

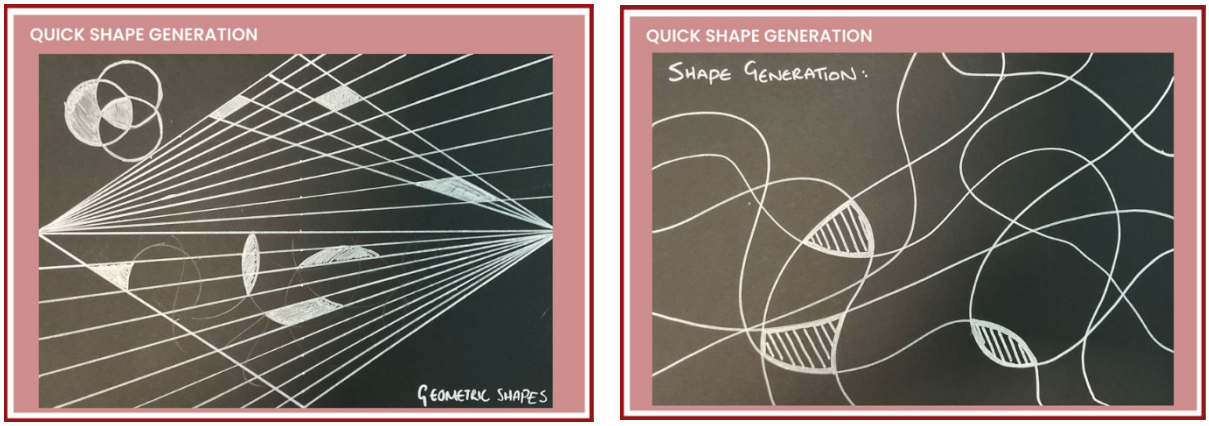


Figure 20 - Concept Shape Generation (Author, 2023)

The initial designs with rounded features felt comparatively calming, appropriate for a safety device for a vulnerable market. Following designs used soft features and leaned into user interaction, physio-pleasure, and ergonomics.

Although, the PDS specified the design should be wearable; it became apparent that the product must be versatile and convenient. As such, concept generation began to focus on desk-based/modular designs (Figure 22).

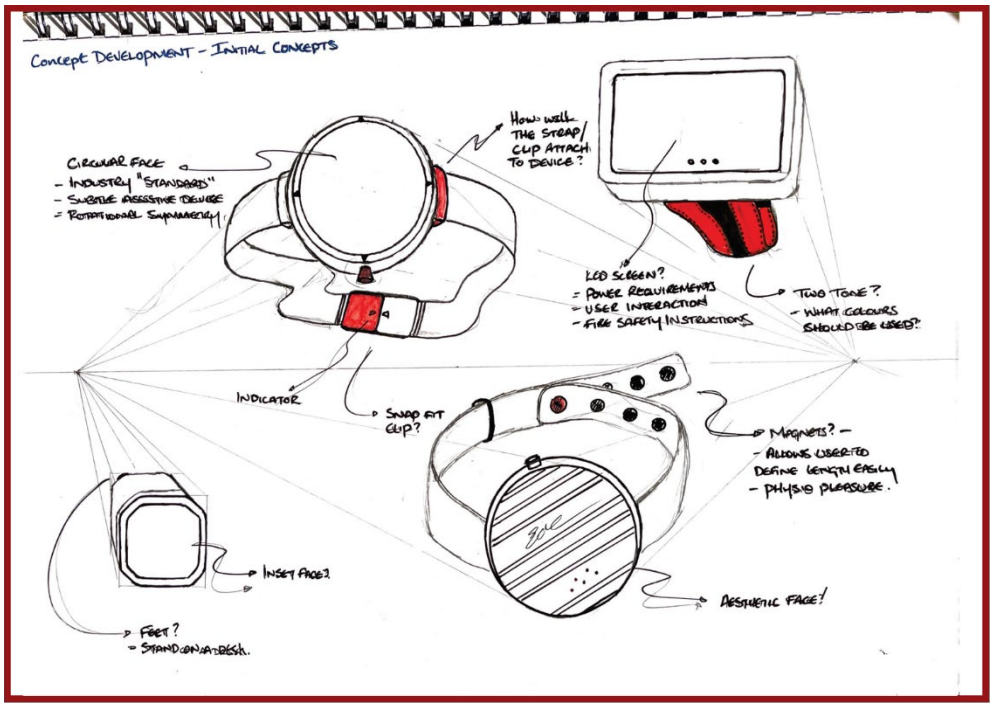


Figure 21 - Initial Concepts (Author, 2023)

As shown in Figure 23, the concepts also began to introduce colour to highlight key/unique aspects of each design. At this stage, red was the primary colour for each design, due to its association with fire and fire-safety products. Research on colour theory suggests light blue and green have connotations of safety, however, it was unknown whether the product should prioritise subtlety.

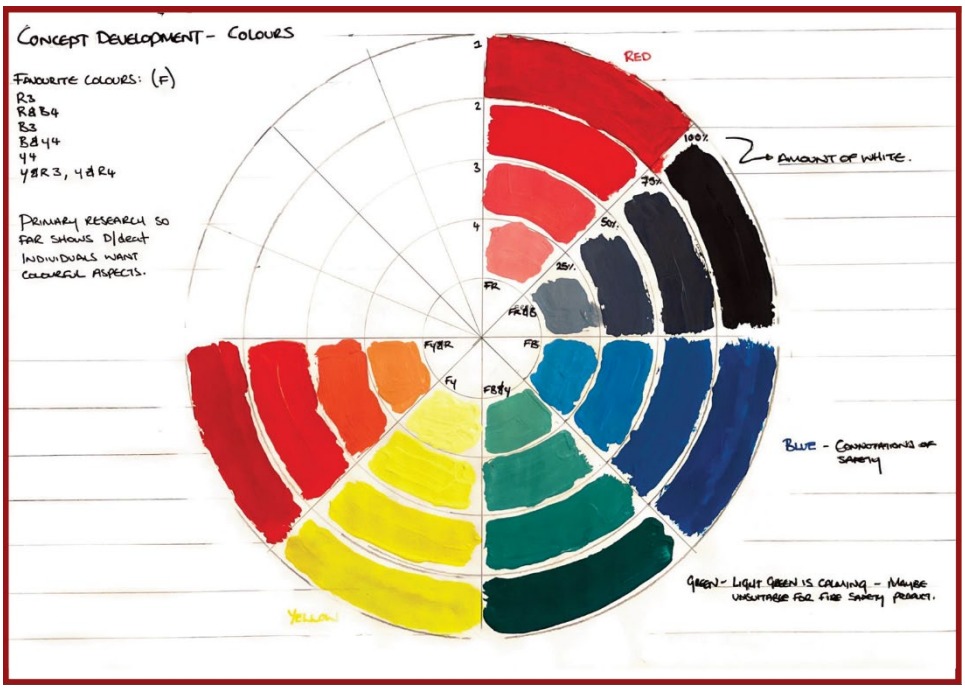


Figure 22 – Colour development (Author, 2023)

Subsequent designs were broken into the categories: inclusivity, desk-based design, and usability/ergonomic design, as shown in appendix H. To evaluate the designs, they were presented in a single document and labelled 1-31; each of these designs were referenced in another matrix analysis against the PDS and marked ‘suitable’ (x), or ‘not suitable’ (N/S) (Appendix I).

The most suitable designs were illustrated as shown in appendix I, with the desirable features being taken forwards for further development.

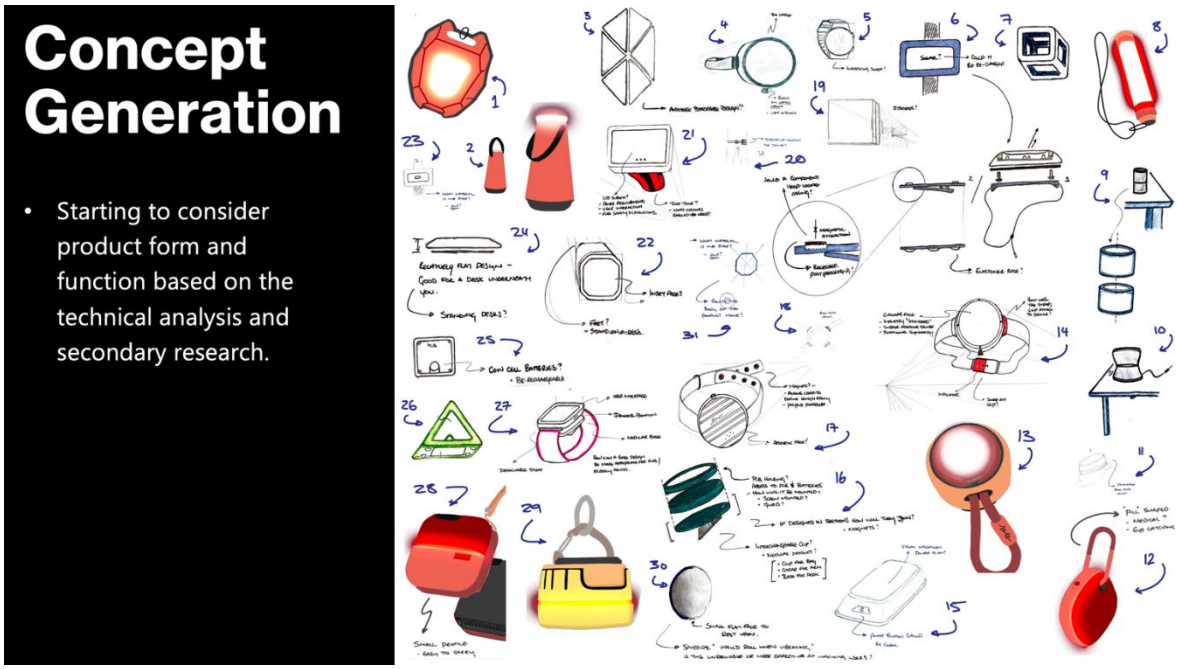


Figure 23 - Concept Generation (Author, 2023)

Foam modelling was also used to establish an appropriate size/shape, using anthropometric data (NC State University, 2006) as a reference. Foam modelling was completed throughout the concept generation/development stage and encouraged a wide variety of ergonomic/modular designs to be created (Figure 25).

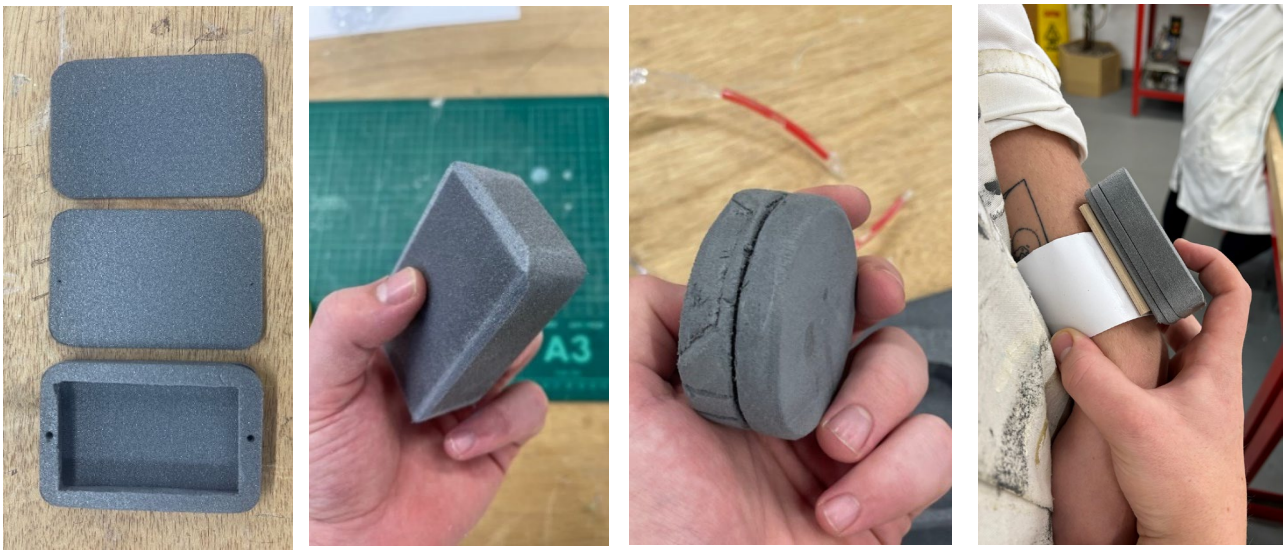


Figure 24 – Foam Modelling (Author, 2023)

As previously mentioned, CAD quickly became an integral part of concept generation/development. The key designs from the matrix analysis (Appendix I) were modelled, allowing each to be visualised with materials, dimensions, colours et cetera. This also allowed designs to be broken into individual parts, which could be manipulated, assisting design for assembly/disassembly, design for manufacture and improved user interaction features (i.e. Figures_).

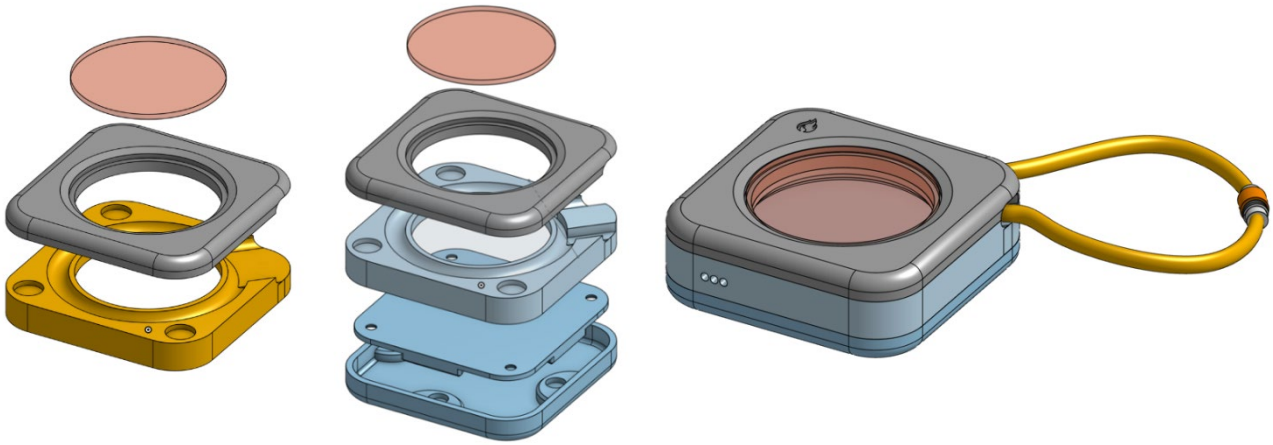


Figure 25 – CAD Development (Author, 2023)

At this stage, a ‘concept-viva’ design was created, sharing features from previous concepts (Figure 27). This design progressed leading up to the concept viva, initiating detailed design (i.e. modular design, appearance, weight, usability features et cetera.).

During concept development, a schematic was also created. Using this, required components and their sizes were understood, influencing aspects of the design (i.e. height). A basic Veroboard test-rig was also built to demonstrate the product’s feasibility.

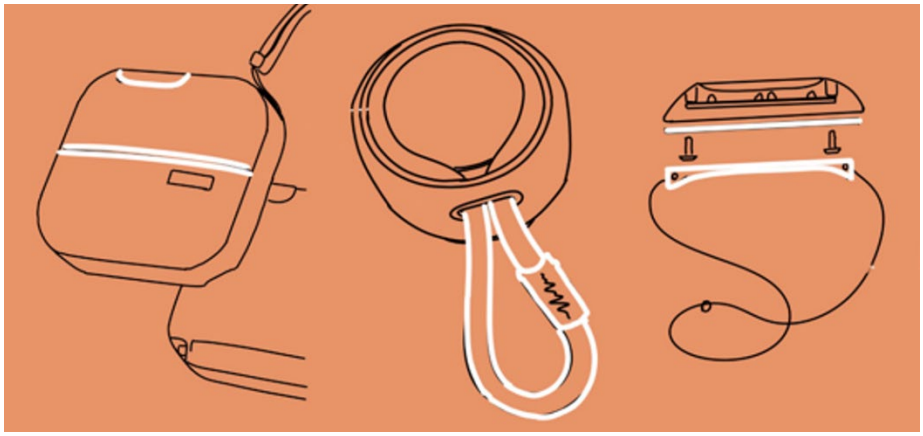


Figure 26 - Matrix Analysis Designs (Author, 2023)

Throughout concept generation, the materials for the product had also been considered. Following research into inclusive design (William S. Green & Patrick W. Jordan, 1999), it was decided an aluminium casing would convey high-quality and long-lasting design. This remained subject to change, depending on cost of manufacture.



Figure 27 - Concept Viva Design (Author, 2023)

2.7 Detailed Design:

Following the ‘concept viva’, a list of design considerations/issues was created (Appendix J). Potential solutions for each consideration were developed in CAD and produced using 3D-printing, allowing further testing to be performed.

Using the schematic previously designed, components were plotted onto a PCB layout, giving approximate dimensions for the circuit (Figure 29). This introduced new design considerations, including battery size and location. Subsequently, a battery holder was to be designed to improve space efficiency for the product (Figure 30).

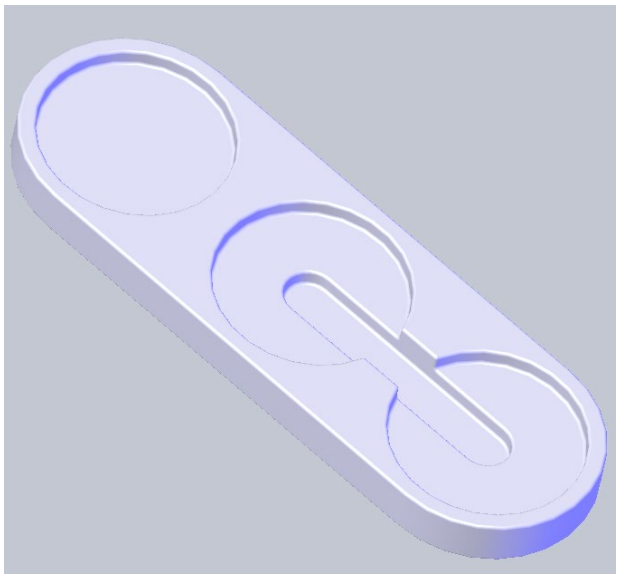


Figure 29 – Battery Casing (Author, 2024)

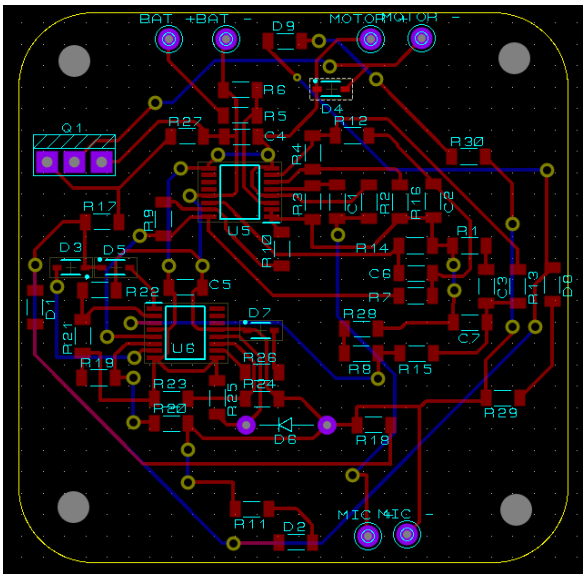


Figure 28 – PCB (Author, 2024)

Another design consideration was integrating the microphone ports. The product required a method of being waterproof (Figure 31). Although this solution requires additional parts, it reduces the use of adhesive during assembly, following the WEEE/MADE directives.

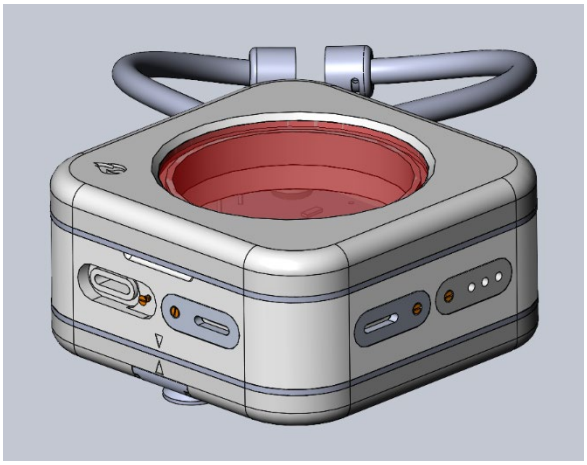


Figure 30 – Waterproofing (Author, 2024)

Designing a convenient strap for users was also necessary. The initial solution featured a modular base that could be swapped out for another (Appendix J), however this would be expensive and inconvenient. Further design development led to a base with a quick-release clip (Figure 32); additional usability testing is required, however.

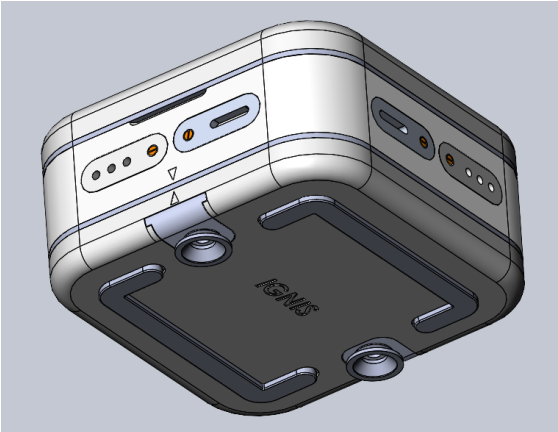


Figure 31 – Strap fitting (Author, 2024)

The ‘secondary’, smaller strap also required development. Initial concepts included a thread to ensure the strap remained fixed during exercise, following results from primary research (Appendix E). Although, this design was not feasible for manufacture, leading to an alternative magnetic strap design (Figure 33).



Figure 32 – Magnet strap (Author, 2024)

Following results from primary research, designing for young adults/children was important. Initial research revealed the colours blue and yellow are important to the D/deaf society, representing their flag (figure 34). Alongside further research, post-modernism also inspired the design, due to its wide use of bright and bold colours as a “rebellion” (Elephant Media, 2024).

Through aesthetic research/concepts, it was realised the ‘top-casing’ should be interchangeable, with multiple colour options and a variety of designs. This also allows the user to determine whether the product is subtle or bold, removing the ‘split-view’ and transgenerational design constraints.

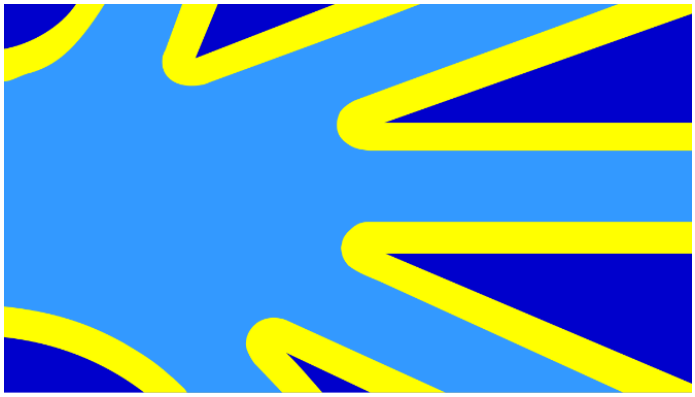


Figure 33 – Deaf flag (Wikipedia, 2023)

During testing, it was found that resonant frequencies of vibrations can activate the circuit. As a result, two silicone ‘dampeners’ were designed and integrated into the ‘base-casing’, reducing the impact of the vibrations on the circuit.

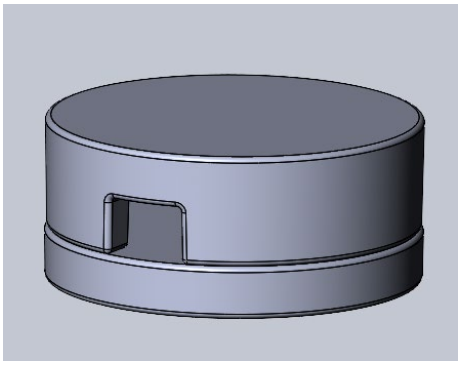


Figure 34 – Dampeners (Author 2024)

Additional features were added throughout detail design, following research and testing.

Initial Quotes:

To establish an approximate cost for the product, a range of companies were contacted from the UK and abroad. It was immediately apparent that manufacturing costs from the UK were not viable for an aluminium casing, however, quotes from China may be feasible (Figure 36).

Proto MFG Co.,Limited
8 Building 3,Shida Road 692#,
Dalingshan Town, Dongguan City
China 523800
www.protoindus.com o@proto-mfg.cn
0086 18778479575

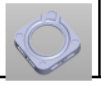
PROTO

BILL TO
Rian Edmondson

QUOTATION

Date of Issue: 23-Feb-24
Due Date: 09-Mar-24

Currency: GBP

NO	Part Name	Picture	Material	Finish	Process	Note	Quantity	UNIT PRICE	TOTAL
1	PCB Casing		AL6061	Deburring	CNC	2250pcs/Month	27000	10	270000.00

SUBTOTAL: 270000.00
QUOTE TOTAL: 270000.00
LEAD TIME: 30 Day

Figure 35 – Initial Quote

Design for manufacture:

Following initial quotes, other materials/methods of manufacture were considered (Appendix K). However, as the thickness of injection moulded parts is larger than

milled components, it would require significantly increasing the size of the design. Die casting was also considered; however, it cannot achieve a similar surface roughness and isn't suitable for anodising.

At this stage, draft angles were added to plastic components (Figures_) and the sizes of parts changed to account for machining tolerances (Appendix L). The wall thicknesses of parts were also edited, ensuring each part was viable for manufacture.

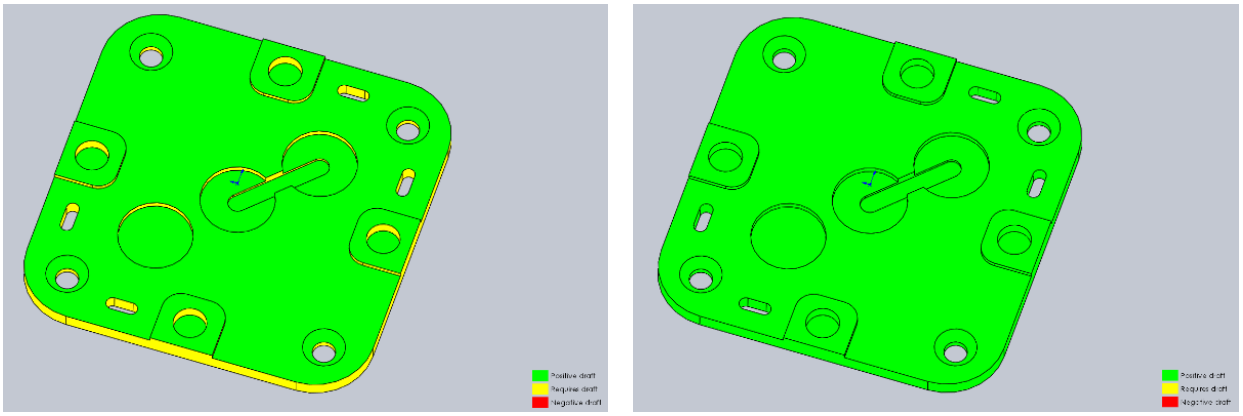


Figure 36 – Draft angles (Author, 2024)

Rapid Prototyping:

As the design progressed further, 3D printing allowed the product to be visualised; it also enabled specific test-rigs (i.e. angle of light) to be completed.

Laser cutting and etching were also used to demonstrate the appearance of the customisable 'top casing', and the acrylic screens.

A test-rig was conducted to determine whether a pattern would display correctly over a curved surface when laser etching. Further testing was also completed to understand how many passes and what power is required to etch a suitable depth into aluminium.



Figure 38 – 3D print (Author, 2024)

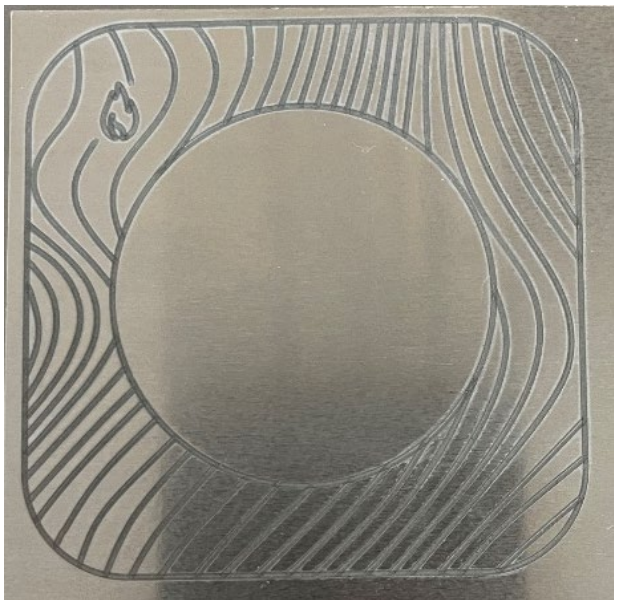


Figure 37 – Laser-etched design (Author, 2024)

Materials Analysis:

Following initial quotes and design for manufacture, the materials were evaluated using online datasheets and Granta EduPack. Aluminium 6061, silicone (KEG-2003-70A/B) and ABS were found to be suitable materials for the product following a matrix analysis due to their recyclability, UV resistance, availability and aesthetic properties (Appendix K).

Final Quotes and BOM:

During detail design, further quotes were received (Appendix M) and listed in a bill of materials (BOM) (Appendix N). Multiple companies were approached for various manufacturing processes and distribution. The quantity stated was based on the obtainable market (27000 individuals) on a yearly basis. As such, the overall cost of the product (including overheads) was found to be £85.00.



Figure 39 – Gasket Quote

Developing engineering drawings (Appendix O) was necessary to receive quotes and explain the manufacturing process. These were later used to develop a set of manufacturing instructions in preparation for prototyping.

At this stage the final design was reached (Appendix P) and presented during the detail viva.

Test-rigs:

Bandpass filter:

During the concept development stage, research and development of a 3kHz bandpass filter led to a Veroboard circuit being created and tested (Figure 41). To test it, a signal generator and a speaker was used to simulate a smoke alarm.

The test showed that the technical concept was feasible and could be developed through further testing. However, it also revealed that the central frequency (f0) was not accurate to the equation (Figures 41).

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{R_1 + R_2}{C_1 C_2 R_1 R_2 R_3}}.$$

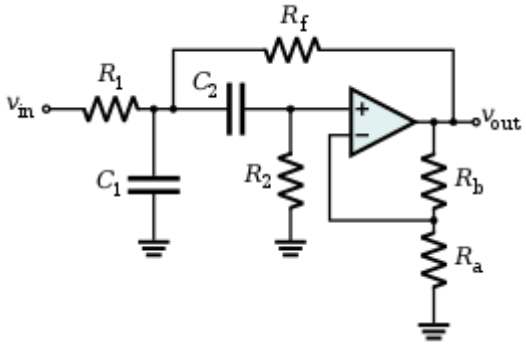


Figure 40 – Bandpass equations (Wikipedia, 2024)

This is likely due to the quality of the components; low-tolerance resistors/capacitors should be used if commercialised.

It was also found that the bandwidth of the filter was too high; the filter allowed frequencies between 2000-4000Hz to pass; to reduce this, further 'poles' should be added to the filter, which would be possible when using smaller surface-mount components.

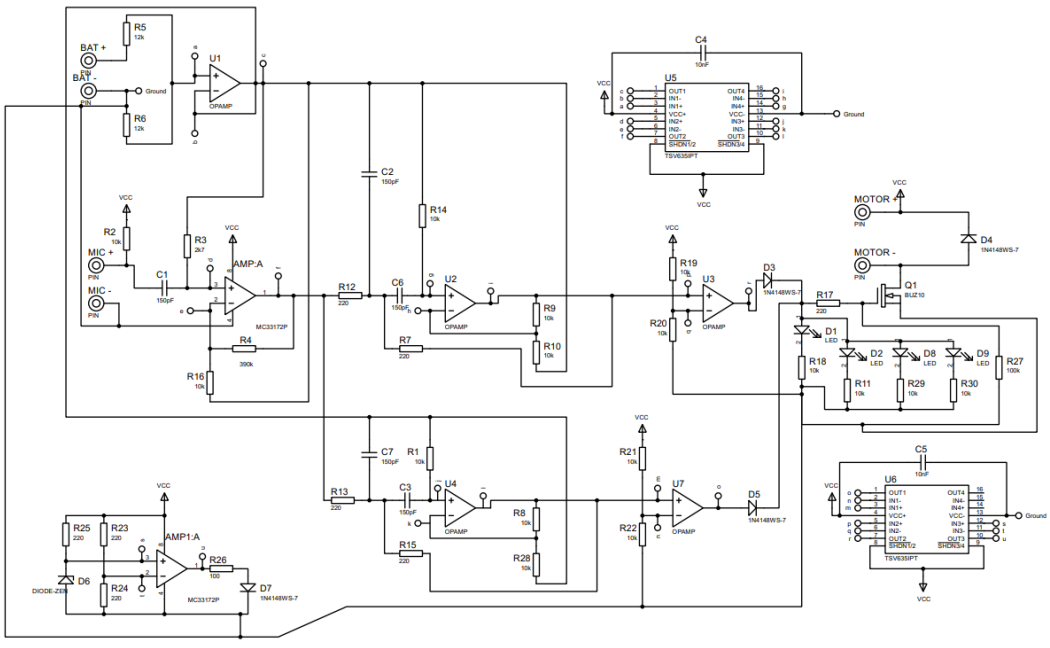


Figure 41 - Schematic (Author, 2024)

It was further realised that a motor can induce a frequency in the microphone; to alleviate this affect the motor should be secure and be physically distant from the PCB.

Vibration testing:

During the detail design stage, a test rig was developed to test vibrations produced by the motor. A vibration motor was attached to different thicknesses of ABS/aluminium sheets and the movement of the material was measured using an accelerometer.

The results demonstrated that the thickness of the material significantly affected the intensity of the vibration felt through it (Figure 43). As a result, a section of the base component was removed, reducing the thickness of the aluminium to 1mm.

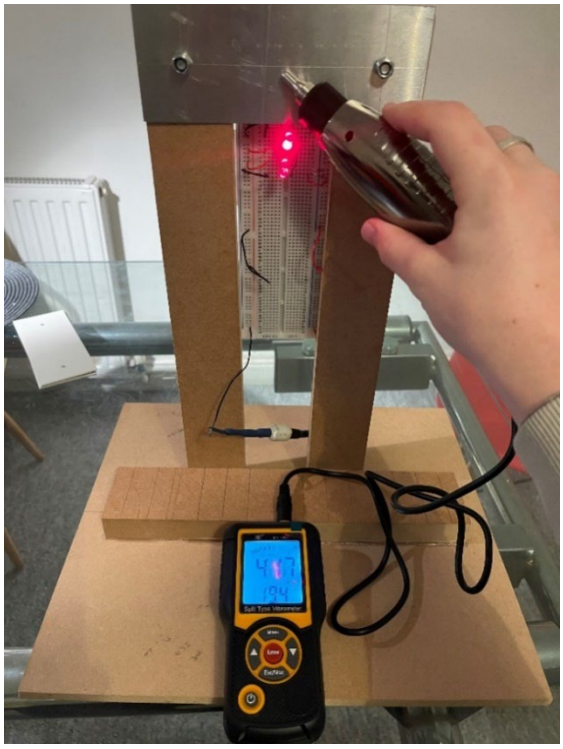


Figure 42 – Vibration Testing (Author, 2024)

Angle/intensity of light:

To measure the intensity of the light emitted by the product, a lux meter was used. Using a set of 3D prints, four LEDs were angled and measured at different distances (Figure 45). It was found that the light was most intense when perpendicular/coincident to the lux meter. As a result, the LEDs for the product are surface mount.

Further testing (Figure 44) under an ambient light of 800 lux, demonstrated that four LEDs could exceed the intensity under BSEN54-23.



Figure 43 – Light Testing (Author, 2024)

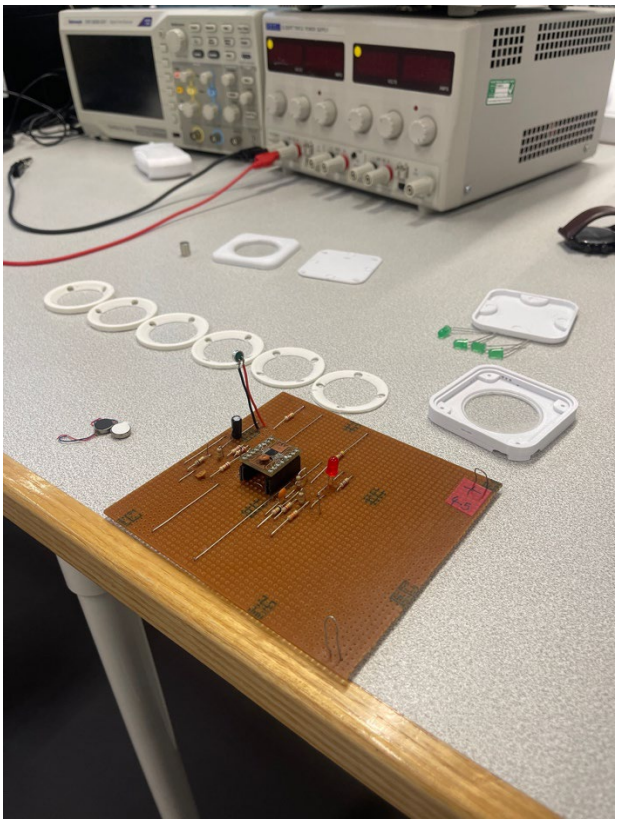


Figure 45 – Angle Testing (Author, 2024)

Magnetic strap testing:

A test rig using a 3D print of the magnet strap demonstrated the strap doesn't detach under pressure, due to the strength of the magnets and the strap's elasticity.

Developing electronics:

It was realised that at specific distances from the speaker, the signal detected by the microphone was more intense. These increments changed with the frequency of the sound, suggesting it was caused by the compression/rarefaction of the soundwave.

Due to a fire/smoke alarms intensity, the circuit would function reliably within the distance specified (13 metres), however at further distances it may begin to “flicker”, as the amplitude/sound pressure decreases.

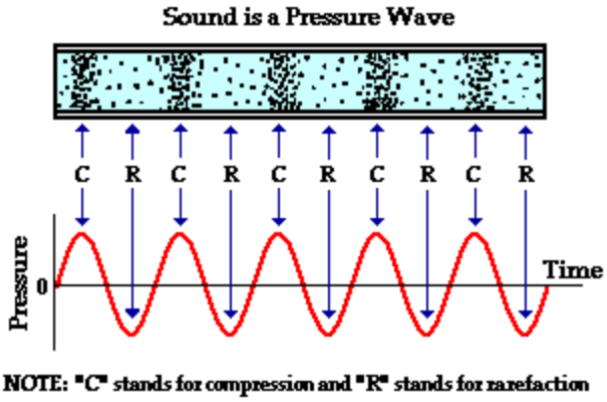


Figure 44 - Sound Characteristics (The Physics Classroom, 2023)

It was also found that each bandpass filter has multiple resonant frequencies. This can also be reduced by adding ‘poles’ to the filter, like the ‘bandwidth’ issue.

Changes made during detail design to reduce vibrations affecting the circuit were also tested to be successful.

IP – Logo Iterations:

Using AI [DALLE], iterations of a logo were generated based on an initial sketch of a flame.

The following images were generated; from which a segment was edited (Figure 46). Although the logo would be updated for commercial use, it communicates the colours of the D/deaf community and the purpose of the product/company.



Figure 45 – Logo Design (Author, 2024)

Chapter Three – Evaluation of the Final Design

Within this section the key points of the PDS are reflected upon, giving an evaluation of the final design (Appendix E).

Final Design:

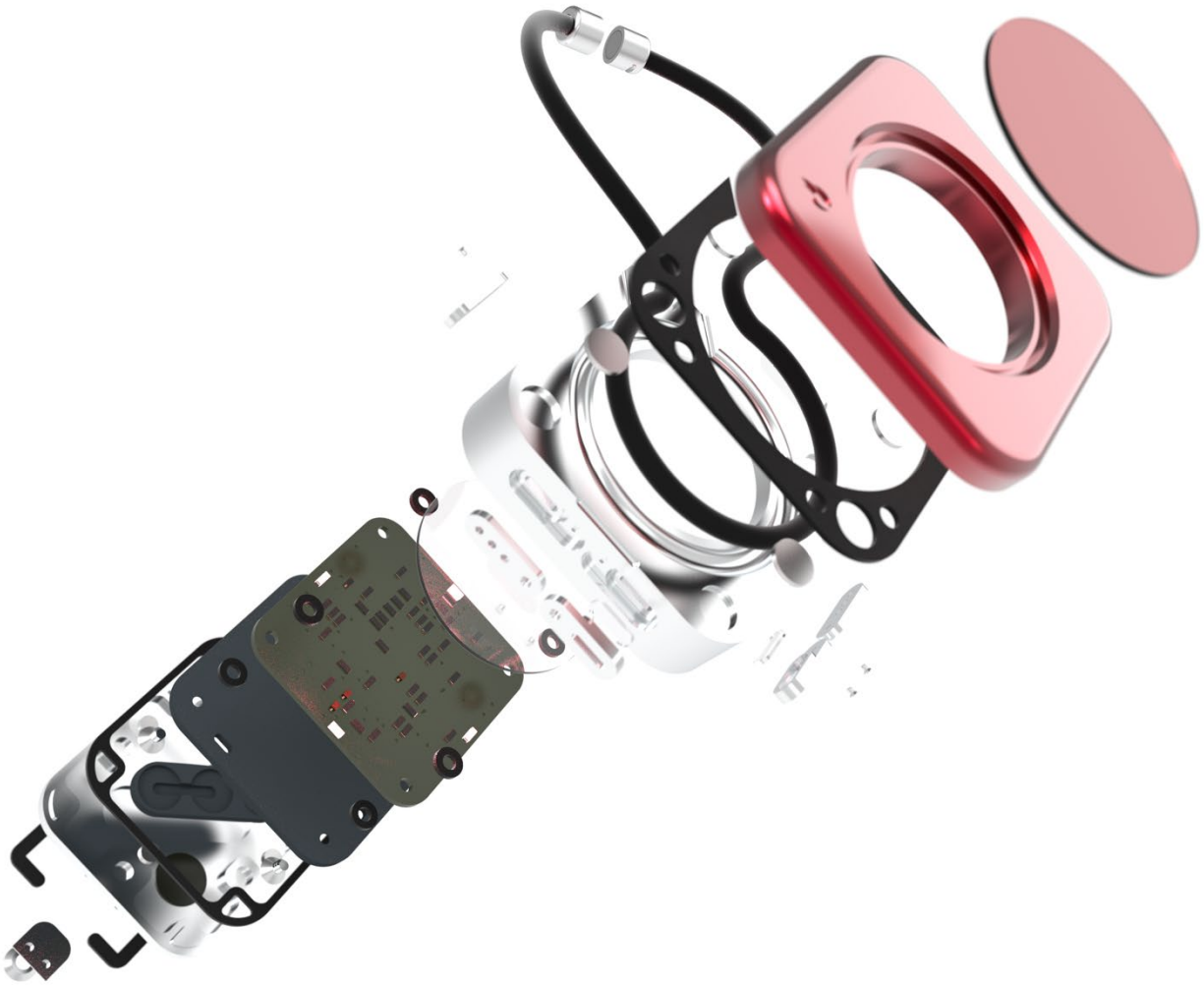


Figure 46 – Final Design (Author 2024)

3.1 Market:

[1.1/1.2] – Market size:

Despite the market size being large (900,000), groups of D/deaf people can be challenging to reach (1.2). The obtainable market size is approximately 27000; meaning every month 2250 would have to be manufactured. The product therefore is suitable for batch manufacture.

Changing the manufacturing process to injection moulding (Figure 54) may allow the product to be mass manufactured, without influencing aesthetics negatively. Further research and quotes are required.



Figure 54 – Plastic Render (Author 2024)

[1.2.1/1.2] – Employment and secondary conditions

“The market includes those with secondary conditions – Maintaining and using the product must be intuitive for the user”. Intuitive design has been considered throughout the design process. When the user is required to change the device’s batteries/straps, the base/top casing have been designed to be easily removed using magnets.

The battery casing has also been designed so the batteries locate themselves between two components. Additionally, to power-off the device, the user can simply rotate the base casing.

To accommodate for the lower employment rate and income of D/deaf individuals, the device has been designed to be significantly more affordable than competitor products, despite a high cost of manufacture.

[1.3/1.3.1] Individual use

The product has been designed to be portable, affordable, and convenient for the user. Whilst Ignis is suitable for both individual and group settings, the design prioritised enforcing the user's confidence and personal safety. As such, the product is intended as a personal device with specific design features encouraging personalisation.

[1.9] – Age and inclusivity

As the design can be customised, it allows the user to express themselves; it has not been designed to be gendered and isn't age specific.

When designing the product, anthropometric data of women and men was used to determine its size limits (width and length) (NC State University, 2006). Despite the product having a large height/depth, the product is an appropriate size to fit on the user's upper arm, whilst being large enough for the PCB.

3.2 – Function:

[2.1] – BS-Standard requirements

Following BSEN54-23, the product emits 0.4 lux on a surface perpendicular to the light emitted, in an ambient light level of 800 lux. Test rigs have revealed that four red LEDs could exceed this level. In most instances however, the ambient light would be lower, improving the device's ability to alert the user.

[2.1.2] – Flashing rate & Epilepsy

The product has been designed to flash at an identical rate to the alarm's tone. BS fire tones are typically 2Hz, however some exceed this. The tones that exceed this limit are typically "sweeping" through frequencies, however, producing a steady light to alert the user (Eaton, N.D.), making the product suitable for D/deaf individuals with epilepsy.

[2.2] – Battery requirements

Ignis uses AG10 coin cell batteries which are commonplace and affordable. The batteries, as previously stated, are replaceable and use a bespoke battery casing to improve the process for the user. This ensures replacing the batteries is "convenient" (2.2.1 – PDS).

[2.3.1] – Environment

As the product has been designed following the specification BS-EN54-23, it can be seen under various light conditions (<800 lux), however, when necessary, the product uses a vibration motor to alert the user.

[2.4] – Light visible through covering material

Two layers of acrylic have been used to cover the PCB and ensure the device is waterproof. One layer of the acrylic is coloured red and frosted, whereas the other layer is clear. The frosted layer has a significantly lower light transmission than clear

acrylic, however. The colour red reduces the light transmission further; it may be necessary to increase the light emitted from the device to compensate (SimplyPlastics, N.D.).

[2.5] – Mounting options

Ignis has been designed with an option of two straps to improve the products versatility, ensuring the user isn't forced to wear the device. As such, it can be used in most scenarios, following primary research responses.

The 'quick connector' fitting and magnetic strap also allow the user to quickly swap between mounting options for convenience ([4.4] – Ergonomics).

[2.6] – Sound filter

A bandpass filter has been designed to filter sound frequencies and decibel levels. Throughout the design process the circuit has been tested and developed to ensure its function is accurate and reliable.

To account for the different frequencies emitted by British fire/smoke alarms, another bandpass filter was added to detect both types of alarm. As previously stated, increasing the poles of the filter would improve its accuracy.

The vibration generated by the filter matches the tone of the fire alarm, potentially assisting the user in identifying the warning. For further development, changing the circuit to be digital would potentially make the circuit more reliable.

[2.10] – Energy consumption

The device has been designed to use low amounts of power whilst idle, enabling it to last longer between replacing the batteries. When the device detects the correct frequency, it activates and remains active throughout the sound's duration.

The product has a capacity of 130mAh and uses approx. 130mA when active (Figure 48) and can operate for 35 minutes. However, when the product is idle, it's capable of lasting multiple days.

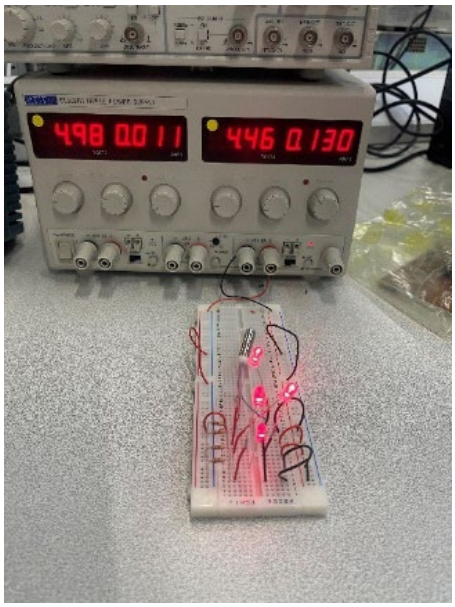


Figure 47 – Capacity Testing (Author, 2024)

[2.11] – Reliability

Through testing it has been established that the device can consistently detect a fire/smoke alarm, making it a safe product to rely upon. False alarms can be generated by loud sounds at a similar frequency, however.

[2.12] – Eaton Database

The Eaton database of Fire/smoke alarm tones was highly influential to the development of the bandpass filter. As British fire/smoke alarms are non-standard, it cannot be guaranteed that all fire/smoke alarms will be detected by Ignis, however, most of these alarms have common frequencies (800-970Hz & 3100Hz) (Eaton, 2023) which can be filtered.

[2.13] – Low battery indication

The product has been designed to produce a light when the battery is low. This will show an orange LED and is easily identifiable. Whilst this has disadvantages (i.e increased battery use), it allows the user to know when to change the battery before their safety is compromised.

[2.14] – Light angles

During testing, the most effective angle for the LEDs was found to be perpendicular, in line with secondary research. As a result, the LEDs are surface mount to the PCB. The device also features smaller screens on its side, allowing light to be seen from wider angles.

3.3 – Aesthetics

[3.3] - Colour

When the product is active it uses red light which has connotations of danger and emergency to draw the user's attention. As "emotional context alters a colours impact" for attention and motor behaviour, during a fire "signs that are vital for safety should use red to attract attention" (Kuniecki et al., 2015).

As the product is customisable, the user also has a degree of control regarding its subtlety.

[3.4] – Visual Cues

Although the product was designed to be intuitive when assembling/disassembling, further visual cues should be included to indicate the correct orientation of components.

The product draws the attention of the user to the top face of the product; as a result, the user's view should be drawn to the acrylic screen and warning light.

[3.6] – D/deaf colour scheme

As discussed under 'detail design', the D/deaf flag influenced the colour scheme of the product and its logo/branding, although further colours were proposed later in the design stage.

3.4 – Ergonomics

[4.4] Quick connector strap

A strap clip was designed to allow the user to quickly swap between different straps; the final design is cost effective.

[4.5] - Weight

The product weighs approximately 100 grams (Figure 56); following guidance from the FAA (2005), this weight is suitable for a portable device. The product was also designed to have a centre of gravity, around the magnetic strap; as a result, the product is more stable when attached to a bag/belt.

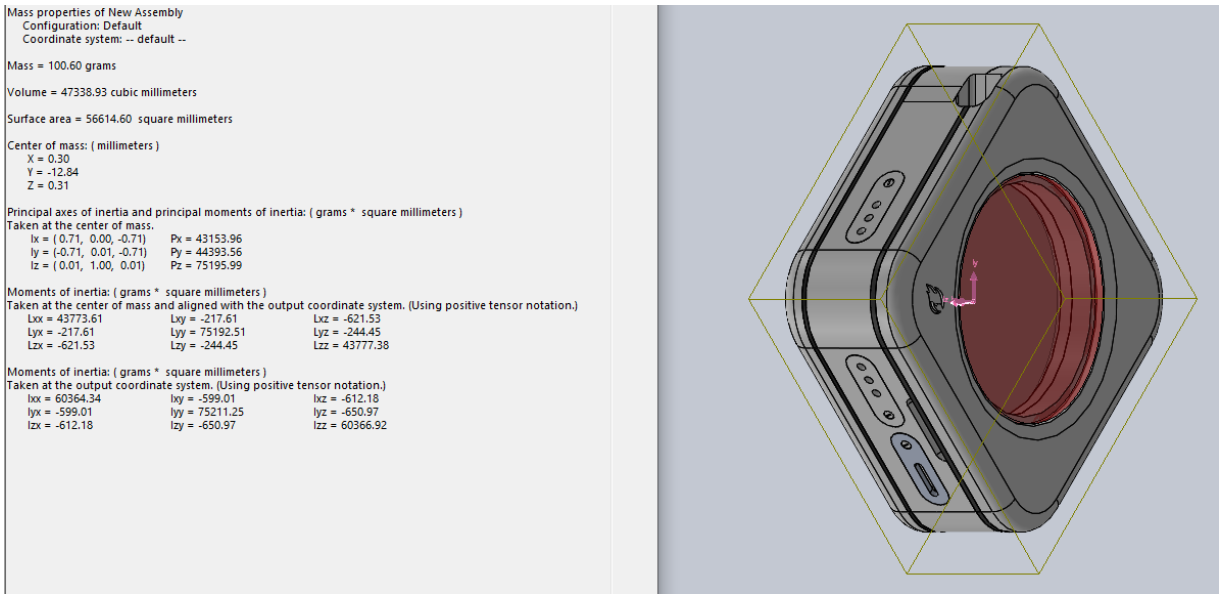


Figure 48 – Weight Calculations (Author, 2024)

[4.6] - Body Movements/size:

When the product is worn, it is located on the user's upper arm. As such, the device doesn't restrict the user's movements; although reducing the product's height would allow it to fit inside the user's pocket/smaller bags.

The design also features a silicone inlay to provide comfort against the skin when worn ([5.3]).

The product is within the size requirements set within the PDS (100*60mm) based on secondary research.

[4.8] – Tactile Features

The PCB casing has two notches removed to assist the user in removing the top/base casing. Further tactile features should be implemented into the design if developed.

[4.9] – Safety

Safety has been a consideration throughout the design process. The design features two rubber gaskets which separates the aluminium casing, reducing the risk of the user pinching their finger under the force of the magnets.

As previously mentioned, the electronics/LEDs are suitable for epileptic users with a flash rate typically under 2Hz. The electronics are also inaccessible for children.

3.6 - Sustainability Goals

The project achieved all of the UN sustainability goals referenced in Chapter one. Most notably, the device contributes to good health and wellbeing; effectively and reliably being able to detect a fire alarm from a reasonable distance and alerting a D/deaf person.

3.7 - IPR

Following advice, a timeline has been created (Figure 50) for IP. Although a sponsorship would be ideal to reduce patent/trademark fees in return for product use, it is equally viable to obtain a ‘trade secret’.

When/if obtaining a patent to commercialise the product, it should also be considered whether it restricts reasonable development of other assistive products for D/deaf individuals.

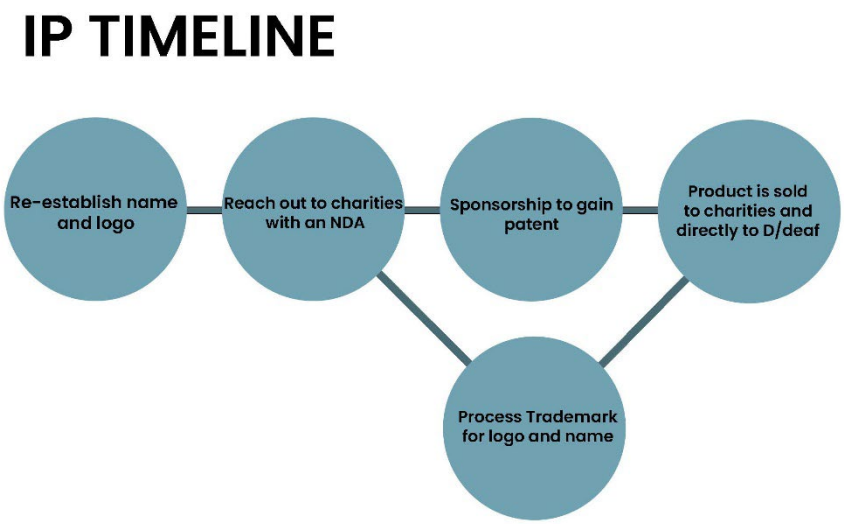


Figure 49 - IP Timeline (Author, 2024)

Chapter Four – Conclusions and Recommendations

4.1 - Technical Challenges:

The final solution has demonstrated technical feasibility, despite being constrained to a small form. The product effectively detects a nearby fire/smoke alarm and alerts the user. Each aspect of its function has been tested and integrated well; achieving the technical goals set during the proposal stage.

4.2 - Human challenges:

Aesthetics and its impact on inclusive design has been a key consideration for the project. By reflecting on primary research and existing design trends, Ignis has given personalisation options and maintained a high-quality appearance through its use of materials.

Other human challenges were presented throughout the design process (i.e. age, safety, usability et cetera.) which influenced concept/detail design. As a result,

features (i.e. battery casing/gasket design) have been designed to improve user experience.

4.2 - Design Improvements:

For future development, the following design improvements could be made to better suit its function/market:

Developing a supporting app that connects to an online system would allow parents/family and carers to be notified if a fire-alarm is activated; although this would require app design and integration, with potential software issues over time.

Changing the circuit to be digital would also allow the product to identify patterns in sound, reducing the chance of false alarms. Developments in AI sound detection (i.e. Altexsoft, 2022) have led to significant advancements in this field.

During the detail design phase, the casing was also increased in height to account for larger components; using smaller surface mount components would allow the casing to be reduced in height (Figure 58), making it convenient to wear on the upper arm.



Figure 58 - Reduced Height (Author, 2024)

As discussed within Chapter 2, additional poles would improve the bandpass filter, reducing its bandwidth and its number of resonant frequencies; using smaller surface-mount components would allow this. Furthermore, changing the components to be low tolerance would improve the accuracy of the filter (f0).

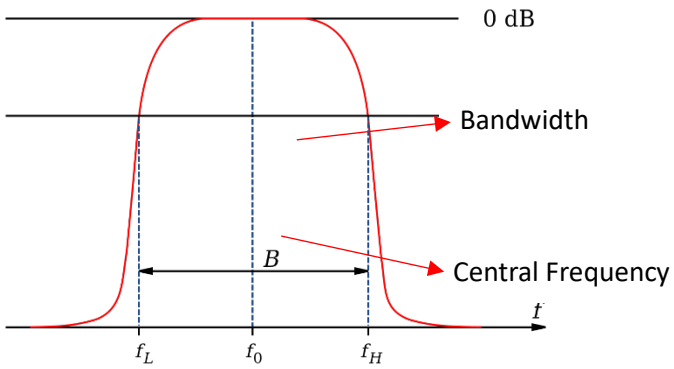


Figure 50 - Bandpass Filter (Wikipedia, 2024)

Ignis would benefit from rechargeable batteries; this would not be convenient, but it would remove the need for a detachable base and waterproof casing, reducing the complexity of the design and its cost.

Although the product has a low battery indication, it would be ideal to also have a method of testing the battery level. Using a microcontroller would allow the low battery indication to occasionally flash in a set pattern, saving battery and making it easy to distinguish from the alarm.

The product should include markings to display the coverage volume of the product alongside markings to display the correct orientation of each part and CE/UKCA markings.

As previously mentioned, (Chapter 2 – 2.4), increasing the light emitted from the product may be necessary. Alternatively, using clear and clear-frosted acrylic screens would increase light transmission; the LEDs would remain red. Further testing should be conducted into the most effective angle of LEDs and how to improve visibility from the side of the product.

References:

Aleksandrova, A. 2023. Choosing the Right Earpiece: The Domes vs Moulds Dilemma. Hear4U. Available from: https://www.hear4u.co.uk/choosing-the-right-earpiece-the-domes-vs-moulds-dilemma/#:~:text=Advantages%20of%20Moulds%3A,occur%20with%20improperly%20fitted%20domes. [Accessed 19 May 2024]

Altexsoft, 2020. Audio Analysis With Machine Learning: Building AI-Fueled Sound Detection App. Available from: https://www.altexsoft.com/blog/audio-analysis/ [Accessed 25/05/24]

Centre For Aging Better, 2023. The State of Aging 2023-24

Channel, N.D. Fire Alarm System Design Guide. Available from: https://www.channelsafety.co.uk/fire-alarm-system-design-guide/#:~:text=General%20spacing%20guidance%3A%205m%20from,be%20treated%20as%20a%20wall[Accessed 19 May 2024]

Design Council, N.D. The Double Diamond. Available from: https://www.designcouncil.org.uk/our-resources/the-double-diamond/ [Accessed 19 May 2024]

Eaton., 2023. VAD Multiplication Factors. Available from: http://www.eaton.eu/gb/engb/products/safety-security-emergency-communications/fire-detection-systems.html/ [Accessed 2 Nov 2023].

Eaton, N.D. Fire alarm tones & sounds. Available from: https://www.eaton.com/gb/en-gb/products/safety-security-emergency-

communications/alarms-and-signaling-devices/fire-rated/fire-alarm-tones-and-sounds.html[Accessed 19 May 2024]

Elephant Media, 2024. The Colourful Return of Postmodernism Celebrates Difference and Diversity. Available from: The Colourful Return of Postmodernism Celebrates Difference and Diversity - ELEPHANT [Accessed 27/05/2024]

Federal Aviation Administration, 2005. Human Factors Guidance for the Use of Handheld, Portable, and Wearable Computing Devices. Available from: https://hf.tc.faa.gov/publications/2005-human-factors-guidance-for-the-use-of-handheld/full_text.pdf [Accessed 27/05/24]

FireAngel, 2020. HOW TO – Quick Overview – Best practice for positioning Smoke, Heat and CO alarms. Available from: https://www.fireangel.co.uk/how-to-quick-overview-best-practice-for-positioning-smoke-heat-and-co-alarms/ [Accessed 19 May 2024]

Green, W.S; Jordan, P.W., 1999. Human Factors in Product Design. CRC Press

GOV, 2012. Hard-wired for sound. Available from: https://www.gov.uk/government/news/hard-wired-for-sound-love-to-hate-your-smoke-alarm--2#:~:text=Background-,Volume,could%20result%20in%20hearing%20loss[Accessed 19 May 2024]

Hear4u. Hearing loss statistics. Available from: https://www.hear4u.co.uk/hearing-loss-statistics/#:~:text=There%20are%2012%20million%20people [Accessed 18 May 2024]

Hearingaid, 2024. The Best Bluetooth Hearing Aids. Available from: https://www.hearingaid.org.uk/hearing-aids/bluetooth [Accessed 19 May 2024]

Hearing Link, 2024. Deafness and hearing loss facts. Available from: https://www.hearinglink.org/your-hearing/about-hearing/facts-about-deafness-hearing-loss/ [Accessed 18 May 2024]

Kuniecki, M., Pilarczyk, J., and Wichary, S., 2015. The color red attracts attention in an emotional context. an ERP stud [online]. Frontiers in human neuroscience. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4413730/#:~:text=However%2C%20a

%20weak% 20influence%20of,on%20attention%20and%20motor%20behavior. [Accessed 2 Nov 2023]

National Deaf Children's Society, 2024., Types of additional needs. Available from: https://www.ndcs.org.uk/information-and-support/childhood-deafness/additional-needs/additional-need-types/ [Accessed 18 May 2024]

NC State University, 2006. Anthropometric Data. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://multisite.eos.ncsu.edu/www-ergocenter-ncsu-edu/wp-content/uploads/sites/18/2016/06/Anthropometric-Detailed-Data-Tables.pdf [Accessed 02 June 2024]

Preston Hearing Care Centre, N.D. Phonak Virto Paradise Titanium. Available from: https://www.prestonhearingcarecentre.co.uk/product/phonak-virto-m-titanium/ [Accessed 05 June 2024]

Preventionweb, 1999. Fire risks for the deaf or hard of hearing. United States Fire Administration. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.preventionweb.net/files/8577_firerisksforthedeaf.pdf [Accessed 18 May 2024]

RNID, 2024. Using your mobile or smartphone. Available at: https://rnid.org.uk/information-and-support/technology-and-products/using-your-mobile-or-smartphone/?gad_source=1&gclid=CjwKCAjw26KxBhBDEiwAu6KXt55X1AhXARvpCckh4Bb2fthuaLaKSls9KUEDG41KTSrxgj1VVY8WXxoCFz4QAvD_BwE [Accessed 18 May 2024]

RNID, N.D. Types of hearing aids. Available from: https://rnid.org.uk/information-and-support/hearing-loss/hearing-aids/types-of-hearing-aids/in-the-ear-and-in-the-canal-hearing-aids/#:~:text=In%2Dthe%2Dear%20(ITE,fit%20inside%20your%20ear%20canal [Accessed 19 May 2024]

S2 Fire Solutions, 2017. Guidance Note FIA Guidance on the application of primary visual alarm devices (VAD) and supplementary visual indication devices (VID). FIA. Available at: "https://s2fire.co.uk/wpcontent/uploads/2019/05/Guidance-on-the-use-of-visual-alarms.pdf" [Accessed 9 Oct. 2023]

Simply Plastics, N.D. Perspex Fluorescent Cast Acrylic Disc. Available from: Perspex Fluorescent Coloured Cast Acrylic Disc Cut to Size - Simply Plastics [Accessed 25/05/24]

The Physics Classroom, 2023. Sound is a Pressure Wave. Avaliable from: https://www.physicsclassroom.com/class/sound/u11l1c.cfm [Accessed 02 June 2024]

United Nations, 2023. THE 17 GOALS. Available from: https://sdgs.un.org/goals [Accessed 19 May 2024]

University of Manchester, N.D. Inverse Square Law. Available from: https://personalpages.manchester.ac.uk/staff/richard.baker/BasicAcoustics/4_inverse_square_law.html[Accessed 19 May 2024]

Wilson, MW et al. 2019., Research into the Deaf audience in the UK. Traverse [Accessed 18 May 2024]

Wikipedia, 2024. Band-pass filter. Available from: https://en.wikipedia.org/wiki/Band-pass_filter [Accessed 25/05/24]

Wikipedia, 2023. Deaf Flag. Available from: https://en.wikipedia.org/wiki/Deaf_flag [Accessed 05 June 2024]

Appendix A – Project Proposal



Safe Awake – Competitor SWOT analysis: [12]

Competitor's strengths:

SafeAwake has developed a product with multiple features that benefit the deaf/hard of hearing community. Its 'intermittent bed shaker' is "eighteen percent more effective than continuous bed shakers for alerting the hard of hearing". The product also emits a low frequency sound (520Hz) which is more effective at alerting the hard of hearing than traditional 3kHz to 3.2kHz smoke and fire alarms. Other features include:

- The product features an indicator that tells the user its active.
- Plug-in power supply (American) with a battery backup provides continuous alarm detection.
- "Large test button"
- Flashing strobe light

SafeAwake claims to be versatile; it notifies individuals of all hearing levels. The bed shaker with a 9ft cord allows is important for waking deaf individuals whilst the 520Hz alarm can alert those who only experience high frequency hearing loss.

SafeAwake includes three CR-123 lithium-ion batteries (non-rechargeable), which provides the battery backup supply.

Competitor's weaknesses:

SafeAwake has been developed for 'T3 smoke detectors', whilst these are the most common and modern version of fire/smoke detectors, it doesn't detect for other 520Hz smoke alarms for people

with hearing loss or alarms that emit a “continuous tone pattern”. This makes the user reliant on the fire/smoke alarm being a specific type.

The back-up battery supply lasts “24 hours” and isn’t rechargeable. This makes the user rely on a mains power supply (with an American outlet). As it’s a product that is (mostly) dependant on the user being near a mains power supply, it is inconvenient and won’t work when the user is moving.

Whilst the product is portable, it has a large form (6” x 3”). This isn’t a wearable design or something that is ideal for placing in a small suitcase/backpack when travelling.

The products main weakness is that it costs $249.95. This is not an easily affordable product for most people and could be hard to replace.

Competitor’s opportunities:

SafeAwake has a reliable function that is unlikely to change. Since 1st of July 1996, T3 smoke/fire alarms have been an international standard in America (ANSI), popularly known as the temporal 3 pattern. This makes it suitable for modern environments.

Otherwise, the SafeWake has limited opportunities, its expensive, not visually appealing, and not practical for all situations.

Competitor’s threats:

A wide variety of similar products exist for their market. Newer versions can be found that are more visually appealing and affordable.

The product cannot be used away from a mains power supply for an extended period, the product is threatened by portable designs that can be used in a more versatile way.



FixFire – Competitor SWOT analysis: [13]

Strengths:

This product is efficient and reliable for alerting workers to a fire. It uses a centralised communication system to alert pagers around a building. The pagers respond to the signal by vibrating and/or emitting a light. These are effective at relaying other messages too, depending on what they're set-up and programmed to do. This is a strength during emergencies where an evacuation coordinator could relay the same message to all deaf/hard of hearing people in a building.

FixFire is a reliable fire safety system provider, it suits premises from small through to large premises such as hospitals, colleges campuses and supermarkets. The company offers pagers with RGB screens, that alert using different colours depending on the message.

Weaknesses:

The product is system based. It requires a central communication unit that sends a signal to the pagers. This isn't practical for deaf or hard of hearing individuals who must travel for work or leisure.

Each system is bespoke and is therefore effective for each workplace, but expensive and perhaps not affordable for small businesses.

The pagers are not designed to be worn directly on a user's body. They're designed to clip/strap to a user's belt which makes them unreliable for constant body contact. The design would be better suited if it was in constant contact with the user's body.

Opportunities:

A standalone product that detects a fire alarm, without needing to communicate with a central 'unit' and alerts the user effectively and reliably would be ideal for any situation.

The product could easily be designed to be more unobtrusive, both visually and physically.

Threats:

There are competitor products in the market that target individuals at a more affordable price range. This product is designed for large buildings and institutions, not for the needs of an individual person. The pagers do not include any technology that can detect a fire, without a central system they are effectively useless.



Dorgard - Competitor SWOT analysis: [11]

Strengths:

The product can "listen" for high decibel sounds and activate whenever it detects a fire-alarm going off for more than 14 seconds. It can hold a door open at any selected angle and is activated using a simple, inexpensive motor. The device also uses batteries as its primary power supply, removing the need for complex wiring and electronic components.

The design is easily fit to existing fire doors.

Tested and certified to BS EN 1155:1997 & BS EN 1634 and conforms to BS 7273-4 "standard" category.

Designed for individuals with disabilities; people with crutches or wheelchairs may find it challenging to use fire doors during day-day life. This product aims to reduce this issue and leave fire doors open when there is not an emergency.

Weaknesses:

The product is expensive at £91.00 each, making it a suitable product for larger institutions such as universities and hospitals but perhaps not smaller institutions or households.

According to reviews: The product has "no instructions" and doesn't have a reliable method of setting a timer. The product also activates based on a decibel reading; any loud sounds such as a vacuum cleaner or loud machinery in a workshop may affect its functionality.

The product only activates after 14 seconds of a fire alarm sounding, by which point the fire could have spread past the door.

Opportunities:

Changing the decibel reading to frequency could reduce the amount of "false alarms" and give a more reliable result.

Threats:

The product has competitor products that claim to be more effective at detecting a fire alarm. Detecting differences in frequencies and filtering out incorrect ones can be important, especially in a fire safety product.

The 'Agrippa' fire door closer, is a direct competitor and claims to also make opening fire doors easier. This is a function that Dorgard doesn't have.

Appendix B – IP Letter

IP Solicitors
1 Bournemouth Lane
Bournemouth
Dorset
BH10 4DE

Mr Edmondson and Mrs Reynolds
1 Holdenhurst Road
Bournemouth
Dorset
BH11 3DU

17th May 2024

Dear Mr Edmondson and Mrs Reynolds,

I am writing to you regarding your recent development of products that you require advice on before releasing.

In this letter, I will advise you on the trademark aspects of your logo and name, alongside a patent for your product. The letter will be laid out for easy access when you require the information.

I understand that Mr Edmondson, your product aims to assist the deaf in hearing fire alarms through visual and vibration signals using a bandpass filter. Mrs Reynolds, your product is used to clean paint brushes using ultrasonic technology, which filters out the microplastics.

Trademark

Trademarks are essential to a modern-day business and create brand distinctness and consumer awareness within the market; they are also used to distinguish a company for what products and services it offers; trademarks last 10 years and, after this period, must be renewed.[1] Trademarks are enforced in the UK through the Trade mark Act 1994 (TMA),[2] and are only enforced within the UK. Worldwide and EU trademarks must be registered separately, which will be explained when we discuss jurisdiction options.

To register a trade mark, your logo and name must meet the absolute grounds[3] set out by the TMA 1994.[4] The absolute grounds for refusal are:

- Avoiding descriptive names such as "orange juice"[5];
- Marks that refer to the quality, purpose and geographical location, such as "Bournemouth Construction"[6];
- Trademarks that are a simple amalgamation of words such as 'headphones'[7] and
- Words that make up part of our vocabulary.[8]

The second stage to registering a trademark under the TMA[9] is meeting the relative grounds.[10] Relative grounds are a period offered to existing trademark holders to dispute your application and are used to assess the likelihood of confusion among the public[11], these grounds are:

- Aural, as the trademark sounds spoken;[12]
- Visually, how the trademark looks;[13] and
- Conceptually, if aural and visual are identical trademarks may be offered under conceptual grounds if they operate in different classes. [14] For example, Morrison construction may be permissible under construction services but not food distribution.

Mr Edmondson

Mr Edmondson, your trademark name, Ignis, will pass these absolute grounds; however, from my research on the UK trademark database,[15] multiple identical trademarks are already registered. Please see below:



Competitors[16]



Yours

- Aurally these trademarks are identical; and
- Visually these trademarks are also identical,[17]

This leaves the last conceptual ground for a trademark to be permissible. As mentioned, trademarks may be granted if identical marks operate in separate classes. There are 45 classes within which businesses can operate, split up into 'goods' and 'services'.[18] From my research, your product will fall under class 9, relating to its audio assistance, and class 10, for helping individuals suffering from hearing loss. Therefore, if Ignis operated in different classes, your trademark and logo could still be passable under relative grounds.

However, from more research on the UK IP database,[19] there appear to be multiple Ignis trademarks operating within these two classes:



Ignis on the 'left'[20] has trademarked its name and logo within class 9, while the trademark on the 'right'[21] has trademarked the word within class 10.

I suggest changing your name, it is essential to have a registered trademark for brand awareness; this may be the right time to rethink the name to something related to your device that consumers can remember. This same advice applies to your logo; it is very similar to British Gas, so creating a logo resembling your product may help your brand recognition, allowing you to trademark it.

I'm also aware that you are also interested in protecting the colour of your product. Based on our conversation, you are toying with multiple colours for your final design. The threshold to obtain a trademark colour for your device is very difficult and costly.[22] Therefore, the main concern is redesigning your name and logo to allow these to be trademarkable.

I understand from both your enquiry forms that you wish to protect your logo and name worldwide; before pursuing this, you must make the abovementioned changes before we can pursue this goal. Due to budget constraints and the uncertainty in the market for your products, I recommend first registering only a UK trademark once the above issues are rectified, as this will roughly cost you £170.[28] Doing this will allow you to assess the product's success through consumer demand before venturing outside the UK. If the product takes off, it would be wise to consider an EU trademark. This protects your logo and name in all of Europe.[29] The next step after this is if you plan to venture further than Europe, you can trademark internationally, protecting your name and logo worldwide.

It is important to note that your business name, even if registered at the company's house, does not offer the same protection as a registered trademark. It is possible to enforce an unregistered trademark, but the threshold is relatively high,[30] and it is not a risk worth taking, so I advise you to register your marks once amended.

Overview

Mr Edmondson:

- Neither your name nor logo are registrable due to infringement and
- Pursuing an unregistered mark will not be a promising avenue since already registered companies can dispute this, as they have attained consumer identity[31].

Patents

Patents are intellectual property rights granted to an individual or business that has invented something new and unique, including products and processes.[33] Patents last a maximum of 20 years but must be renewed continuously to reach this maximum.[34] Patents allow the inventor a monopoly over their invention, restraining competitors from using, making, selling, or importing it.[35] An example of this is Paracetamol; when first created, only the pharmaceutical company that invented it could distribute it, however, once the 20-year period had ended, competitors such as supermarkets could now create their version and sell it,[36] this is possible as after 20 years the invention reaches the public domain, and the rights over the invention are lost.[37]

Patents are not essential for inventions, many inventions have been made and not patented, but this restricts the monetary gain as once something is patented if someone wishes to use your invention, they will need your consent, through

compensation. An example of this is the ball on the Dyson vacuum cleaner.[38] This ball allows the cleaner to reach tricky areas, although this is now in the public domain for other manufacturers, while it was patented, if a rival company wanted to use this invention, they would have to obtain consent from Dyson, through a license agreement.

Patents within the UK are granted under the Patents Act 1977,[39] which contains stringent measures required to obtain a patent. The criteria under the Patents Act are as follows:

- The invention is new, known as novelty. Novelty[40] refers to the originality of your idea, it prevents an individual from re-inventing the wheel.[41] These past ideas are referred to as state-of-the-art due to their publicity.[42] At this stage, to prevent your idea from becoming state-of-the-art, you must not disclose information to anyone who is not under a contractual agreement. Once something has been disclosed to someone, not under contract, it will amount to a public disclosure.[43] Public disclosure means you must prevent the physical nature of your invention or any information that the "intellectually intelligible" skilled person could understand,[44] which would then form part of the existing state-of-the-art. Therefore, if you plan on sharing sensitive information concerning your invention, you must ensure you obtain a non-disclosure agreement (NDA) to prevent this restriction on patenting.
- Inventive step,[45] relating to the development of existing art. This requires the individual making the application to demonstrate a sufficiently high level of inventiveness to justify the reward of a patent.[46] The Patents Act[47] outlines that an invention shall involve an inventive step not obvious to a skilled person in that art.[48] This is assessed by looking at the skilled person within that art, who will not "join the dots" from previous inventions to come up with your idea unless it is obvious to do so.[49] Obviousness is described as the step taken, which is not the next logical step in the development, but rather a leap forward.[50] Therefore, if your invention is unimaginative from previous creations, it will fail at this stage.
- The final criterion you must meet is industrial application.[51] This requires your product to be applicable in any industry, including agriculture. Most products meet this criterion, as the threshold is broad.[52]

Mr Edmondson

As instructed in your inquiry form, you wish to patent and license your invention to charitable organisations. We will assess its patentability and offer alternative methods that may benefit your business.

- As mentioned, the first hurdle to obtaining a patent is novelty. From my understanding, you are using old technology known as a 'bandpass filter' alongside circuits that do not require code or software, as this process is 'non-digital'. As mentioned, your product must not be part of the state of the art to surpass the novelty hurdle. From my extensive research on The World Intellectual Property Organization (WIPO),[53] there appear to be products similar to your device.



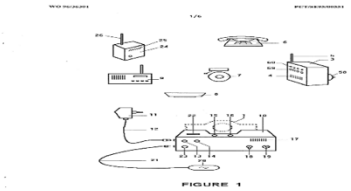


FIGURE 1

The product on the right[54] is a familiar invention that alerts the deaf. This product is not portable and is suitable for home use. Further review shows that the technology used is a transett sound detector, sufficiently different from your invention's technology. Therefore, your product would be considered novel due to its drastic differences in use and technology. The only issue that would arise is that you must ensure not to disclose information unless, under a contractual agreement, this is vital as there appears to be a gap in the market your device fills. If you did disclose information, the product would become unpatentable.

Further to my research, it appears that the technology used within your device mimics that of a baby monitor[55] although this technology is not protected by a patent, it does qualify as prior art, which could pose issues for patentability. However, how your product uses this technology is sufficiently different, potentially allowing it to pass this obstacle.

- We must then move onto the inventive step[56] of patentability; we have assessed existing art and competitors within your market. The inventiveness, as explained, must not be an 'obvious' development.[57] We have discovered that the central part of your technology has been used for products such as baby monitors, but not anything related to portable fire alarms for the hard of hearing, which would allow it to pass on novelty.[58]

  To pass inventiveness, the development of your product from this prior art above must not be generic, that an individual cannot 'connect the dots' [59] without extensive knowledge in this area, which, from your invention, they would not. Using this old technology is not a futile attempt at development but rather a leap forward,[60] with the product's portability and accessibility. An example of this is Dyson's development of bagless vacuums;[61] although, in today's view, with hindsight, this seems like a noticeable development on prior art. However, this was considered novel and inventive because it solved a problem,[62] albeit not severe.

- The final hurdle for you to cross is industrial application.[63] Your product applies within the industry because it tackles a problem for the deaf, passing this broad threshold.[64]

From the following advice, your product could be permissible for a patent application, however, per your enquiry form, there may be another avenue you may wish to take. It may be beneficial to your business model not to patent the product but to allow these charities to use it free of charge, as I understand your budget is limited for IP protection and a patent alone may cost over £2000.00.[65] This path may allow you to help people in need fulfilling a non-monetary side to your goals.

If this route seems feasible, you could ensure the process of making this product stays secret without needing a patent. This would be achieved through a trade secret,[66] which is free and easily created. This would protect the process of making it, preventing competitors from understanding the components of your product. This would be achieved by ensuring secrecy,[67] through an NDA, for example, and keeping the process adequately protected,[68] such as ensuring manufacturing is kept confidential.[69]

However, if monopoly is the goal, you must obtain a patent, allowing you up to 20 years to control the use and distribution of your creation.[70] This route may be the best option; from my research, charitable organisations may sponsor your patent application[71] for free product use. This route would allow you to monopolise the commercial use of your creation while allowing charities to use it for free, fulfilling two business goals. Ultimately, until you have decided your route, you cannot disclose any information to any individual not under contract, as if you choose to patent, it will fail under novelty.

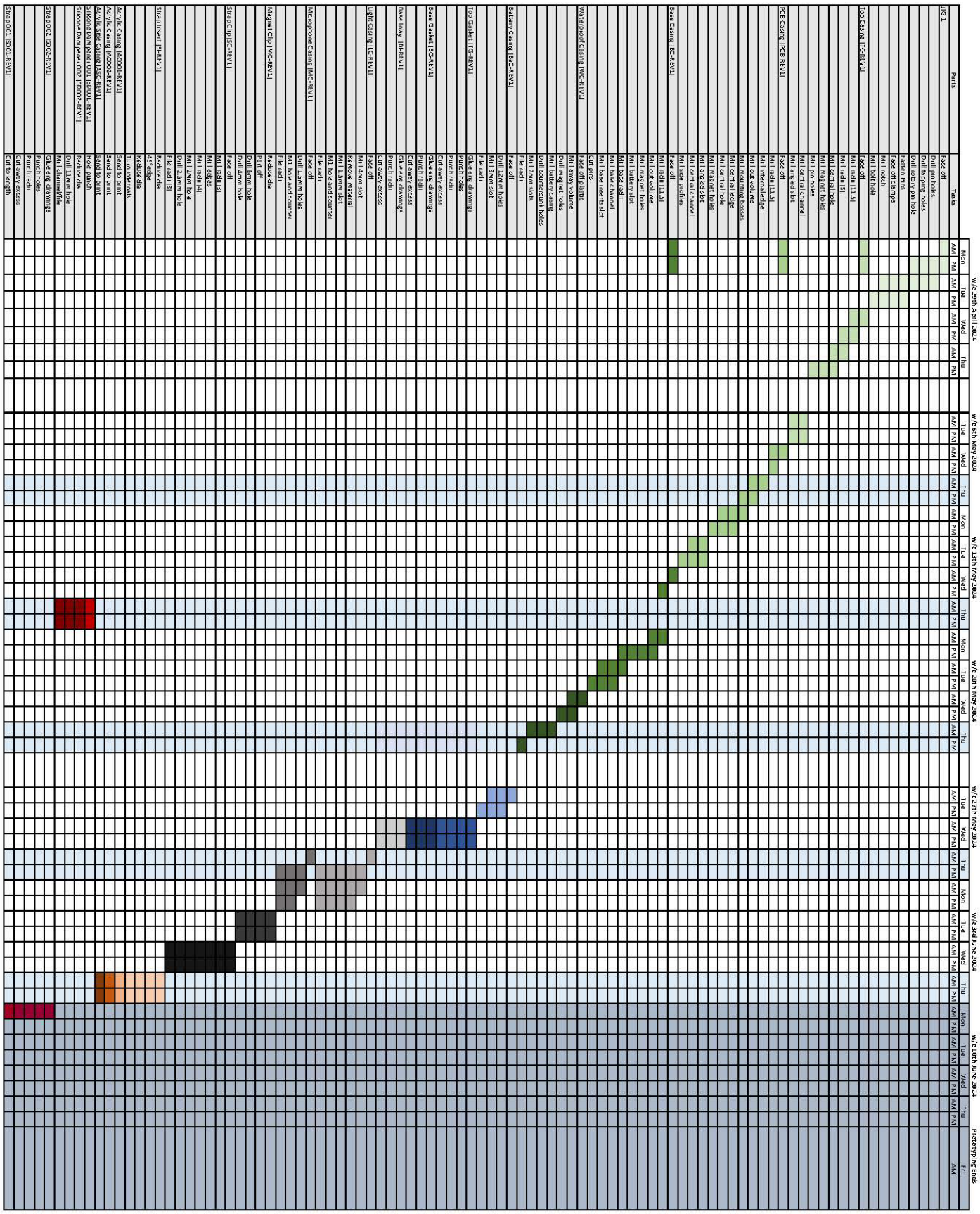
If you wish to act on this advice, please contact our firm, and we can pursue this goal further with more extensive research.

Overview

Mr Edmondson:

- Your product meets the novelty, inventiveness, and industrial application[89] requirements, potentially permitting you to obtain a patent.
- I understand you would like to help charities, refraining from a patent will allow charities to use your product free of charge, which may seem morally right for your goals. In this scenario, you may wish to pursue a trade secret[90] to protect your product from competitors. If this does not align with your business goals, obtaining a monopoly through a patent may satisfy these ideas.
- Regardless of your path, you must not discuss any information without an NDA; otherwise, your application will fail on novelty if you choose the patent route.

Appendix C – Time Plan



Appendix D – Ethics Documents

Research Ethics Checklist

About Your Checklist	
Ethics ID	52396
Date Created	19/10/2023 12:21:48
Status	Approved
Date Approved	30/10/2023 10:01:29
Risk	Low

Researcher Details	
Name	Rian Edmondson
Faculty	Faculty of Science & Technology
Status	Undergraduate (BA, BSc)
Course	BA/BSc/MDes (Hons) Product Design

Project Details	
Title	A visual and sensory alarming device that alerts deaf and hard of hearing users to a fire.
Start Date of Project	18/09/2023
End Date of Project	21/06/2024
Proposed Start Date of Data Collection	30/10/2023
Supervisor	John Powell
Approver	John Powell

Summary - no more than 600 words (including detail on background methodology, sample, outcomes, etc.)

This project will aim to detect frequencies of an active fire/smoke alarm and alert the user to it. The product will use sensory or visual indication to alert the user; using light and vibrations to ensure the user is aware the device has detected an active fire/smoke alarm.

The product will be versatile and improve upon existing products on the market. It will be a portable device that can adapt to any environment with existing fire/smoke alarms installed. The product will provide comfort in the user that they're safe, without having to rely on an institutions fire safety standard.

This ethics study will conduct questionnaires on two main groups of participants. These participants will either be working in the fire service or be individuals who are hard of hearing or deaf.

Filter Question: Does your study involve Human Participants?

Participants

Describe the number of participants and specify any inclusion/exclusion criteria to be used

The study will target two main groups; individuals who are hard of hearing or deaf (**group one**), and individuals who currently work in the fire service (**group two**).

The study will consist of questionnaires.

Inclusion criteria for **group one** includes:

The participant must -

- Be over eighteen years old
- Have high-frequency hearing loss
- Consider themselves profoundly hard of hearing or deaf
- Be enrolled in education or have a part-time/full-time job.
- Have travelled without supervision
- Taken part in a fire evacuation drill
- They have had a hearing test (seen by an audiologist) regarding their hearing loss.

Inclusion criteria for **group two** includes:

The participant must -

- Currently work for the fire service
- Have experience responding to fire emergencies

If the prior inclusion/exclusion criteria allow a participant to take part in the study; any gender, race, ethnicity or age of a person would allow them to be included in the study.

The study will attempt to reach 30 participants from **group one** to complete a questionnaire.

The study will attempt to reach 15 participants from **group two** to complete a questionnaire.

Do your participants include minors (under 16)?	No
Are your participants considered adults who are competent to give consent but considered vulnerable?	No
Is a Disclosure and Barring Service (DBS) check required for the research activity?	No

Recruitment

Please provide details on intended recruitment methods, include copies of any advertisements.

I will be looking to advertise to organisations for the deaf and hard of hearing and the fire services, in order to recruit participants for my study. Advertising through organisations such as 'Bournemouth Deaf Club' and 'Wiltshire and Dorset Deaf Association', local audiologist clinics and local fire stations using physical advertisements would be my primary method of recruitment.

I could also advertise online using Facebook to reach social media groups for the deaf/hard of hearing.

Physical advertising would include a QR code, or a URL to copy. A digital advertisement would provide a link to a questionnaire.

Do you need a Gatekeeper to access your participants?	No

Data Collection Activity

Will the research involve questionnaire/online survey? If yes, don't forget to attach a copy of the questionnaire/survey or sample of questions.	Yes

How do you intend to distribute the questionnaire?	
online,other	
If online, do you intend to use a survey company to host and collect responses?	Yes
If yes, please provide details of survey company.	
Jisc online surveys	
If Other, please provide details.	
I would ask to have an advertisement of the questionnaire put up by the gatekeeper of an organisation.	
Will the research involve interviews? If Yes, don't forget to attach a copy of the interview questions or sample of questions	No
Will the research involve a focus group? If yes, don't forget to attach a copy of the focus group questions or sample of questions.	No
Will the research involve the collection of audio recordings?	No
Will your research involve the collection of photographic materials?	No
Will your research involve the collection of video materials/film?	No
Will the study involve discussions of sensitive topics (e.g. sexual activity, drug use, criminal activity)?	No
Will any drugs, placebos or other substances (e.g. food substances, vitamins) be administered to the participants?	No
Will the study involve invasive, intrusive or potential harmful procedures of any kind?	No
Could your research induce psychological stress or anxiety, cause harm or have negative consequences for the participants or researchers (beyond the risks encountered in normal life)?	No
Will your research involve prolonged or repetitive testing?	No
What are the potential adverse consequences for research participants and how will you minimise them?	
The questions asked should not cause any adverse consequences. I could refer them to a suitable hard of hearing/deaf organisation that provide comfort and support, if they are not already a member.	

Consent	
Describe the process that you will be using to obtain valid consent for participation in the research activities. If consent is not to be obtained explain why.	
Participant agreement form for adults will be the method of obtaining valid consent. A gatekeeper for an organisation must not affect the participants consent. The consent form must be read and signed before any questions related to the study is asked.	
Do your participants include adults who lack/may lack capacity to give consent (at any point in the study)?	No
Will it be necessary for participants to take part in your study without their knowledge and consent?	No

Participant Withdrawal
At what point and how will it be possible for participants to exercise their rights to withdraw from the study?
During the questionnaire, the participants reserve the right to withdraw. Online questionnaires would simply require exiting/closing the survey and not submitting it. Participants answering a questionnaire in-person can verbally or physically withdraw at any time.
If a participant withdraws from the study, what will be done with their data?
Data collected during questionnaires may be considered personal; including experiences and characteristics, however it will not be identifiable data. If a person withdraws from the study whilst they're completing the questionnaire, no data will be submitted or used. However, once the questionnaire is submitted, they will no longer have access to the data or be able to withdraw it. Participants who complete a questionnaire in person have the right to withdraw whilst they're completing it; however I will not be collecting names or identifiable-personal information. They may not be able to withdraw their data after submitting the questionnaire.

Participant Compensation	
Will participants receive financial compensation (or course credits) for their participation?	No
Will financial or other inducements (other than reasonable expenses) be offered to participants?	No

Research Data	
Will identifiable personal information be collected, i.e. at an individualised level in a form that identifies or could enable identification of the participant?	No
Will research outputs include any identifiable personal information i.e. data at an individualised level in a form which identifies or could enable identification of the individual?	No

Storage, Access and Disposal of Research Data	
Where will your research data be stored and who will have access during and after the study has finished.	
Research data will be stored using online cloud-based software, using google forms to record the data and upload it to a spreadsheet (google sheets). Only I will have access to the data during and after the study has finished. The participant has the ability to review and change/withdraw from the study until they submit the form, at which point they loose access to the data.	
Once your project completes, will your dataset be added to an appropriate research data repository such as BORDaR, BU's Data Repository?	No
Please explain why you do not intend to deposit your research data on BORDaR? E.g. do you intend to deposit your research data in another data repository (discipline or funder specific)? If so, please provide details.	
Project related undergraduate research.	

Final Review	
Are there any other ethical considerations relating to your project which have not been covered above?	No

Risk Assessment	
Have you undertaken an appropriate Risk Assessment?	Yes

Filter Question: Does your study involve the use or re-use of data which will be obtained from a source other than directly from a Research Participant?

Additional Details	
Please describe the data, its source and how you are permitted to use it	In this case, I will only be using data obtained directly from the participant.

Attached documents
Advertisement (G2).pdf - attached on 26/10/2023 16:56:11
Advertisement (G1).pdf - attached on 26/10/2023 16:56:30
Ethics Questionnaire G2.pdf - attached on 26/10/2023 16:56:41
Ethics Questionnaire G1.pdf - attached on 26/10/2023 16:56:54
Participant Agreement Form (Ethics).docx - attached on 26/10/2023 16:57:28
Participant Information Sheet (Ethics) v2.docx - attached on 27/10/2023 12:20:19

Ref & Version: PAF V1
Ethics ID number: 52396
Date: 23/10/2023

Participant Agreement Form

Full title of project: A visual and sensory alarming device that alerts deaf and hard of hearing users to a fire.

Name, position and contact details of researcher: Rian Tobias Edmondson – Product Design Bsc (undergraduate student) - S5310597@bournemouth.ac.uk

Name, position and contact details of supervisor: John Powell – Supervisor [Senior Lecturer in Design and Engineering] - jpowell@bournemouth.ac.uk

To be completed prior to data collection activity

Section A: Agreement to participate in the study

You should only agree to participate in the study if you agree with all the statements in this table and accept that participating will involve the listed activities.

I have read and understood the Participant Information Sheet (PIS001 V1) and have been given access to the BU Research Participant Privacy Notice which sets out how we collect and use personal information (https://www1.bournemouth.ac.uk/about/governance/access-information/data-protection-privacy).
I have had an opportunity to ask questions.
I understand that my participation is voluntary. I can stop participating in research activities at any time without giving a reason and I am free to decline to answer any particular question(s).
I understand that taking part in the research will include the following activity/activities as part of the research: • my words will be quoted in publications, reports, web pages and other research outputs without using my real name.
I understand that, if I withdraw from the study, I will also be able to withdraw my data from further use in the study **except** where my data has been anonymised (as I cannot be identified) or it will be harmful to the project to have my data removed.
I understand that my data may be used in an anonymised form by the research team to support other ethically approved research projects in the future, including future publications, reports or presentations.

Bournemouth University

Participant Information Sheet

The title of the research project

A visual and sensory alarming device for deaf and hard of hearing people.

Invitation to take part:

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part.

What is the purpose of the project?

The purpose of the project is to develop a portable, visual and sensory alarming device for deaf and hard of hearing individuals. The device will detect sound frequencies of nearby fire/smoke alarms and alert the user through visual and sensory components (i.e. LEDs or vibration motors); the device will filter out unwanted frequencies to be reliable regardless of its environment.

The aim of the project is to produce a versatile product that can be used when the individual is travelling alone, it should provide comfort and a reliable function. It should alert the user to any active nearby fire/smoke alarms.

The project will be taking place until the 21st June 2024.

Why have I been chosen?

You have been chosen as a participant as you fit within the inclusion/exclusion criteria for this study and are a valued source of information for the development of my project.

You have been chosen under the following criteria -
You must either:

- Currently work for the fire service
- Have experience responding to fire emergencies.

Or:

- Be over eighteen years old.

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- Have high-frequency hearing loss.
- Consider themselves profoundly hard of hearing or deaf.
- Be enrolled in education or have a part-time/full-time job.
- Have travelled without supervision.
- Taken part in a fire evacuation drill.
- They have had a hearing test (seen by an audiologist) regarding their hearing loss.

Do I have to take part?

It is up to you to decide whether to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a participant agreement form. We want you to understand what participation involves, before you decide on whether to participate.

If you or any family member have an on-going relationship with BU or the research team, e.g. as a member of staff, as student or other service user, your decision on whether to take part (or continue to take part) will not affect this relationship in any way.

Can I change my mind about taking part?

Yes, you can stop participating in study activities at any time and without giving a reason.

If I change my mind, what happens to my information?

After you decide to withdraw from the study, we will not collect any further information from or about you.

As regards to the information we have already collected before this point, your rights to access, change or move that information are limited. This is because we need to manage your information in specific ways for the research to be reliable and accurate. Further explanation about this is in the Personal Information section below.

What would taking part involve?

Answering an online or physical questionnaire.

Will I be reimbursed for taking part?

Unfortunately, you will not be reimbursed for taking part in the questionnaire.

What are the advantages and possible disadvantages or risks of taking part?

Whilst there are no immediate benefits for those people participating in the project, it is hoped that this work will lead to the development of an affordable visual/sensory aid that can be relied upon in any situation. This project is about exploring the challenges of a deaf/hard of

hearing individual during a fire evacuation drill and attempting to alleviate associated health risks.

There should be no possible disadvantages or risks associated with the study. If a participant takes a long period of time to finish the questionnaire, it might induce eyestrain; the participant is advised to take breaks every 20 minutes.

What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives?

Qualitative and quantitative (written and numerical based) responses. This will provide clear statistics as well as more personal written answers and opinions. These responses will help to corroborate secondary research I have conducted and to identify new data.

Will I be recorded, and how will the recorded media be used?

You will not be recorded at any stage of the study.

How will my information be managed?

Bournemouth University (BU) is the organisation with overall responsibility for this study and the Data Controller of your personal information, which means that we are responsible for looking after your information and using it appropriately. Research is a task that we perform in the public interest, as part of our core function as a university.

Undertaking this research study involves collecting and/or generating information about you. We manage research data strictly in accordance with:

- Ethical requirements and
- Current data protection laws. These control use of information about identifiable individuals, but do not apply to anonymous research data: "anonymous" means that we have either removed or not collected any pieces of data or links to other data which identify a specific person as the subject or source of a research result.

BU's Research Participant Privacy Notice sets out more information about how we fulfil our responsibilities as a data controller and about your rights as an individual under the data protection legislation. We ask you to read this Notice so that you can fully understand the basis on which we will process your personal information.

Research data will be used only for the purposes of the study or related uses identified in the Privacy Notice or this Information Sheet. To safeguard your rights in relation to your personal information, we will use the minimum personally identifiable information possible and control access to that data as described below.

Publication

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You will not be able to be identified in any external reports or publications about the research without your specific consent. Otherwise, your information will only be included in these materials in an anonymous form, i.e. you will not be identifiable.

Security and access controls
BU will hold the information we collect about you in hard copy in a secure location and on a BU password protected secure network where held electronically.

Personal information which has not been anonymised will be accessed and used only by appropriate, authorised individuals and when this is necessary for the purposes of the research, or another purpose identified in the Privacy Notice. This may include giving access to BU staff or others responsible for monitoring and/or audit of the study, who need to ensure that the research is complying with applicable regulations.

Data recorded will be kept anonymous and will not require personal information.

All recorded information will be stored on a password-protected computer.

Further use of your information
The information collected about you may be used in an anonymous form to support other research projects in the future and access to it in this form will not be restricted. It will not be possible for you to be identified from this data.

Keeping your information if you withdraw from the study
If you withdraw from active participation in the study, we will keep information which we have already collected from or about you, if this has on-going relevance or value to the study. As explained above, your legal rights to access, change, delete or move this information are limited as we need to manage your information in specific ways for the research to be reliable and accurate. However, if you have concerns about how this will affect you personally, you can raise these with the research team when you withdraw from the study.

You can find out more about your rights in relation to your data and how to raise queries or complaints in our Privacy Notice.

Retention of research data

Project governance documentation, including copies of signed **participant agreements**: we keep this documentation for a long period after completion of the research, so that we have records of how we conducted the research and who took part. The only personal information in this documentation will be your name and signature, and we will not be able to link this to any anonymised research results.

Research results:

Version: PIS V1
Ethics ID: 52396
Date: 23/10/2023

As described above, during the course of the study we will anonymise the information we have collected information about you as an individual. This means that we will not hold your personal information in identifiable form after we have completed the research activities.

You can find more specific information about retention periods for personal information in our Privacy Notice.

We keep anonymised research data indefinitely, so that it can be used for other research as described above.

Contact for further information

If you have any questions or would like further information, please contact:
Rian Edmondson – S5310597@bournemouth.ac.uk
John Powell - jpowell@bournemouth.ac.uk

In case of complaints
Any concerns about the study should be directed to John Powell. If you concerns have not been answered by Rian Edmondson, you should contact professor Tiantian Zhang, faculty of Science and Technology, Bournemouth University by email to researchgovernance@bournemouth.ac.uk.

Finally

If you decide to take part, you will be given a copy of the information sheet and a signed participant agreement form to keep.

Thank you for considering taking part in this research project.

Appendix E - Questionnaires (G1/G2)

Jisc Online surveys

A visual and sensory alarming device for hard of hearing individuals (G1)

Showing 6 of 6 responses
Showing **all** responses
Showing **all** questions
Response rate: 6%

1 Have you read the participant information sheet provided?



2 Do you agree to participate in the study?



3 How regularly do you travel inside of the United Kingdom?

Showing all 5 responses	
monthly	1110556-1110538-118515089
Daily? Assuming this includes driving not just public transport	1110556-1110538-118515899
Daily	1110556-1110538-118517796
Every day	1110556-1110538-118645359
Occasionally	1110556-1110538-118739911

4 How regularly do you travel outside of the United Kingdom?

1 / 6

Showing all 5 responses	
occasionally	1110556-1110538-118515089
Once a year	1110556-1110538-118515899
Yearly	1110556-1110538-118517796
Rarely	1110556-1110538-118645359
Once in a while but not since Covid pandemic	1110556-1110538-118739911

5 Do you currently use/own any products or systems that would aid you during a fire? (If so, what are they?)

Showing all 5 responses	
at home, have a bellman pager system linked to smoke alarm and alerts me via pager or under pillow vibration	1110556-1110538-118515089
Yes - at work I have a bleep that is activated every time a fire alarm goes off in the building. It vibrates loudly and is a clip on device in one location and like a mobile phone that goes in my pocket at a second location. Nothing for inside the house or in public	1110556-1110538-118515899
Flashing alarm	1110556-1110538-118517796
Fire alarm for deaf. Alarm lights up. I have been given a pager but never take it with me or use it	1110556-1110538-118645359
No.	1110556-1110538-118739911

6 In your opinion, does your work (or educational institution) provide adequate visual alarming device(s) to accomodate for your lack of hearing?

Showing all 5 responses	
n/a	1110556-1110538-118515089
Yes and no- it took me a long time to be able to get the devices. They didnt teach me how to use it properly. It also goes off weekly when there is a fire alarm test which can be annoying. I am also charged myself if it gets lost	1110556-1110538-118515899
Yes	1110556-1110538-118517796
No	1110556-1110538-118645359
Used to be but im no longer working	1110556-1110538-118739911

7 At work (or your educational institution) are you required to use a pager for fire safety?

Showing all 5 responses	
n/a	1110556-1110538-118515089
I have a pager but no one else does - mine was provided for my hearing loss. It vibrates.	1110556-1110538-118515899
No	1110556-1110538-118517796
No	1110556-1110538-118645359
Pager no, my work has visual flashing lights.	1110556-1110538-118739911

8 Do you require a vibration pad when sleeping? (If so, what are some issues you associate with the product?)

Showing all 5 responses	
yes - won't hear an alarm as profoundly deaf. Problem is not knowing straight away what the problem is - my clock also has a vibration pad.	1110556-1110538-118515089
Probably should have one but I do not as when I was at university they supplied me one when on campus. It would activate at times when the alarm did not go off, and other times didn't go off when the main alarm apparently did	1110556-1110538-118515899
No	1110556-1110538-118517796
I do. Very strong vibration alarm. Very good. No issues	1110556-1110538-118645359
Yes its a must as at work we had some sleepover nights.	1110556-1110538-118739911

9 Do you require NHS funding to obtain fire safety products (for use at home?)

Showing all 5 responses	
council funding yes as expensive	1110556-1110538-118515089
I have PIP but no NHS funding	1110556-1110538-118515899
No	1110556-1110538-118517796
Yes	1110556-1110538-118645359
NHS? Not really, social services usually provides them.	1110556-1110538-118739911

10 How would a portable fire-alarming product increase your confidence when alone?

Showing all 5 responses	
while out and about, it would allow me to relax a bit more and not worry about having to use a cochlear implant at all times	1110556-1110538-118515089
Very much so! As long as it is small and easy to use I would always have it with me	1110556-1110538-118515899
Unsure	1110556-1110538-118517796
Already have a pager but don't use it	1110556-1110538-118645359
Some supermarkets do offer pagers but not sure which one.	1110556-1110538-118739911

11 Do you consider most fire safety products on the market for deaf and hard of hearing individuals to be overly expensive? (If so, what price would you consider reasonable for an assistive device?)

Showing all 5 responses	
Very expensive. Most are not portable so can't take away. Costs are higher for disabled people due to equipment costs so cheaper the better	1110556-1110538-118515089
Have not looked before as did not know any were out there. Wouldn't want to pay unless is recommended by audiologist/ GP etc Maybe around £50 mark?	1110556-1110538-118515899
No	1110556-1110538-118517796
I dont know as I get it all free from NHS Free fire alarm system with light flasher and vibration pager. Doorbell light flash and vibration pager. The vibration pager is for doorbell and fire alarm.	1110556-1110538-118645359
I know they're expensive but most of us receive DLA/PIP and they are there to use to buy their own equipment when needed.	1110556-1110538-118739911

12 How long have you had (high-frequency) hearing loss?

Showing all 5 responses	
since birth	1110556-1110538-118515089
Since birth (now 24) but was diagnosed age 7	1110556-1110538-118515899
No	1110556-1110538-118517796
38 years	1110556-1110538-118645359
Since birth.	1110556-1110538-118739911

13 If you experienced hearing loss; was it gradual or sudden?

Showing all 5 responses	
born with it	1110556-1110538-118515089
N/a	1110556-1110538-118515899
No	1110556-1110538-118517796
Sudden	1110556-1110538-118645359
Totally deaf.	1110556-1110538-118739911

14 Do you believe your lack of hearing was untreated/undiagnosed for a period of time? (If so, please explain how and why)

Showing all 5 responses	
no, discovered at 6 months of age	1110556-1110538-118515089
Was not recognised until I was 7 years old but have had since I was born Sister got diagnosed after me for same hearing loss. Recently she got cochlear implant but I'm in a different area with different criteria so I do not qualify	1110556-1110538-118515899
No	1110556-1110538-118517796
Had a csr crash when I was 9 years old which damaged my hearing nerves that instantly made me deaf. There was a bone in my neck that was jamming the hearing nerves. If hospital had of x Ray that area. They could of moved the bone and free hearing nerves before they got too damaged. But no x Ray was given till a few years later. By that time the bone had settled into place damaging the nerves beyond repair. Doctors said if had of treated damaged area early I could of had my hearing saved. But due to bone healing over trapped nerves. Nerves become in repairable and doctors said. Moving the bone to free the nerves at that time was a percentage of chance I could bexbrain damaged in the process so decided not to go ahead with operation.	1110556-1110538-118645359
Born deaf br didn't diagnosed until I was about 14months old, that was 60+yrs ago. Now most babies are tested one or two days old.	1110556-1110538-118739911

15 At home, do you have an alarming device (to assist you during a fire) in each room and outside? (If not, which rooms currently lack them?)

Showing all 5 responses	
pager system so wear around the house	1110556-1110538-118515089
No	1110556-1110538-118515899
Yes	1110556-1110538-118517796
Alarming devise is in living room only	1110556-1110538-118645359
Don't have one here yet.	1110556-1110538-118739911

16 Do you take part in any activities that would make a wearable design inconvenient?

Showing all 5 responses	
swimming, horse riding etc.. would need to be waterproof and small - small watch/bracelet size	1110556-1110538-118515089
I play sports but these are outside so would not require it for that	1110556-1110538-118515899
Yes	1110556-1110538-118517796
Yes	1110556-1110538-118645359
Not at this moment	1110556-1110538-118739911

17 Would you prefer a product that is colourful or more subtle?

Showing all 5 responses	
depends on what I wear tbh! But something that looks good in all situations	1110556-1110538-118515089
Colourful so it is easily recognisable by workers in shops / emergency crew etc to recognise my hearing loss	1110556-1110538-118515899
Subtle	1110556-1110538-118517796
More subtle	1110556-1110538-118645359
Subtle. Some may want them visible, some want them hidden.	1110556-1110538-118739911

Jisc Online surveys

A visual and sensory alarming device for hard of hearing individuals (G2)

Showing 6 of 6 responses

Showing **all** responses

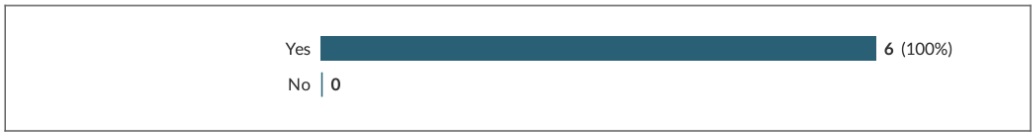
Showing **all** questions

Response rate: 6%

1 Have you read the participant information sheet provided?



2 Do you agree to participate in the study?



3 What fire safety precautions do you currently advise hard-of-hearing/deaf individuals to take for their safety?

Showing all 5 responses	
We currently provide a deaf alert as part of out safe and well service if the occupant cannot hear the normal alarm without their hearing aid	1110588-1110570-118501683
Vibrating device and flashing beacon	1110588-1110570-118507194
Currently i install Fire Hawk control units and Fire angel smoke and c0 detectors. I also advise client to have installed if possible monitored assistive tech to support them to live independently at home.	1110588-1110570-118550886
I work with children and young people, the advice we give them (depending on their age) sis 1) talk to their adults about their fire safety 2) if possible get a speciality smoke alarm 3) how they can text 999 if needed	1110588-1110570-118652239
This depends on the situation if the I am making a recommendation an individual within a single private domestic dwelling then there details will be forwarded to our safe and well teams to provide support and ultimately provide a solution. however, if the premises is regulated by DWFRS under the Fire Safety Order, then the recommendation will be that the Responsible Person needs to engage with a suitably competent risk assessor to ensure that the needs of vulnerable persons are considered and that the appropriate measures are in place. If we feel that vulnerable persons are at significant risk then we may take formal action.	1110588-1110570-118850727

4 What are some improvements you've recognised in fire-safety standards in recent years?

Showing all 5 responses	
The regulatory reform act has seen improvements. Also the The Fire Safety (England) Regulations 2022 and the new 2023 Regulations.	1110588-1110570-118501683
Access to deaf sleeping devices has become easier	1110588-1110570-118507194
The ability to link stand alone smoke alarms and the fact the more people are becoming aware of the risks in not having a working alarm installed and tested.	1110588-1110570-118550886
I deal more with the actions of children/ young people so don't really look at fire safety standards, we focus more on not touching matches, care with electicity, cooking etc	1110588-1110570-118652239
As a result of the Grenfell Tower disaster new legislation has been introduced to bolster the existing legislation, the regulatory bodies have increased their department sizes to support the increasing workloads as a result of government initiatives, and training to frontline operational staff has also increased t recognise failings within fire safety. Increased engagement with responsible persons and greater appetite to issue formal notifications and even prosecute. Greater requirements for professional persons to demonstrate competence through recorded CPD and third-party accreditation.	1110588-1110570-118850727

5 In your experience, how instrumental are early fire-warning systems in preventing injury?

Showing all 5 responses	
Very. There are many recorded incidents where lives and property have been saved due to fire detection and warning systems	1110588-1110570-118501683
Very - critically important	1110588-1110570-118507194
Working smoke alarms saves life's and everyone should have one installed	1110588-1110570-118550886
Incredibly important - having working smoke alarms and knowing what to do if it detects fire is the number one safety message we teach	1110588-1110570-118652239
In all cases, early notification is a fundamental part of fire safety, so much so that it has its own article within the Fire Safety Order. However, it is important that human behaviour is considered as well as the occupancy of the premises, often the appropriate notification system will reduce the Required Safe Egress Time (RSET) combined with good management and training to ensure all persons are notified and able to escape safety line with the evacuation strategy.	1110588-1110570-118850727

6 In your opinion, how could a visually alarming device (VAD) leave a deaf/hard of hearing individual vulnerable to a fire?

Showing all 5 responses	
Some premises do not have a VAD. E.g. if the individual is visiting a private building without smoke detection or VAD or the VAD is in bright sunlight.	1110588-1110570-118501683
If sleeping they may not see the visual device resulting in serious injury or death.	1110588-1110570-118507194
It the client was unable to see a flashing beacon because they were asleep the alarm would not be effective in helping them escape a fire.	1110588-1110570-118550886
If they are not in the room where the visual alarm they may not be alerted to the fire. If they are asleep and the light doesnt wake them. If they are away from home, can they take it with them? ie do children/ teenagers miss events such as sleepovers as they have no alarm syste, or do they put themselves at risk?	1110588-1110570-118652239
The key term we consider is appropriate, a VAD is appropriate for persons that are alert, awake, familiar and under some control of a responsible person, e.g, an office full of employees, as opposed to a hotel where persons may neither be awake, alert, or familiar, in such environments further measures would need to implement to ensure compliance.	1110588-1110570-118850727

7 How do you account for deaf/hard-of-hearing individuals during a fire evacuation? (Do you have to consider the possibility they are unaware of a fire)?

Showing all 5 responses	
DWFRS promotes the use of PEEPS https://www.gov.uk/government/consultations/personal-emergency-evacuation-plans These will enable attending fire crews to understand the risk of a person not evacuating. However PEEPS are not always used	1110588-1110570-118501683
In premises covered by the fire safety order (FSO) the responsible person should have considered 'those especially at risk' as part of their fire risk assessment. Person emergency evacuation plans (PEEP) should be in place to support their safe evacuation prior to FRS arriving on scene. In domestic premises not covered by the FSO consideration needs to given (by the FRS commander) to occupants that may not of heard an alarm.	1110588-1110570-118507194
I'm unable to answer this question and as don't deal with large groups of people that need evacuating.	1110588-1110570-118550886
for children and young people we teach have a meeting point / follow the escape plan discussed with your adults, this doesnt account for their location though and doesn't help at an incident	1110588-1110570-118652239
This depends on the types of premises, in a building containing flats or a hotel for example then yes significant consideration must be given to the fact that persons may be aware or even decide not to evacuate, however for premises that a the Responsible Person had a greater level of control then we would expect that these considerations would have been made, however, these should not be relied on. during an incident, it is important that we meet with the point of contact (more likely for a place of work) and we are able to determine whether all persons are accounted for.	1110588-1110570-118850727

8 In your opinion, how would a portable assistive device aid the hard of hearing during everyday life?

Showing all 5 responses	
It would reduce the risk to the individual of not evacuating in a fire situation	1110588-1110570-118501683
It would support people away from their home/usual hardwired devices to evacuate should a fire occur. It may also support responsible persons under the fire safety order by providing a fire safety system to protect those especially at risk.	1110588-1110570-118507194
I can imagine that this type of device would be very empowering to an individual and would support them to and enable them to live independently. To move freely from private to domestic properties would be helpful.	1110588-1110570-118550886
freedom with the security of safety. from a children/young people's view - this would aid them to be able to participate in activities with their peers (such as sleepovers) with the additional safety mesaures to be alerted to a possible fire their hearing peers have in place. It think it would be an incrediable device	1110588-1110570-118652239
This would be an ideal solution, however, it depends on how the device is managed, does it have a British Standard or other form of best practice code, how often is it tested and maintained can without question the device be relied on to operate in all circumstances and instances, what type of fail-safe id there imbedded into the system.	1110588-1110570-118850727

9 Some competitor products are considered "prohibitively expensive"; what price would you consider affordable/appropriate for a portable assistive device?

Showing all 5 responses	
£40 - £50	1110588-1110570-118501683
For commercial premises I feel £1K to £2K would be reasonable For domestic use this price maybe to high and £1K would be reasonable. If I was deaf I would happily pay £1K to support my safety.	1110588-1110570-118507194
under 100 pound	1110588-1110570-118550886
I am not sure, I dont work with the budget which is for devices the fire service currently give away. However, if I was a parent/carer concerned about giving my child freedom but also knowing they are safer I would be willing to spend the money . Sorry this isnt a helpful answer	1110588-1110570-118652239
A good question, this is not really something I can comment on, however being expensive means it won't be utilised especially if this is optional and your target customer is members of the public. If it is being considered for Responsible Persons to use/consider then higher purchase prices may not be a larger issue, however, would still need to be measured against other solutions, let us not forget that a solution to this may be to give further training to a member of staff to ensure those persons whom this is being developed for is notified in the event of an emergency.	1110588-1110570-118850727

10 Do you educate fire safety to hard of hearing/deaf communities? (If so, what's some key advice you give them)?

Showing all 5 responses	
We will educate any groups that approach the service. Please see specific advice below https://www.dwfire.org.uk/safety/advice-for-carers/hearing-and-sight-difficulties/#:~:text=Hearing%20difficulties&text=Please%20contact%20us%20via%20email,telecare%2C%20carecall%20or%20lifeline%20system.	1110588-1110570-11850168
Yes, through Safe and Well visits. Covering safety in the home and what to do if a fire occurs.	1110588-1110570-11850719
I visit individual clients in their own homes. I offer a safe and well visit and i explain about the dangers of smoking, candles, poor electrics emollients and medication, white goods and many others things that may put people at a higher risk of fire.	1110588-1110570-11855088
https://www.dwfire.org.uk/safety/advice-for-carers/hearing-and-sight-difficulties/ children and young people - same education as their peers, but we talk about being able to have specialised alarms and how to text 999	1110588-1110570-11865223
Most of if not all my engagement is with those regulated individuals such as the Responsible Persons or their nominated representative, by ensuring they comply with the legislation such as having a suitable risk assessment in place we can conclude that they are implementing the appropriate measures to ensure that vulnerable persons remain safe. This is done by carrying out inspections of specific high-risk premises or by responding to compliant submissions.	1110588-1110570-11885072

11 Do you regularly advise an institution/public building's fire safety measures? (If so, what commonly requires improving/changing)?

Showing all 5 responses	
Blocked emergency escape routes, insufficient risk assessments, no detection or insufficient detection	1110588-1110570-118501683
DWFRS fire safety team will provided advice and enforcement as required by the Fire Safety Order	1110588-1110570-118507194
No	1110588-1110570-118550886
no	1110588-1110570-118652239
Unfortunately not really a question I can have an answer for, however, these types of premises usually have good management systems in place.	1110588-1110570-118850727

Product Design Specification

Project Title: A visual and sensory alarming device for deaf and hard of hearing adults.

Student Name: Rian Tobias Edmondson (S5310597)

#	Revision:	Date:
1.	Initial revision – Updated sections [1.1, 1.1.1, 1.2, 1.2.1, 1.3, 1.4, 1.5, 1.6, 1.6.1]	10/10/2023
2.	Revision 1 – Updated sections [2.1, 2.1.1, 2.1.2, 2.1.3, 2.2, 2.3, 2.3.1, 2.4, 2.5, 2.6, 2.6.1, 2.7]	15/10/2023
3.	Revision 2 – Updated sections [3.1, 3.2, 3.3, 3.3.1, 3.4]	16/10/2023
4.	Revision 3 – Updated sections [2.8, 2.8.1, 2.8.2, 2.8.3]	19/10/2023
5.	Revision 4 – Updated sections [3.3, 3.3.1, 3.3.2, 3.3.3, 3.3.4]	19/10/2023
6.	Revision 5 – Updated sections [Figure 1, 1, 2, 3]	30/10/2023
7.	Revision 6 – Updated sections [All figures]	02/11/2023
8.	Revision 7 – British Fire/Smoke alarm tones	05/12/2023
9.	Revision 8 – Aesthetics	15/12/2023
10.	Revision 9 – Ergonomics	14/1/2024

1. Market:

1.1 – The product will be designed for a market size of nine-hundred thousand (Demographic - United Kingdom citizens that are severely or profoundly deaf) [1]
1.1.1 – Assuming the product reaches 3-5% of the total market size (in the UK); I am expecting to have an obtainable market size of between twenty-seven and forty-five thousand people.
1.2 – The market for deaf and hard of hearing individuals is widely spread; the product should be inclusive for all members of the community.
1.2.1 – The market includes those with secondary conditions – Deaf and hard-of-hearing individuals have a higher association with ADHD and ASD than average [2] – Maintaining and using the product must be intuitive for the user.
1.2.2 – Hard of hearing or deaf adults have a lower employment rate than the average UK citizen (sixty-five percent compared to seventy-nine percent) – The market is likely to be less able to afford an expensive product; it must be priced accordingly. [3]
1.2.3 – Of the 11 million deaf/hard-of-hearing adults in the UK, there are approximately 151,000 who use BSL (British sign language) [4]. 65% of this submarket cannot speak English; a percentage also cannot read English [5] – The product/product's marketing must be suitable for BSL users.
1.2.3.1 – The product should be marketed using BSL interpretation/captions to reach a higher quantity of users who are entirely deaf. [6]
1.2.3.2 – The product should have instructions in BSL, with captions.
1.3 – The product will not be designed for institutions, such as hospitals, hotels, and universities. The product will be designed for individual use.
1.3.1 – The product must be designed for adults who travel; it must be portable.
1.5 – Target groups for the product should include national charities (i.e. RNID) and deaf and HOH organisations (i.e. Bournemouth Deaf Club and Wiltshire & Dorset deaf association)
1.5.1 – Advertising the product to national charities and organisations would allow the product to reach a greater quantity of potential users. **[1.2.3]**
1.6 – The product must not be marketed unethically – Advertisements of the product should outline the realistic limits of the product - The user shouldn't have unrealistic expectations of the products' functionality.
1.7 – The price of the product should be dependent on the market. As the market is likely to be unable to afford an expensive product [1.2.1]; I should make the design affordable. The cost price of manufacturing my product should be low, making the trade and retail prices more affordable.
1.7.1 – The "recommended retail price" of my product should be under £100. Whilst there are no direct competitors for my product, other products designed to wake a deaf or hard of hearing person during a fire emergency are (typically) "prohibitively expensive". [7]
1.8 – The product should have a low environmental impact during manufacture, assembly, disassembly, and end-of-life processing (MADE)
1.9 – The design should be inclusive; it should be designed for adult (men and women) aged over 20 years old.
1.10 – Competitor products outlined in figure 1 are examples of assistive devices. To be competitive; the product must implement some/all the features stated. [13]

2. Function:

2.1 – The product should follow BS-EN54-23 requirements for 'O-type' VADs as guidance; a visual alarming device should maintain the following: (2.1.1 to 2.1.4) [7]
2.1.1 – The product must be capable of emitting 0.4 lux "on a surface perpendicular to the light emitted" to compete with competitive products. [7]
2.1.1.1 – COP0001 (External influences (i.e. ambient light) and multiplication factors) – An open space has considerably lower lux, compared to an enclosed area. The product will be designed on the basis that the user is typically inside. [12]
2.1.1.2 – The device must exceed 0.4 lux in an ambient light level (lux) of <100 to 800, to compare to competitive VADs. [11]
2.1.2 – Rate of flash must be between 0.5Hz and 2Hz to reduce the risk of it inducing a photosensitive seizure. [7]
2.1.4 – The device must emit white or red flashing light(s). [7]
2.2 – The product must have replaceable or rechargeable batteries.
2.2.1 – Access to the batteries (if rechargeable), must be "convenient" (i.e. through the use of a snap fit joint)
2.3 – The light emitted from the product should be visible in (high ambient) light conditions outside. [5.1]
2.3.1 – Where the light cannot be relied upon (high ambient light), a sensory output is required (i.e. using a vibrating motor).
2.4 – The light emitted must be clearly visible through the covering material of the product.
2.5 – The product, if removed, must be able to be strapped or clipped to a bag or belt to ensure the product is still useful during an emergency.
2.6 – The product must identify the sound/frequency of a fire alarm; filtering out other sounds and frequencies to reduce "false alarms".
2.6.1 – Modern fire/smoke alarms use a 'T3 tone' which can be identified as a pattern. A product that identifies the pattern would be more reliable at giving feedback. [11]
2.7 – The product should give tactile feedback to alert the user to a fire emergency; visual indicators shouldn't be solely relied upon.
2.9 – The product should have an IP rating of IP66
2.10.1 – The energy consumption of the product when idle should be low by comparison to the capacity of the battery.
2.11 – The product must reliably produce the same function – The market requires a reliable brand [1.6]

2.12 – As British fire/smoke alarms are non-standard tones/frequencies, the product will have to identify a range of suitable frequencies

2.12.1 – Eaton database provides the adequate frequencies [800-970Hz & 3100Hz] [13]

2.12.2 – Current software-based devices exist with various complications: The design should not include software (analogue) to preserve reliability.

2.13 – The device should indicate a low battery, allowing the user enough time to recharge or change the battery before it's inactive

3. Aesthetics:

3.1 – Following BS-EN54-23 requirements for 'O-type' VADs: coverage volume should be displayed on the product or supporting documentation. [7]

3.2 - The product should always be visible to ensure the users safety.

3.3 – The product is used in emergency situations and must draw the user's attention during a fire.

3.3.1 - When the product isn't being used, it should be subtle. [This would draw the user's attention to the product when it's activated.]

3.3.2 – When the product is active, it should use colours/light that has "negative connotations" of "emergency" and "danger", which also draw the user's attention.

3.3.3 – "Emotional context can alter colour's impact, both on attention and motor behaviour" – During a fire, or emergency, "signs that are vital for safety should use red to attract attention". [8]

3.3.4 – The light/colours used by the product should be easily distinguished. A characteristic flashing/changing colour may help the user understand the situation.

3.4 – The product must be intuitive for the user [1.2.1] - The product should feature "visual cues" (i.e. diagrams/text) to imply/remind the user how the product is used (and assembled/disassembled)

3.4.1 – "Sometimes, a simple colour palette is the perfect solution. Black and white eliminates the complexities of working with multiple colours while allowing enhancements of other design elements" – The product should highlight features by using sparse bright colours. [10]

3.5 – It is important the product draws inspiration from other modern wearable products, such as wristwatches, smartwatches, and other personal safety products.

3.5.1 – Individuals may wish to hide or keep their disability aid subtle or hidden; other individuals may not – The product must be customisable to suit the user's needs. [3.3.1]

3.6 – The branding of the company/product should follow the colours of the deaf community (Blue and yellow) to encourage deaf individuals to represent themselves. [Figure 2]

4. Ergonomics:

4.1.1 – The design should be inclusive [1.9]; the method of wearing/attaching the device should be ergonomic for men and women (over the age of 20).

4.2 – The product be designed to fit on a shoulder bag strap if removed by the user.

4.3 – The product should emit a light that is always visible, this means ensuring that the light is bright enough and that it is not obstructed by other objects (i.e. clothing).

4.4 – The product must be intuitive for the user [1.2.1]. It should be quick to remove or attach/wear the product.

4.4.1 – The method of attaching the product to the user's body should involve a simple mechanism (i.e., a clasp, clip, buckle or similar).

4.5 – The product should be a suitable weight to carry, it shouldn't be over 500 grams.

4.6 – The product must not restrict the user's body movements.

4.6.1 – The size of the product shouldn't exceed 10cm in length (smallest percentile of upper arm length [6], excluding shoulder length)

4.6.2 – The size of the product shouldn't exceed 6cm in width [6]

4.7 – The product must be easy to use for individuals with physical disabilities; interactive aspects of the product (i.e. the power button) must be clearly indicated and easily used.

4.7.1 – The 'power button' should be clearly indicated by the design. If a power button is not used, part of the casing should activate/deactivate the circuit (i.e a removable base).

4.8 – The removeable aspects of the casing should have ergonomic aspects (i.e notches for the user to grip)

4.9 – The removeable casing of the design should have a gasket that separates the components – This is to reduce the risk of the user injuring themselves by trapping their finger.

4.9.1 – The thickness of this gasket should be 1mm minimum to provide suitable compression.

4.10 – The design should feature ergonomic fittings that can be adjusted or removed to suit the user (i.e for desk use, the user should be able to remove the strap)

5. Materials, Standards & Manufacture:

5.1 - The product is portable and will be transported in different environmental conditions – It must be waterproof (IP66) and resistant to UV degradation. [2.9]

5.2 - The light emitted must be clearly visible through the covering material of the product [2.4] – The covering material of the product must be made of a transparent/translucent plastic (i.e. Acrylic, Butyrate, Lexan (polycarbonate), PETG et cetera.) [9]

5.3 – The product shouldn't restrict movement. [4.1.2] – The components in contact with the skin shouldn't feel "hard"; they should have plasticity.

5.3.1 – The casing should use elastomers where appropriate to cover hard surface(s).

5.4 – Manufacturing methods should take into consideration the market size [1.1] and the return on investment.

5.4.1 – The product must be designed for batch manufacture (due to the market size & requirement)

5.4.2 – Injection moulding may be a suitable option (i.e. assuming an obtainable market size of twenty-seven to forty-five thousand individuals; a product retailed at £50.00 would return £1,350,000 minimum in the UK alone).

5.4.2.1 – Complex injection moulding should be avoided (where possible) to limit manufacturing costs.

5.5 – The product will follow appropriate BSI standards (i.e. BS-EN54-23) to suit retail in the United Kingdom.

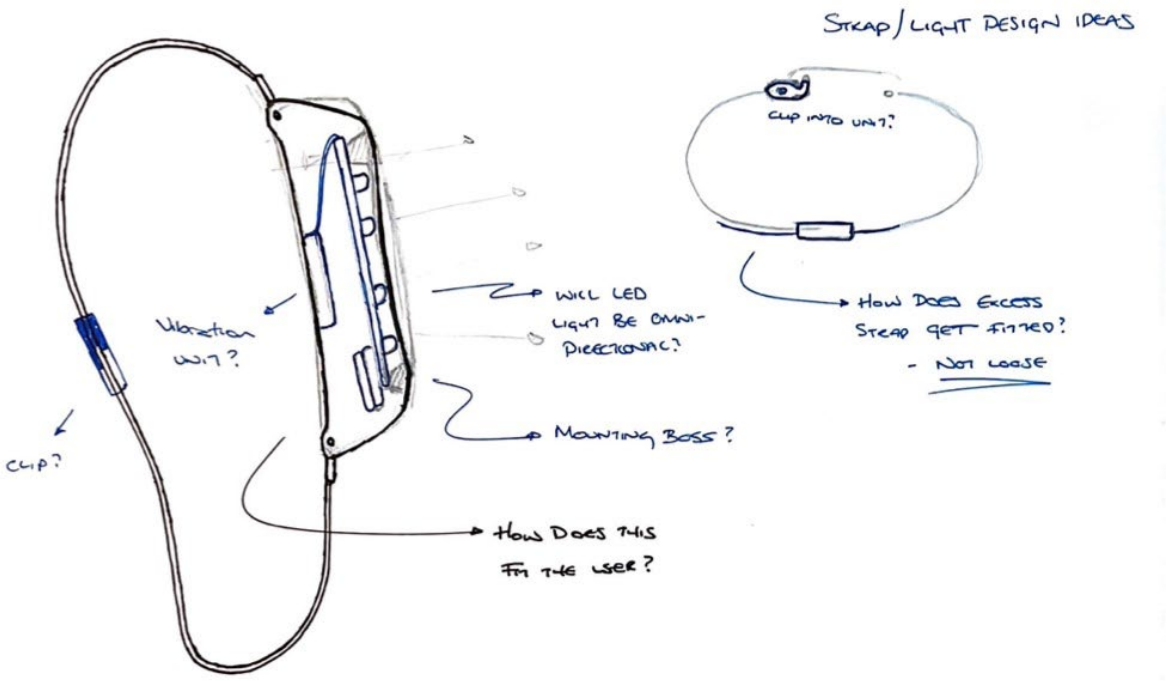
5.6 – The product should follow BS8887 standards.

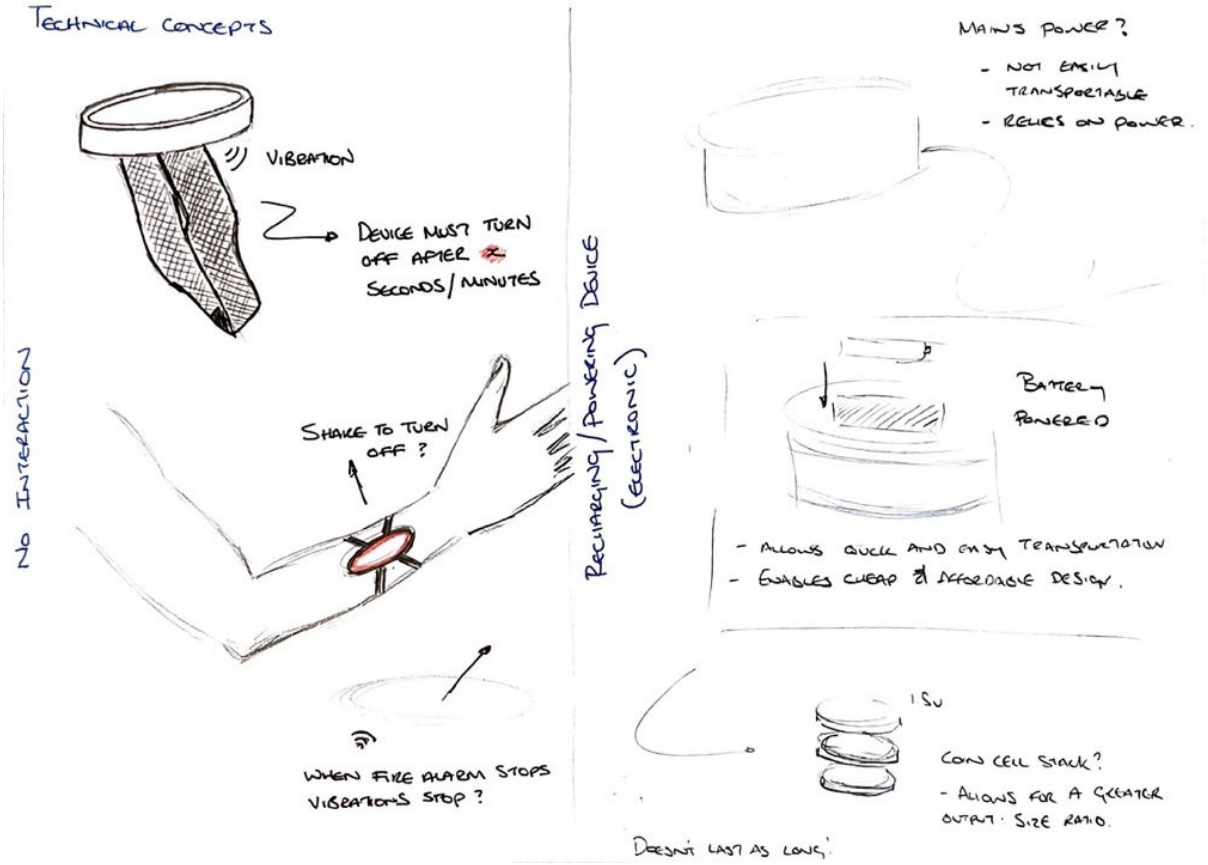
5.6.1 – Recyclable components should be able to be separated from any non-recyclable components (if necessary)

5.6.2 – WEEE legislation – Electronic items should be easily removed from the product's casing (i.e. batteries, PCBs, LEDs etc.)

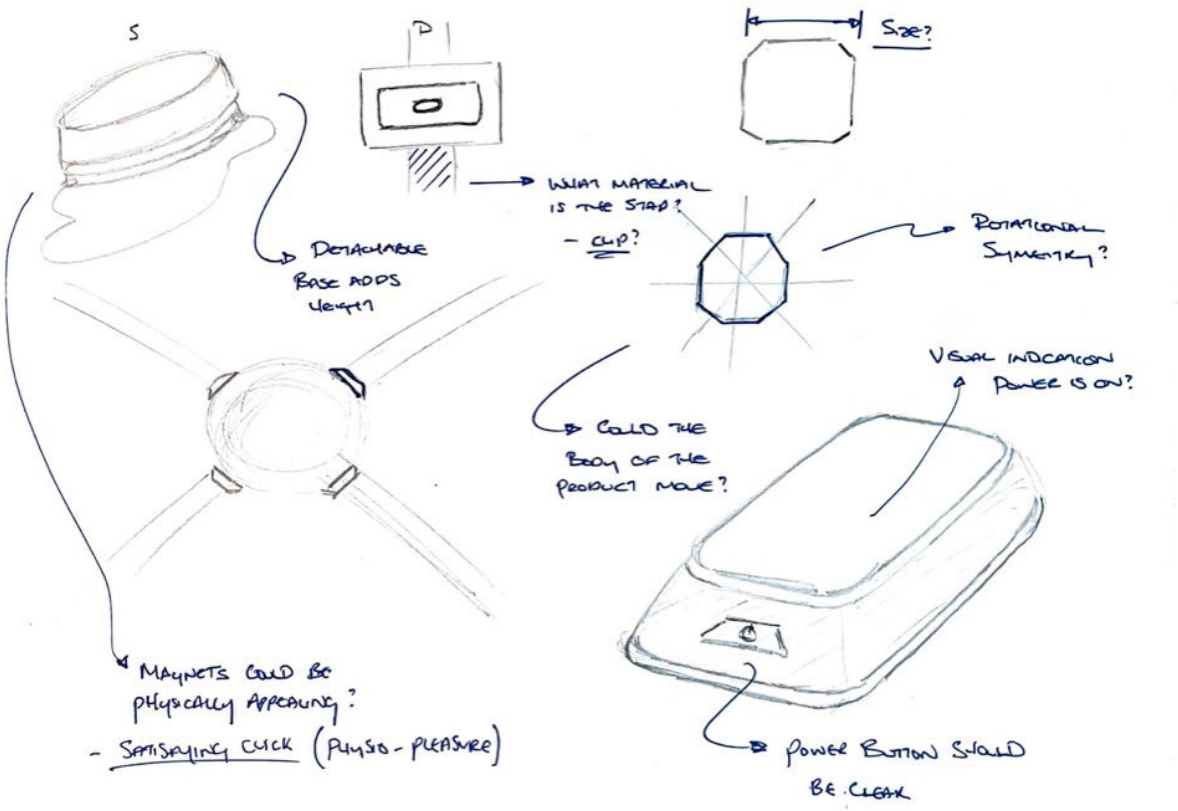
2.6.2.1 – The device should use limited adhesives to encourage the user to recycle the product at the end of it's life.

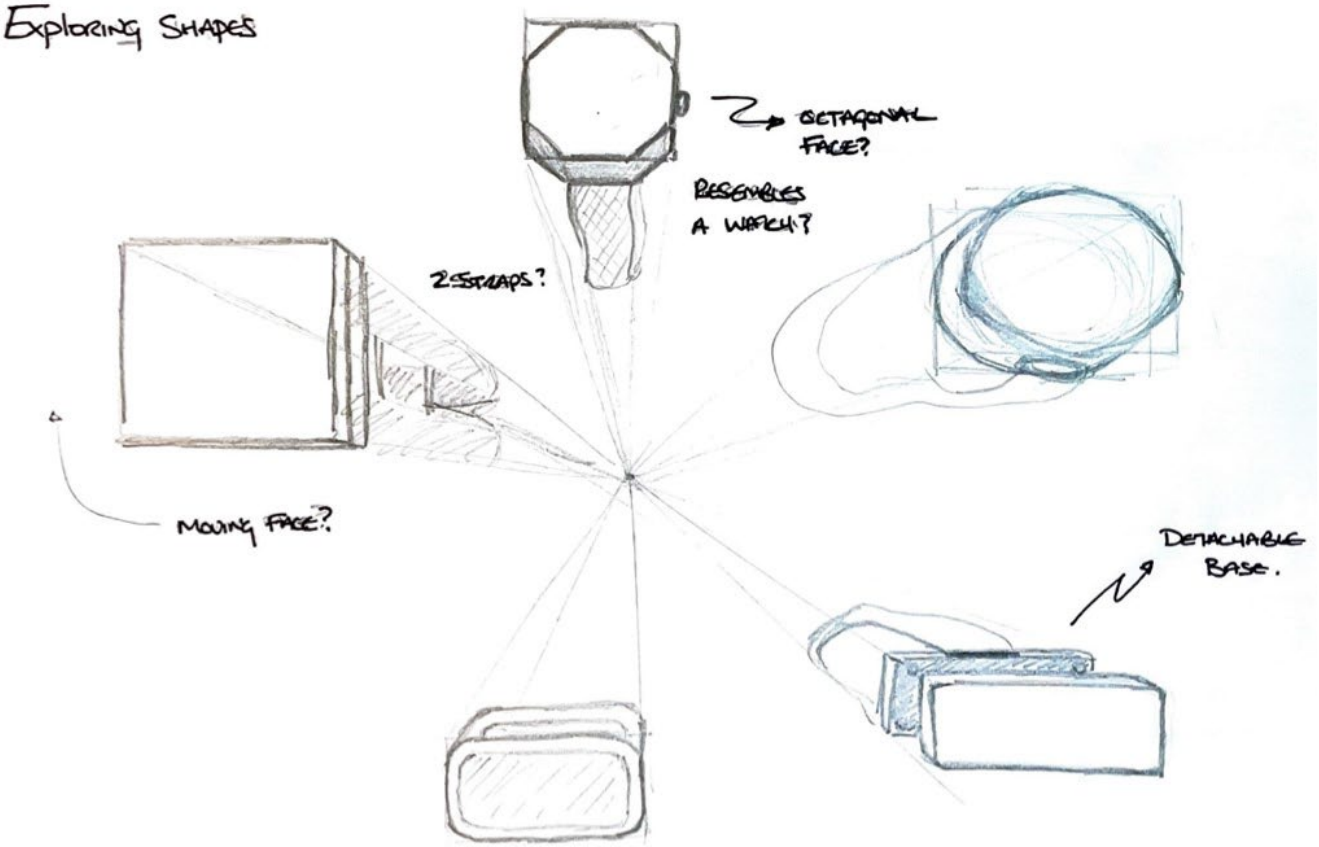
Appendix G – Technical Concepts

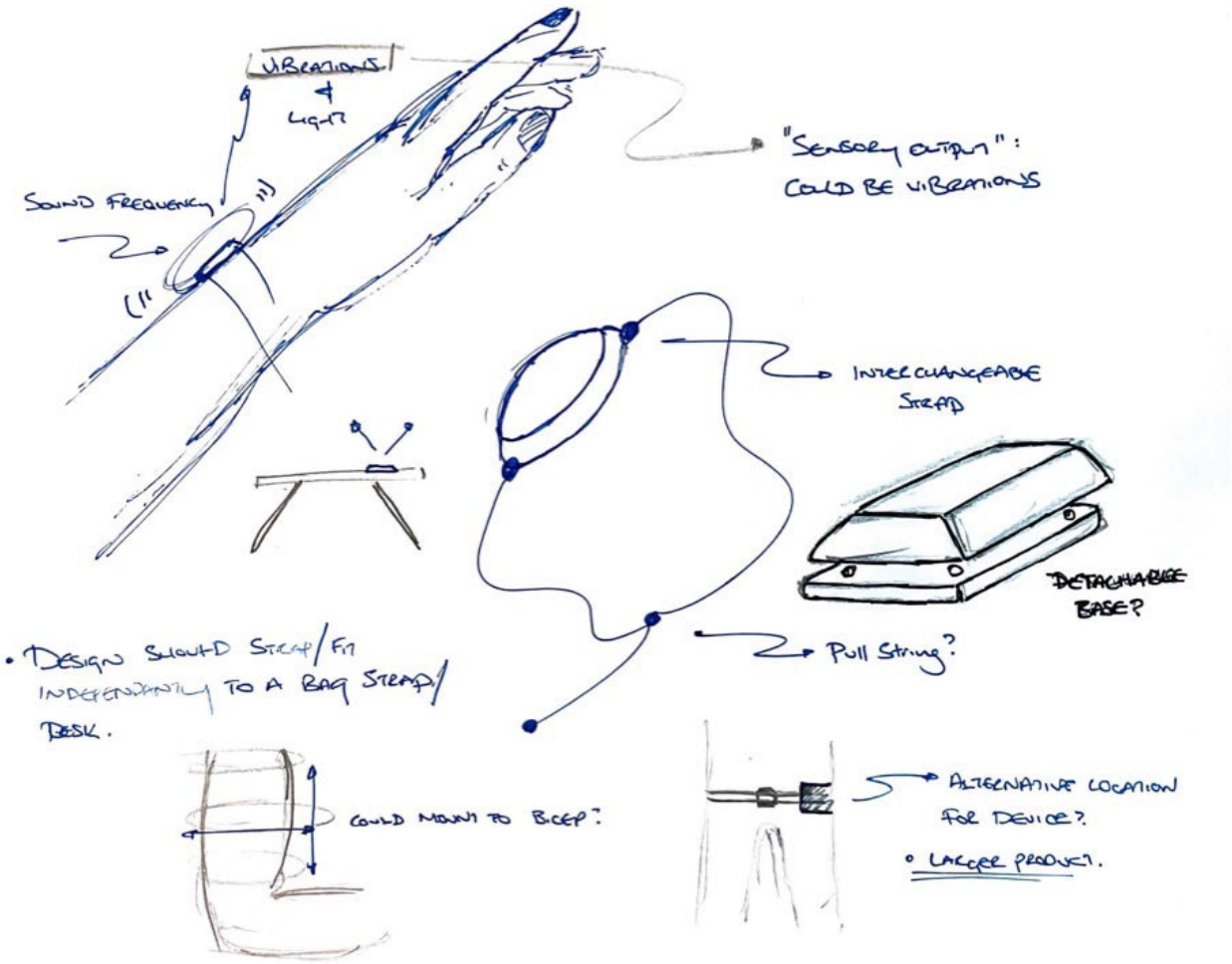


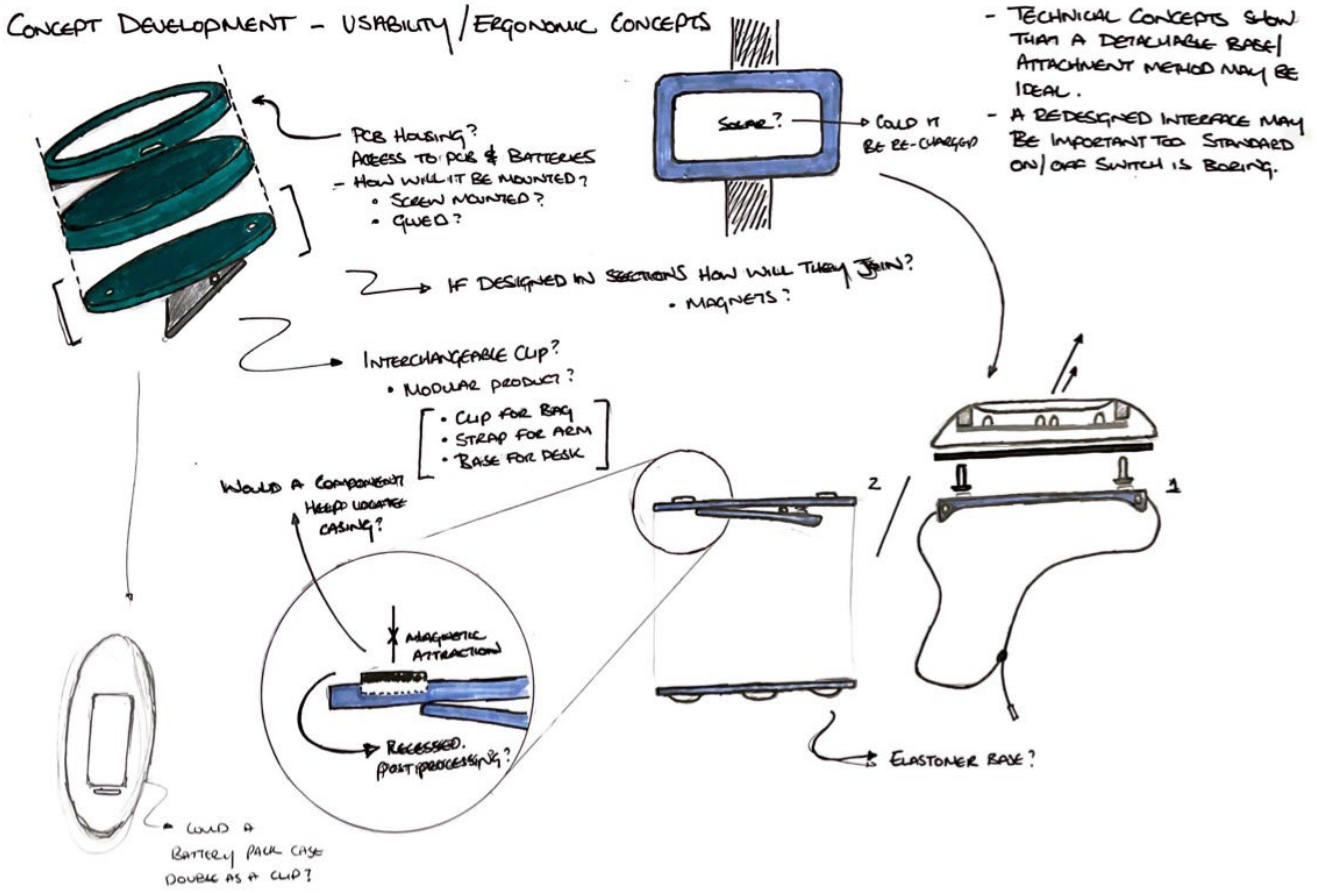


Appendix H – Concept Generation






VIBRATIONS
+
LIGHT?
SOUND FREQUENCY
"SENSORY OUTPUT":
COULD BE VIBRATIONS
INTERCHANGEABLE STRAP
DETACHABLE BASE?
PULL STRING?
• DESIGN SHOULD STRAP/FIT INDEPENDANTLY TO A BAG STRAP/ DESK.
COULD MOUNT TO BICEP?
ALTERNATIVE LOCATION FOR DEVICE?
• LARGER PRODUCT.

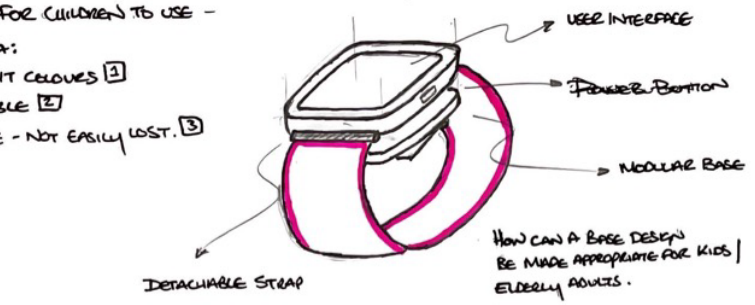

CONCEPT DEVELOPMENT - USABILITY/ERGONOMIC CONCEPTS
- TECHNICAL CONCEPTS SHOW THAT A DETACHABLE BASE/ ATTACHMENT METHOD MAY BE IDEAL.
- A REDESIGNED INTERFACE MAY BE IMPORTANT TOO STANDARD ON/OFF SWITCH IS BORING.
PCB HOUSING?
ACCESS TO PCB & BATTERIES
- HOW WILL IT BE MOUNTED?
• SCREW MOUNTED?
• GLUED?
SCREW?
COULD IT BE RE-CHARGED
IF DESIGNED IN SECTIONS HOW WILL THEY JOIN?
• MAGNETS?
INTERCHANGEABLE CLIP?
• MODULAR PRODUCT?
• CLIP FOR BAG
• STRAP FOR ARM
• BASE FOR DESK
WOULD A COMPONENT NEED LOCATED CASING?
MAGNETIC ATTRACTION
RECESSED. POST PROCESSING?
2
1
ELASTOMER BASE?
COULD A BATTERY PACK CASE DOUBLE AS A CLIP?

Concept Development – Inclusivity

Design for children to use –

Criteria:

- Bright colours [1]
- Durable [2]
- Secure – not easily lost. [3]

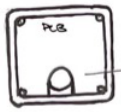


Responses from primary research indicates a younger market may exist.

↓

Parents may be inclined to make D/deaf wear/use the product too.

Refer to Scenario 3

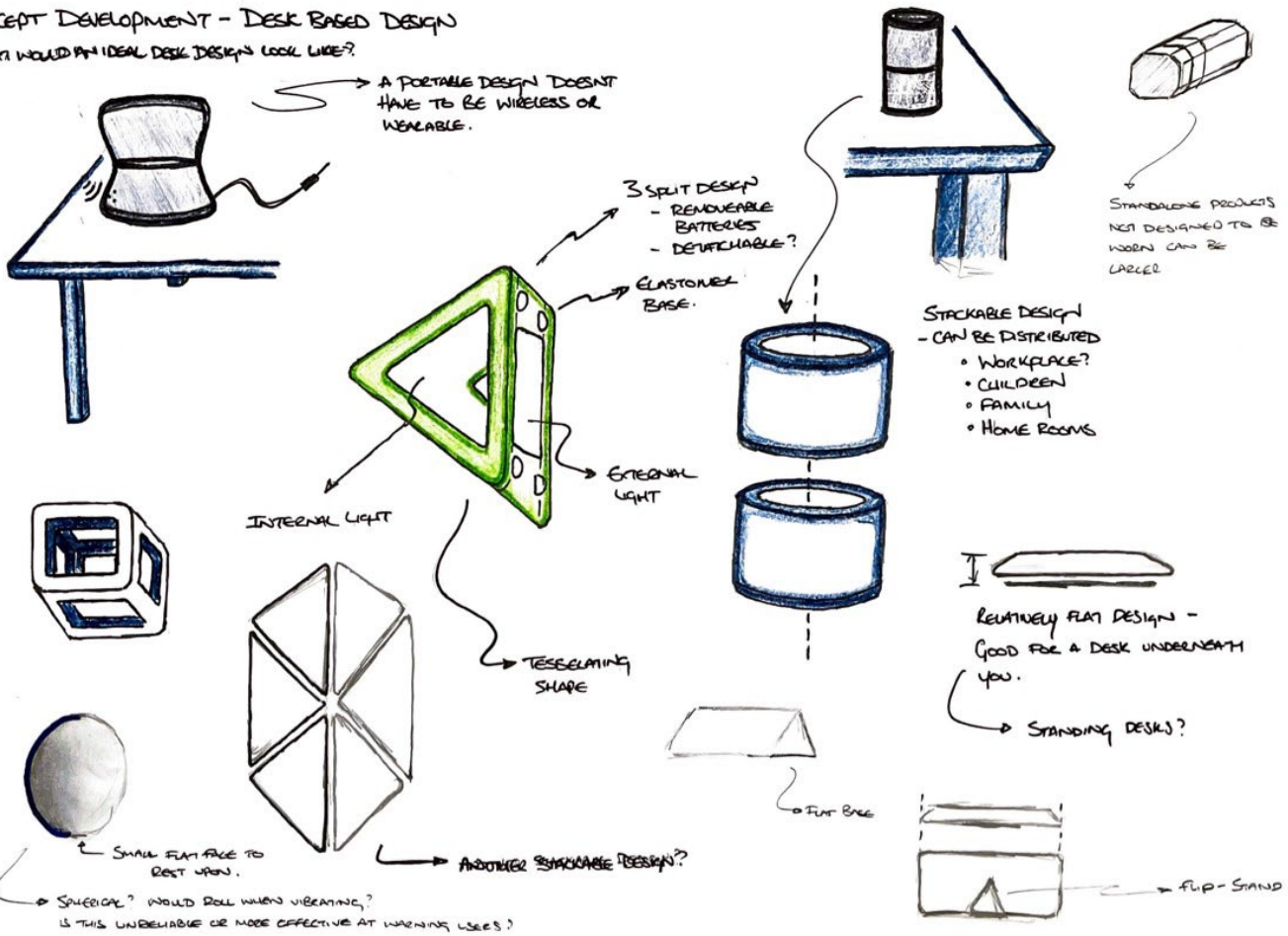


→ Coin cell batteries?

- Be: Rechargeable → More convenient → Technically feasible?
- Replaceable

Concept Development – Desk Based Design

– What would an ideal desk design look like?



Appendix I – Matrix Analysis

	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	Concept 7	Concept 8	Concept 9	Concept 10	Concept 11	Concept 12	Concept 13	Concept 14	Concept 15	Concept 16	Concept 17	Concept 18	Concept 19	Concept 20	Concept 21	Concept 22	Concept 23
Market																							
1.1 - Market size	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.2 - Inclusive market	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.2.2/1.7 - Low income	N/S	N/S	N/S	x	x	x	x	x	N/S	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
1.2.3 - Inuitive UI for BSL users	N/S	x	N/S	x	x	N/S	N/S	x	N/S	N/S	x	N/S	N/S	x	N/S	N/S	N/S	N/S	N/S	x	N/S	N/S	N/S
1.3 - Design for individual/personal use	x	x	N/S	x	x	x	N/S	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
1.3.1 - Design for travel (portability)	x	N/S	N/S	x	x	x	N/S	x	N/S	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
1.8 - Low environmental impact	x	N/S	N/S	x	x	x	N/S	x	N/S	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
1.10 - Must compete with competitors	x	x	x	x	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Function																							
1.10/2.1 - 0.4 lux is required (BS-EN)	x	x	x	x	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2.1.4 - Red light emitted	x	x	x	x	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2.3.1 - Sensory aspect	x	x	x	x	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2.5 - Strapped to bag/belt if removed	x	N/S	x	x	x	x	N/S	x	N/S	N/S	x	x	x	N/S	x	x	N/S	N/S	x	x	x	N/S	x
2.10 - Low consumption (LCA)	x	x	x	x	x	x	N/S	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
Aesthetics																							
3.2 - Product should be visible for safety	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3.3 - Must draw the users attention	x	x	x	x	x	x	N/S	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
3.5 - Inspiration from other products	x	x	x	x	x	x	N/S	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
3.5.1 - Users may wish to hide their hearing loss	N/S	N/S	x	x	x	x	N/S	x	N/S	N/S	x	x	x	x	N/S	x	x	x	x	x	N/S	x	x
Ergonomics																							
4.1 - Ergonomic for men and women over 20	x	N/S	N/S	x	x	x	N/S	x	N/S	N/S	x	x	x	x	x	x	x	x	x	x	x	N/S	x
4.4 - Simple mechanism to attach to user	N/S	N/S	N/S	x	x	x	N/S	x	N/S	N/S	x	x	x	x	x	x	x	x	x	x	x	N/S	x
4.5 - Suitable weight to carry	x	x	x	x	x	x	x	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
4.6 - The product must not restrict the users movement	N/S	N/S	N/S	x	x	x	N/S	x	N/S	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
4.7 - Interactive elements clearly indicated and easily used	N/S	N/S	N/S	x	x	x	N/S	x	N/S	N/S	x	x	x	x	x	x	x	x	x	x	x	N/S	x
Materials, Standards & Manufacturing																							
5.1 - Waterproof and UV resistant	x	x	x	x	x	x	N/S	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x
5.3 - Should feel soft/comfortable	x	x	x	x	x	x	N/S	x	x	N/S	x	x	x	x	x	x	x	x	x	x	x	x	x

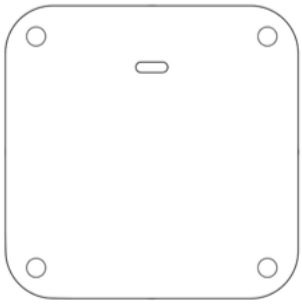
Appendix J – Concept Viva Design/Considerations



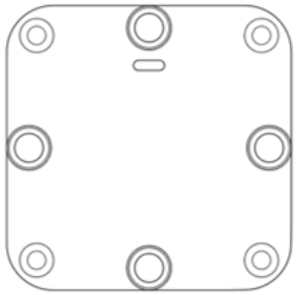
Top Casing – Top View:



Top Casing – Bottom View:



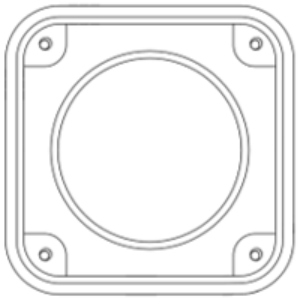
Waterproof Casing Top View:



Waterproof Casing Bottom View:

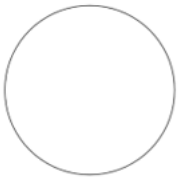


PCB Casing Top View:



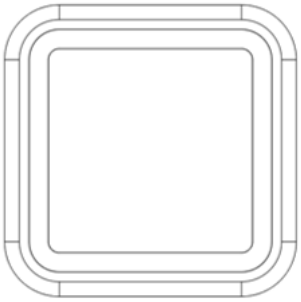
PCB Casing Bottom View:

Acrylic Top:

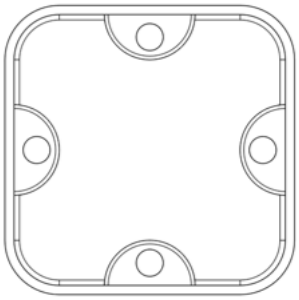




Strap – Retracted:



Base Casing – Bottom View:

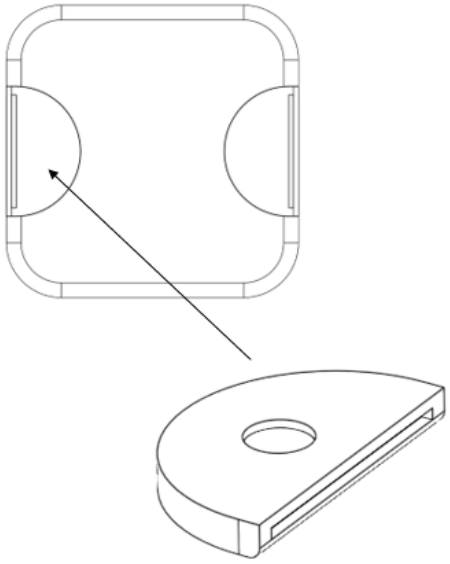


Base Casing – Top View:

Base Casing (Strap) – Bottom View:



Base Casing (Strap) – Top View:



Summary of Design Considerations:

Does the nylon cord rub against the aluminium top/pcb casing? – What properties are desirable for this cord to stop this from happening?

What material could soften the vibrations to stop false alarms?

Weight?

Vibrations through the metal

Angle of light

Intensity of light

Colour of the top casing

Size/Ergonomics

User interaction

Power/Low battery

Additional Bandpass filter

Placement and strength of magnets

Design for manufacture

Waterproofing

Design for children (aesthetics and ergonomics)

Cost of manufacture (quotes)

Safety

Visibility of LEDs through acrylic

Influence of magnets on the circuit

How can the rubber moulding be attached to base casing?

Other methods of joining components (magnets)

Weight testing

Chosen Material Qualities:

Benefits of ABS:

Strength and Durability:

ABS is renowned for its toughness and impact resistance. It can withstand heavy use and mechanical stress without easily breaking or deforming, making it suitable for a wide range of applications.

Chemical Resistance:

ABS exhibits resistance to many chemicals, including acids and alkalis, which makes it suitable for applications where exposure to such substances is a concern.

Electrical insulation:

ABS is an excellent electrical insulator, making it ideal for applications where electrical conductivity is not desired.

Surface Finish:

ABS has good surface finish characteristics. It can also be easily machined and sanded to achieve desired surface textures.

Lightweight:

Despite its strength and durability, ABS is relatively lightweight, making it suitable for applications where weight is a concern, such as in automotive and aerospace industries.

Cost Effectiveness:

ABS is generally cost-effective compared to many other engineering plastics, offering a balance of performance and affordability.

Recyclability:

ABS is recyclable, which makes it an environmentally friendly option compared to some other plastics. It can be reprocessed and reused in various applications, contributing to sustainability efforts.

Aesthetic Appeal:

- ABS is available in a wide range of colours and finishes, including glossy, matte, and textured surfaces, making it suitable for applications where aesthetics are important, such as consumer products and automotive interiors.

ABS is preferred for my project over ASA since all plastic casing/components are located inside an external, sealed aluminium casing. As ASA is used typically for its weather resistance; my project doesn't require these properties. ABS has better aesthetic qualities and is more cost effective overall.

Benefits of Aluminium 6061:

High Strength:

Aluminium 6061 offers good strength-to-weight ratio, making it suitable for applications where strength is essential while keeping weight relatively low.

Corrosion Resistance:

This alloy has excellent corrosion resistance, particularly in environments where other metals may corrode easily. It forms a protective oxide layer when exposed to air, preventing further oxidation and corrosion.

Machinability:

It is relatively easy to machine Aluminium 6061, allowing for the creation of complex shapes and intricate parts with precision. This property is beneficial for manufacturing processes such as milling, drilling, turning, and tapping.

Versatility:

Aluminium 6061 has applications in various industries, including aerospace, automotive, marine, construction, and consumer goods, due to its properties and ease of manufacture.

Recyclability:

Like other aluminium alloys, Aluminium 6061 is highly recyclable without compromising its properties. Recycling aluminium consumes significantly less energy compared to primary production, making it an environmentally sustainable material choice.

Aesthetic Appeal:

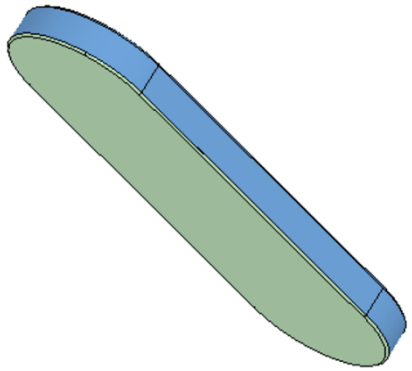
Aluminium 6061 can be finished with various surface treatments, such as anodizing to provide additional protection against corrosion and wear.

Injection Moulding Requirements:

Parts to be injection moulded:

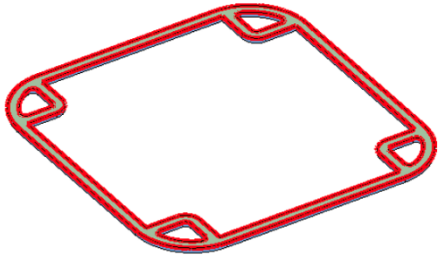
- **Battery Casing (BaC-REV1)**
- **Waterproof Casing (WC-REV1)**
- **Top Gasket**
- **Bottom Gasket**
- **Strap 001 (To be worn on arm)**
- **Silicone Dampener 001**
- **Silicone Dampener 002**

All parts will be injection moulded using a two-part mould without 'sliders'. As shown in the BOM, all injection moulding will take place in the UK (Protolabs) as cost margins are relatively similar for a complex mould between China and the UK.



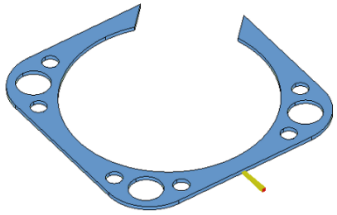
This is shown by the green and blue diagram:

- The blue represents the top of the mould (and the green represents the base)



[Protolabs analysis of the top/bottom gasket (BG-REV1/TG-REV1)]

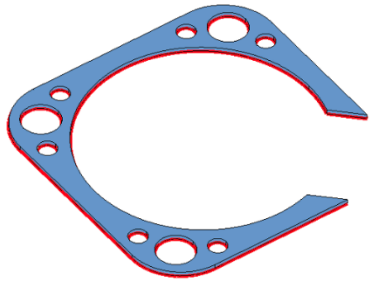
There is flash associated with silicone rubber that must be removed during post processing, which will add manual labour costs.



Tab gate will be added to allow material to flow, this is usually within 0.13mm of a mating surface. This must be removed and should be placed in line with a mating part to "hide" the defect.

In this instance it's not possible to remove the gate from a visible edge, so a permanent cut out will be visible, however it should have a minimal impact on the overall aesthetic.

The part is thin, which restricts material flow and may cause an increase in flash. As post processing is required to remove flash for the top component it won't add significant costs.



All parts stated can be injection moulded, however, in an appropriate material for its application.

Silicone KEG-2003-70A/B:

- Silicone KEG-2003-70A/B has a high degree of elasticity and can returns to its original shape under reasonable tension/compression.

- Additives can change the colour of the material, allowing it to be black to match the shown aesthetic of my design.
- The material is also food-safe; although this is not a crucial aspect of my design, it makes the end-life of the product more sustainable as the material doesn't contain toxic chemicals.

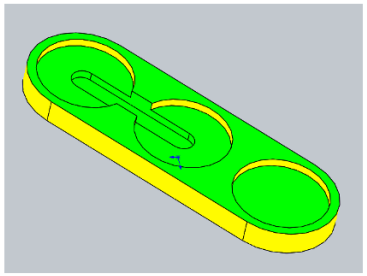
Adding draft angles to my components:

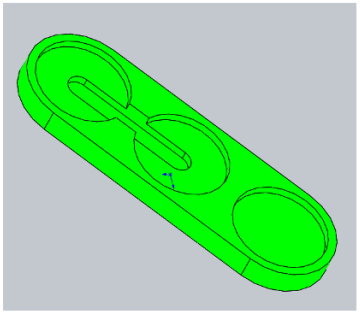
All components have radii of 0.2mm on every edge alongside a draft angle of 1 degree.

This should assist with removing the part from the mould and allowing a fine surface finish to be added to the part.

The draft angle tool in Solidworks shows that the draft.

angles have been applied properly.





Milled Components:

- **Top Casing**
- **PCB Casing**
- **Base Casing**
- **Magnet Strap**
- **Strap Inserts**
- **Strap 'Buttons'**

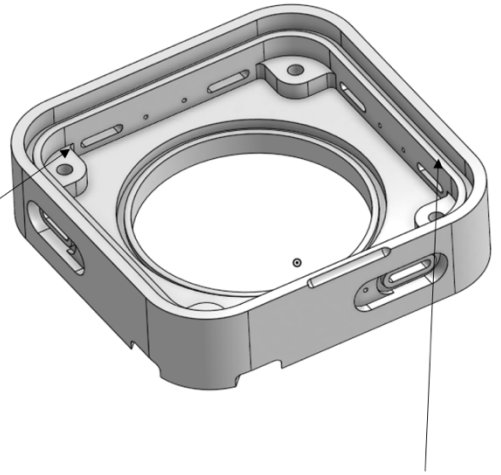
All milled parts are milled from Aluminium-6061 Alloy due to its desirable properties for machining and corrosion resistance. It is also a highly cost-effective metal.

All parts have been designed using industry standard tolerances and by using standard tooling where possible to reduce set up times and costs.

PCB CASING:

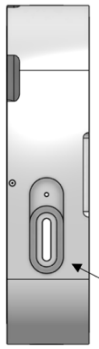
Most of the material for this part will be removed using a 7.5mm slot cutting bit.

Will be detailed using a 1mm slot cutter.



O-ring groove (1.2mm) would be cut using a 1mm cutter.

This is possible using a CNC as it can offset 0.1/0.2mm in increments.



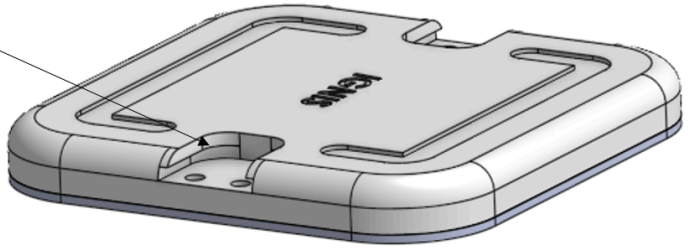
The side channels can be cut using a 6mm slot cutter before adding a fine 1.2mm 0-ring channel.

The top of the PCB Casing will be milled using a 5mm ball nose cutter and an 8mm slot drill.

Small 1mm radii can be milled using a 1mm ball nose cutter.



A woodruff cutter (12mm*1.5mm) is required for cutting the slot

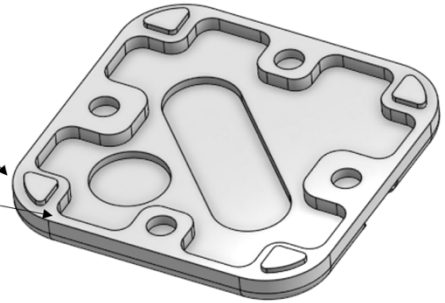


A 3mm radius cutter would be required for the Top Casing and Bottom Casing.



A 14mm cutter can be used for most of the casing.

A 3mm cutter is required for finer details.



List of tolerances:

Acrylic/Top Casing:

42mm dia – CNC milled part tolerance = +/- 0.05mm (Largest = 42.05/Smallest = 41.95)

41.8mm dia – Laser cut part = +/- 0.15mm (Largest = 41.95/Smallest = 41.65)

Largest tolerance distance (d) = 0.3mm (diameter) / 0.15 distance (radius)

Drill bit required: 42mm

O-ring Channel [Top Component]:

41mm dia – O-ring tolerance = +/- 0.1mm (Largest = 41.1/Smallest = 40.9)

Channel OD = 42 +/- 0.05mm (Smallest = 41.95/Largest = 42.05)

Channel ID = 39.6 +/- 0.05mm (Smallest = 39.55/Largest = 39.65)

Channel Width = 1.2mm +/- 0.1mm

Drill bit required: 1.2mm

Rian Edmondson

Mass properties of New Assembly
Configuration: Default
Coordinate system: -- default --

Mass = 100.60 grams

Volume = 47338.93 cubic millimeters

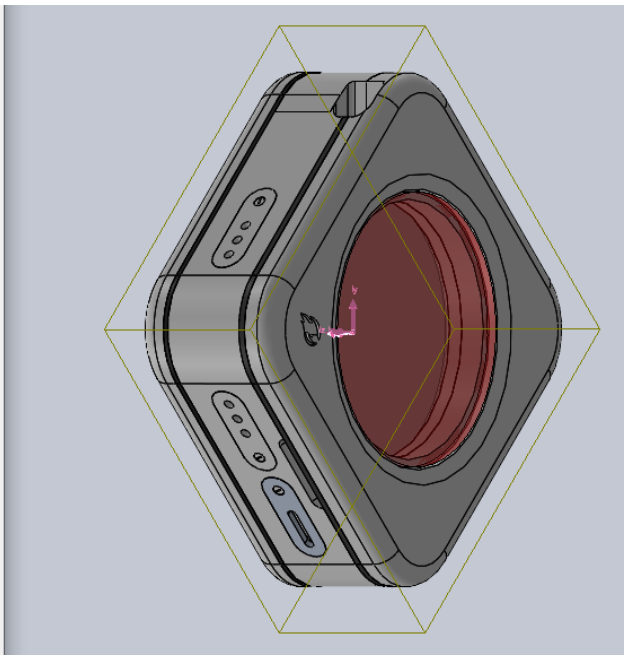
Surface area = 56614.60 square millimeters

Center of mass: (millimeters)
X = 0.30
Y = -12.84
Z = 0.31

Principal axes of inertia and principal moments of inertia: (grams * square millimeters)
Taken at the center of mass.
Ix = (0.71, 0.00, -0.71) Px = 43153.96
Iy = (-0.71, 0.01, -0.71) Py = 44393.56
Iz = (0.01, 1.00, 0.01) Pz = 75195.99

Moments of inertia: (grams * square millimeters)
Taken at the center of mass and aligned with the output coordinate system. (Using positive tensor notation.)
Lxx = 43773.61 Lxy = -217.61 Lxz = -621.53
Lyx = -217.61 Lyy = 75192.51 Lyz = -244.45
Lzx = -621.53 Lzy = -244.45 Lzz = 43777.38

Moments of inertia: (grams * square millimeters)
Taken at the output coordinate system. (Using positive tensor notation.)
Ixx = 60364.34 Ixy = -599.01 Ixz = -612.18
Iyx = -599.01 Iyy = 75211.25 Iyz = -650.97
Izx = -612.18 Izy = -650.97 Izz = 60366.92



Mass properties of Detail Design - Weight Sim - PCB Casing
Configuration: Default
Coordinate system: -- default --

Density = 0.00 grams per cubic millimeter

Mass = 32.42 grams

Volume = 12009.13 cubic millimeters

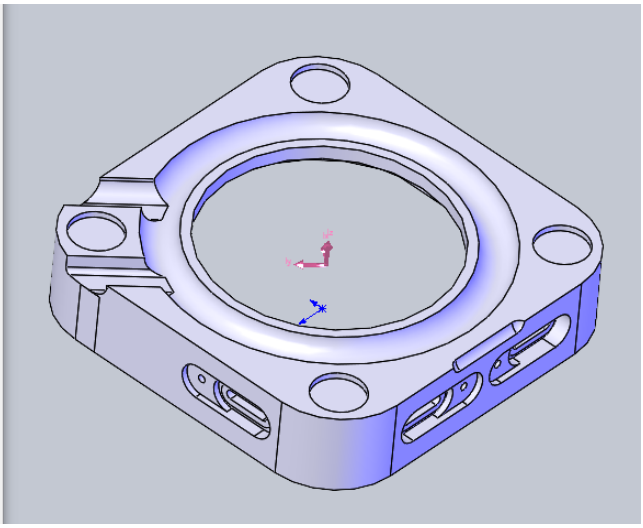
Surface area = 11584.84 square millimeters

Center of mass: (millimeters)
X = -0.02
Y = -0.07
Z = 7.98

Principal axes of inertia and principal moments of inertia: (grams * square millimeters)
Taken at the center of mass.
Ix = (0.71, -0.70, 0.00) Px = 15038.77
Iy = (0.70, 0.71, -0.01) Py = 15414.71
Iz = (0.00, 0.01, 1.00) Pz = 29711.99

Moments of inertia: (grams * square millimeters)
Taken at the center of mass and aligned with the output coordinate system. (Using positive tensor notation.)
Lxx = 15225.84 Lxy = -188.37 Lxz = -71.31
Lyx = -188.37 Lyy = 15228.46 Lyz = -81.74
Lzx = -71.31 Lzy = -81.74 Lzz = 29711.16

Moments of inertia: (grams * square millimeters)
Taken at the output coordinate system. (Using positive tensor notation.)
Ixx = 17291.46 Ixy = -188.33 Ixz = -76.19
Iyx = -188.33 Iyy = 17293.93 Iyz = -100.19
Izx = -76.19 Izy = -100.19 Izz = 29711.34



Mass properties of Detail Design - Weight Sim - Top strap component
Configuration: Default
Coordinate system: -- default --

Density = 0.00 grams per cubic millimeter

Mass = 25.01 grams

Volume = 9262.80 cubic millimeters

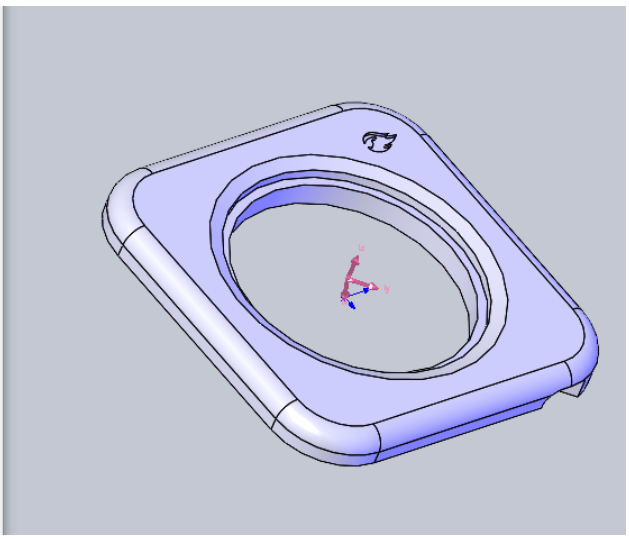
Surface area = 7119.60 square millimeters

Center of mass: (millimeters)
X = -0.58
Y = -0.61
Z = 3.69

Principal axes of inertia and principal moments of inertia: (grams * square millimeters)
Taken at the center of mass.
Ix = (0.71, -0.71, 0.00) Px = 9691.69
Iy = (0.71, 0.71, 0.00) Py = 10254.44
Iz = (0.00, 0.00, 1.00) Pz = 19830.71

Moments of inertia: (grams * square millimeters)
Taken at the center of mass and aligned with the output coordinate system. (Using positive tensor notation.)
Lxx = 9972.62 Lxy = -281.40 Lxz = 15.74
Lyx = -281.40 Lyy = 9973.55 Lyz = 14.13
Lzx = 15.74 Lzy = 14.13 Lzz = 19830.67

Moments of inertia: (grams * square millimeters)
Taken at the output coordinate system. (Using positive tensor notation.)
Ixx = 10323.28 Ixy = -272.47 Ixz = -38.19
Iyx = -272.47 Iyy = 10323.39 Iyz = -42.37
Izx = -38.19 Izy = -42.37 Izz = 19848.54



Appendix M – Quotes

Dongguan Plus Industrial Investment Co., Ltd
www.plusproto.com

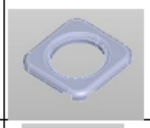
Mob: +86-189 9804 2926 TEL: +86-769-8307 8290 FAX: +86-769-8307 8290 ext 1
Email: info@plusproto.com

Offic Add: Block 1, Finance Building, Guantai Road No.111, Nancheng,DongguanCity,Guangdong Province, China.523000

QUOTATION

To
Company:
Attn: MR.Rian Edmondson
Tel:
Email:

Quote Number: HA309-P240223-1
PO Number: N/A
Contact: Frank MOU
Quote Date: 2024/2/26
Valid until: 2024/5/26

Item	Part Pictures	Part Name	Material	Part Size (mm)	Surface Finished	Production Method	Quantity (Sets)	Lead Time (Working Days)	FOB China Unit Price (GBP)	FOB China Unit Price (EUR)	Total Cost (EUR)	Remark
1		Base Casing	AL 6061	As per drawings	deburring, natural anodized	CNC machining	**27,000**	in batches	£2.05	2.46 €	**66,420.00 €**	
2		Top Casing	AL 6061	As per drawings	deburring, natural anodized	CNC machining	**27,000**		£2.70	3.25 €	**87,750.00 €**	
3		Light Casing	AL 6061	As per drawings	deburring, natural anodized	CNC machining	**54,000**		£0.79	0.95 €	**51,300.00 €**	
4		Mic Casing	AL 6061	As per drawings	deburring, natural anodized	CNC machining	**108,000**		£0.74	0.89 €	**96,120.00 €**	
						GRAND TOTAL	**216,000**				**301,590.00 €**	



Detail Design - Weight Sim - Top... £1,590,030.00
1078-9317-001 Quantity 27000
Request for Quote Options

Aluminium 6082-T651/T6 | 3.2315 | AlSi1MgMn - most popular
Edges broken and light bead blast
Anodising Decorative | ISO 7599 Clear (+5 Days)
CNC milling
X: 60.00mm Y: 60.00mm Z: 5.99mm
Machining Tolerance: +/- 0.1 mm

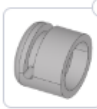
Per Part £46.89
Other £324,000.00



Detail Design - Weight Sim - Mi... £3,132,000.00
1200-5301-001 Quantity 108000
Request for Quote Options

Aluminium 6082-T651/T6 | 3.2315 | AlSi1MgMn - most popular
Edges broken and light bead blast
Anodising Decorative | ISO 7599 Clear (+5 Days)
CNC milling
X: 16.49mm Y: 1.49mm Z: 5.49mm
Machining Tolerance: +/- 0.1 mm

Per Part £17.00
Other £1,296,000.00



Magnet Clip.SLDPRT £2,006,100.00
1466-5925-001 Quantity 54000
Request for Quote Options

Aluminium 6082-T651/T6 | 3.2315 | AlSi1MgMn - most popular
Edges broken and light bead blast
Anodising Decorative | ISO 7599 Clear (+5 Days)
CNC turning centre
Threading (0 features selected)
X: 8.19mm Y: 8.19mm Z: 6.50mm
Machining Tolerance: +/- 0.1 mm

Per Part £25.15
Other £648,000.00



Detail Design - Weight Sim - PC... £3,315,870.00
1284-7413-001 Quantity 27000
Request for Quote Options

Aluminium 6082-T651/T6 | 3.2315 | AlSi1MgMn - most popular
Edges broken and light bead blast
Anodising Decorative | ISO 7599 Clear (+5 Days)
CNC milling
Threading (0 features selected)
X: 60.00mm Y: 60.00mm Z: 12.50mm
Machining Tolerance: +/- 0.1 mm

Per Part £110.81
Other £324,000.00



Ocean Freight LCL

38 - 40 DAYS

Sailing: Flexible dates

Port to port transit time: 30 DAYS

Route: HONG KONG ISLAND, HONG KONG ISLAND > HKHKG>GBSOU > S...

Valid until: Mar312024

Cancellation Policy: *Standard*

Export & import custom clearance not included

$331[11]

Valid

Hong Kong Island, Hong Kong Island > HKHKG, Hong Kong

Fee code	Fee name	Comment	Units	Unit price	Amount	Final Amount
32000	TRUCKAGE/PICK UP	Minimum	1	HKD 500.00	HKD 500.00	USD 63.90
				Subtotal		**USD 63.90**

Origin charges

Fee code	Fee name	Comment	Units	Unit price	Amount	Final Amount
30387	VGM SUBMISSION FEE	Per Shipment	1	HKD 150.00	HKD 150.00	USD 19.17
34700	HANDLING CHARGE (ORG)	Per Shipment	1	HKD 300.00	HKD 300.00	USD 38.34
35000	DOCUMENTATION FEE (ORG)	Per SET	1	HKD 500.00	HKD 500.00	USD 63.90
30320	CFS CHARGE	Per RT	0.01	HKD 230.00	HKD 2.30	USD 0.29
30380	AUTOMATED MANIFEST SYSTEM	per BL	1	USD 35.00	USD 35.00	USD 35.00
32803	WEIGHMENT FEE (ORG)	per RT	0.01	HKD 15.00	HKD 0.15	USD 0.02
				Subtotal		**USD 156.72**

HKHKG, Hong Kong > GBSOU, Southampton

Fee code	Fee name	Comment	Units	Unit price	Amount	Final Amount
OCEAN	Ocean Freight Cost	Per CBM	0.01	USD 113.00	USD 1.13	USD 1.13
				Subtotal		**USD 1.13**

Destination charges

Fee code	Fee name	Comment	Units	Unit price	Amount	Final Amount
40065	INT. SHIP AND PORT FACILITY SECURITY (ISPS)	Per Shipment	1	GBP 3.50	GBP 3.50	USD 4.45
40534	TERMINAL HANDLING CHARGE (DST)	Per W/M	0.01	GBP 53.00	GBP 0.53	USD 0.67
41010	CUSTOMS DOCUMENTATION FEE (DST)	Per B/l	1	GBP 17.50	GBP 17.50	USD 22.24
				Subtotal		**USD 27.36**

GBSOU, Southampton > SW1A 2DD, London

Fee code	Fee name	Comment	Units	Unit price	Amount	Final Amount
42000	Delivery Charges	Per Shipment	1	USD 82.00	USD 82.00	USD 82.00
				Subtotal		**USD 82.00**

100% port-to-port carbon-free LCL shipping by purchasing credits for reducing GHG emissions. Learn more about our LCL Carbon Offset Service

General Remarks:

- The rates provided do not apply to shipments of dangerous goods, hazardous materials, perishables, oversized and/or heavy cargoes.
- The rates provided subject to Carrier surcharges such as but not limited to PSS/ GRI.
- Government-imposed charges not included in rates provided (will be charged to customer as a pass-through cost).
- Rates exclude duties, taxes and VAT & subject to Government's policy.
- All third party charges are not inclusive

Summary exchange rate:1HKD = 0.1278USD | 1GBP = 1.271USD

Total **USD 331.11**

Appendix N – Bill of Materials

DWG Number	Part Name	Quote No.	Supplier	Quantity	Material	Finish	Material Supplier	Surface Roughness	Manufacturing Process	Weight (kg)	Material Cost	Tooling Cost	Tooling Cost P.P	Quoted Tool Life
CNC Parts														
BC-REV1	Base Casing	1	PlusProto	1	Aluminium 6061 Alloy	Anodised Clear	PlusProto	1.6um Deburr	CNC Milled	0.0228	Included	N/A	N/A	N/A
		2	Protolabs	1	Aluminium 6061 Alloy	Anodised Clear	Protolabs	1.6um Deburr	CNC Milled	0.0228	Included	N/A	N/A	N/A
TC-REV1	Top Casing	1	PlusProto	1	Aluminium 6061 Alloy	Anodised [RED/YELLOW/BLUE]	PlusProto	1.6um Deburr	CNC Milled	0.025	Included	N/A	N/A	N/A
		2	Protolabs	1	Aluminium 6061 Alloy	Anodised Clear	Protolabs	1.6um Deburr	CNC Milled	0.025	Included	N/A	N/A	N/A
LC-REV1	Light Casing	1	PlusProto	2	Aluminium 6061 Alloy	Anodised Clear	PlusProto	1.6um Deburr	CNC Milled	0.00039	Included	N/A	N/A	N/A
		2	Protolabs	2	Aluminium 6061 Alloy	Anodised Clear	Protolabs	1.6um Deburr	CNC Milled	0.00039	Included	N/A	N/A	N/A
MC-REV1	Mic Casing	1	PlusProto	4	Aluminium 6061 Alloy	Anodised Clear	PlusProto	1.6um Deburr	CNC Milled	0.024	Included	N/A	N/A	N/A
		2	Protolabs	4	Aluminium 6061 Alloy	Anodised Clear	Protolabs	1.6um Deburr	CNC Milled	0.024	Included	N/A	N/A	N/A
PCBC-REV1	PCB Casing	1	PlusProto	1	Aluminium 6061 Alloy	Anodised Clear	PlusProto	1.6um Deburr	CNC Milled	0.0324	Included	N/A	N/A	N/A
		2	Protolabs	1	Aluminium 6061 Alloy	Anodised Clear	Protolabs	1.6um Deburr	CNC Milled	0.0324	Included	N/A	N/A	N/A
		3	ProtoMFG	1	Aluminium 6061 Alloy	Anodised Clear	ProtoMFG	3.2um Deburr	CNC Milled	0.0324	Included	N/A	N/A	N/A
SI-REV1	Strap Inserts	1	PlusProto	2	Aluminium 6061 Alloy	Anodised Clear	PlusProto	1.6um Deburr	CNC Milled	0.00016	Included	N/A	N/A	N/A
		2	Protolabs	2	Aluminium 6061 Alloy	Anodised Clear	Protolabs	1.6um Deburr	CNC Milled	0.00016	Included	N/A	N/A	N/A
SC-REV1	Strap Clip	1	PlusProto	2	Aluminium 6061 Alloy	Anodised Clear	PlusProto	1.6um Deburr	CNC Milled	0.0077	Included	N/A	N/A	N/A
		2	Protolabs	2	Aluminium 6061 Alloy	Anodised Clear	Protolabs	1.6um Deburr	CNC Milled	0.0077	Included	N/A	N/A	N/A
MS-REV1	Magnet Strap	1	PlusProto	2	Aluminium 6061 Alloy	Anodised Clear	PlusProto	1.6um Deburr	CNC Milled	0.00062	Included	N/A	N/A	N/A
		2	Protolabs	2	Aluminium 6061 Alloy	Anodised Clear	Protolabs	1.6um Deburr	CNC Milled	0.00062	Included	N/A	N/A	N/A
Electronic Parts														
N/A	PCB		PCBWAY	1	FR-4	N/A	PCBWAY	N/A	Soldered/Assembled	0.0005	Included	N/A	N/A	N/A
N/A	Motor		Precisionminidrives	1	Various	N/A	Precisionminidrives	N/A	Bought in	0.0001	Included	N/A	N/A	N/A
N/A	Mic		RS	1	Various	N/A	RS	N/A	Bought in	0.0001	Included	N/A	N/A	N/A
N/A	Battery		Eunicell	3	Various	N/A	Eunicell	N/A	Bought in	0.003	Included	N/A	N/A	N/A
Plastic Parts														
AC001-REV1	Acrylic (RED) - 48.8	1	Yinuo	1	PMMA (RED)	N/A	Yinuo	Standard	Laser Cut	0.00165	Included	N/A	N/A	N/A
		1	PlusProto	1	PMMA (RED)	N/A	PlusProto	Standard	Laser Cut	0.00165	Included	N/A	N/A	N/A
AC002-REV2	Acrylic (CLEAR) - 48.8	1	Yinuo	1	PMMA (CLEAR)	N/A	Yinuo	Standard	Laser Cut	0.00165	Included	N/A	N/A	N/A
		2	PlusProto	1	PMMA (CLEAR)	N/A	PlusProto	Standard	Laser Cut	0.00165	Included	N/A	N/A	N/A
ASC-REV1	Acrylic (C) Small	1	PlusProto		PMMA (CLEAR)	N/A	PlusProto	Standard	Laser Cut	>0.001	Included	N/A	N/A	N/A
WC-REV1	Waterproof Casing	1	Protolabs	1	ABS - Novodur HD 15	Anthracite Grey' 2% (RAL 7016) - PM-T2	INEOS	PM-T2	Injection moulding	0.003	Included	£2,935	£0.15	N/A
		2	Protolabs	1	ABS - Novodur HD 15	Anthracite Grey' 2% (RAL 7016) - PM-T2	INEOS	PM-T2	Injection moulding	0.003	Included	£14,095	£0.70	N/A
		3	PlusProto		ABS - Novodur HD 15	Anthracite Grey' 2% (RAL 7016) - PM-T2	PlusProto	PM-T2	Injection moulding	0.003	Included	£2,738	£0.10	100k units
BaC-REV1	Battery Casing	1	Protolabs	1	ABS - Novodur HD 15	Anthracite Grey' 2% (RAL 7016) - PM-T2	INEOS	PM-T2	Injection moulding	0.002	Included	£1,815	£0.09	N/A
		2	Protolabs	1	ABS - Novodur HD 15	Anthracite Grey' 2% (RAL 7016) - PM-T2	INEOS	PM-T2	Injection moulding	0.002	Included	£7,400	£0.37	N/A
		3	PlusProto		ABS - Novodur HD 15	Anthracite Grey' 2% (RAL 7016) - PM-T2	PlusProto	PM-T2	Injection moulding	0.002	Included	£2,037	£0.08	100k units
S001-REV1	Strap001	1	Protolabs		Silicone Rubber (KEG-2003H-70A/B)	SP1 A2 - Black	Protolabs	SPI-A2 (Black)	Injection moulding	0.011	Included			N/A
S002-REV1	Strap002	1		1	VITON	N/A	SimplyBearings	N/A	Bought in	0.005	Included	N/A	N/A	N/A
TG-REV1	Top Gasket	1	Legenday	1	KEG-2003-70A/B OR. CHN-97000-U	SP1 A2 - Black	Legenday	SPI-A2 (Black)	Injection moulding	0.00195	Included	$800	$0.03	N/A
		2	Protolabs			SP1 A2 - Black	Protolabs	SPI-A2 (Black)	Injection moulding	0.00195	Included	£2,940	£0.11	N/A
		3	Protolabs			SP1 A2 - Black	Protolabs	SPI-A2 (Black)	Injection moulding	0.00195	Included	£10,615	£0.15	N/A
BG-REV1	Base Gasket	1	Legenday	1	KEG-2003-70A/B OR. CHN-97000-U	SP1 A2 - Black	Legenday	SPI-A2 (Black)	Injection moulding	0.00071	Included	$800	$0.03	N/A
		2	Protolabs	2		SP1 A2 - Black	Protolabs	SPI-A2 (Black)	Injection moulding	0.00071	Included	£2,870	£0.11	N/A
		3	Protolabs			SP1 A2 - Black	Protolabs	SPI-A2 (Black)	Injection moulding	0.00071	Included	£10,025	£0.51	N/A
BI-REV1	Base Inlay	1	Protolabs	2	KEG-2003-70A/B OR. CHN-97000-U	SP1 A2 - Black	Protolabs	SP1 A2 - Black	Injection moulding	0.00045	Included			
Fasteners														
Washer	Silicone washer	1	Vital-Parts	8	Silicone	N/A	Vital-Parts	N/A	Bought in	0.00002	Included	N/A	N/A	N/A
Screw [1]	M3*8mm	1	Accu	4	Stainless Steel	N/A	Accu	N/A	Bought in	0.001	Included	N/A	N/A	N/A
Screw [3]	M3*6mm	1	Accu	2	Stainless Steel	N/A	Accu	N/A	Bought in	0.001	Included			
Screw [2]	M1*3mm	1	Accu	6	Stainless Steel	N/A	Accu	N/A	Bought in	>0.001	Included	N/A	N/A	N/A
O-ring [1]	48mm o-ring (1mm dia)	1	SimplyBearingsLTD	2	VITON Rubber	N/A	SimplyBearingsLTD	N/A	Bought in	>0.001	Included	N/A	N/A	N/A
O-ring [2]	30mm o-ring (1mm dia)	1	SimplyBearingsLTD	6	VITON Rubber	N/A	SimplyBearingsLTD	N/A	Bought in	>0.001	Included	N/A	N/A	N/A
O-ring [3]	205mm o-ring	1	SimplyBearingsLTD	1	VITON Rubber	N/A	SimplyBearingsLTD	N/A	Bought in	>0.001	Included	N/A	N/A	N/A
4mm*2mm	Magnet	1	First4magnets	8	Neodynium	N/A	First4magnets	N/A	Bought in	>0.001	Included	N/A	N/A	N/A
8mm*1	Magnet	1	First4magnets	8	Neodynium	N/A	First4magnets	N/A	Bought in	>0.001	Included	N/A	N/A	N/A
5mm*2	Magnet	1	First4magnets	2	Neodynium	N/A	First4magnets	N/A	Bought in	>0.001	Included	N/A	N/A	N/A
1mm*1mm	Spring	1	Primeminiatures	4	304 Stainless Steel	N/A	PrimeMiniatures	N/A	Bought in	>0.001	Included	N/A	N/A	N/A
2mm Ball B.	Ball Bearing	1	ballandrollerstore	4	Chrome Steel - Grade 100	N/A	ballandrollerstore	N/A	Bought in	>0.001	Included	N/A	N/A	N/A

Sub Assemblies	Assembly Time (Approx)	Sub-Assembly Cost
A	3 mins	£0.51
B	5 mins	£0.85
C	3 mins	£0.51
D	PRE-COSTED	
	Total Time: 11mins	
	6 products/hr P.P	
O-Market = 27000	27000/365 = 74units/day	
	74/6=12	
	2 workers (6 hours a day)	Total Cost: £125.04/day

Product Cost = CostP.P (exc VAT) + (Shipping/27000) + (Overheads/27000)
£19.52 exc. Overheads

Overheads: £125.04 labour & 1500 yen (£7.85) rent
£125.32 /day

£1.69 added to product price

Product Cost inc. overheads:
£21.21

Final Retail Cost:
£84.84

Total Weight: 0.13366
134g

Product Overall Size: 60mm*60mm*32
Packaging Size approx: 80mm*80mm*42

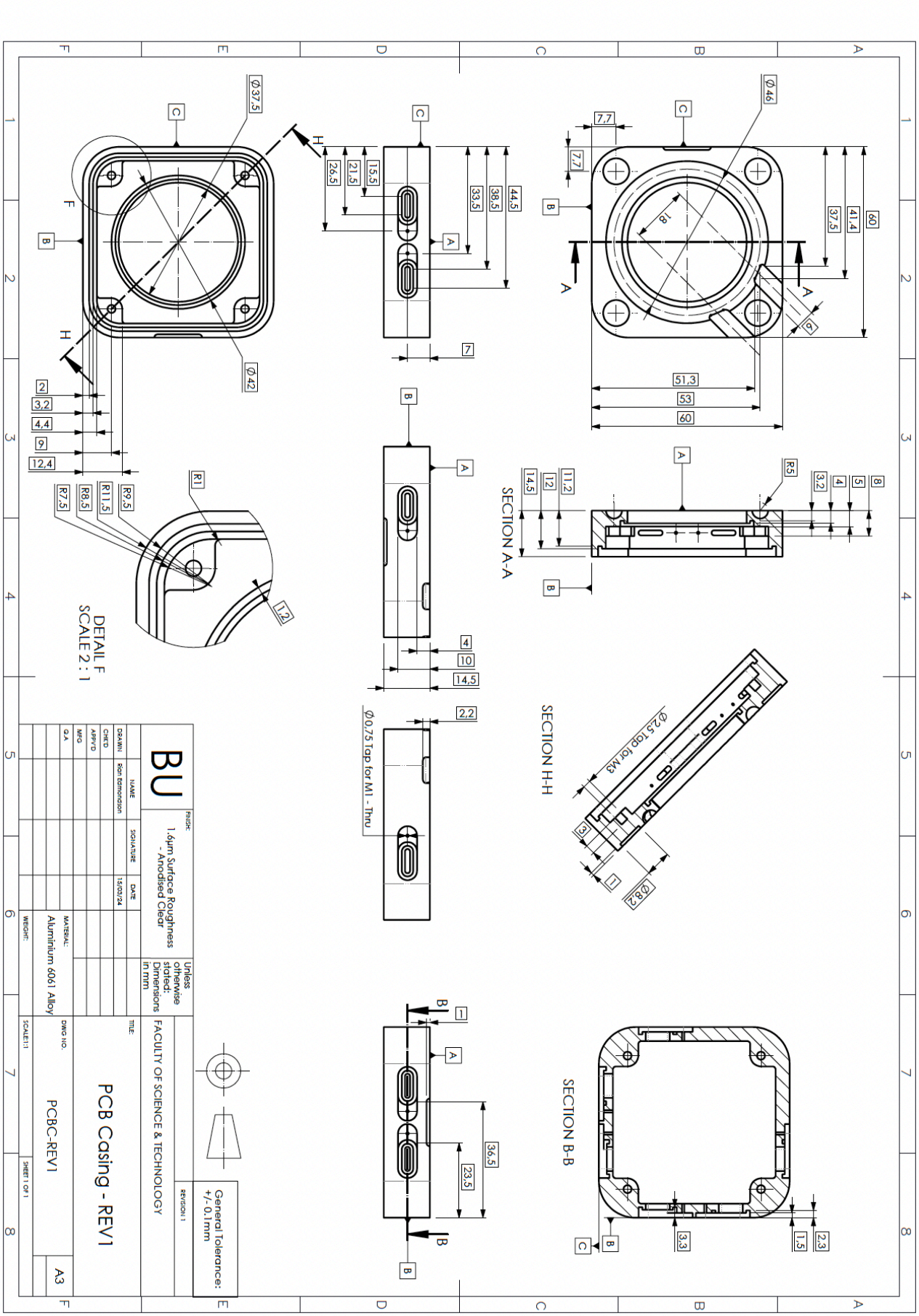
Monthly Shipments: 2250 units

Shipment Cost: £260/month
£0.12

Rian Edmondson

Manufacture Location	Assembly Cost	Packaging and Shipping	Units Quoted	Total Cost (Max Order Q)	Total Yearly Cost	Cost PP. (Pre mould paid)	Cost P.P (After mould paid)	EXC. VAT	Sub-Assembly Type	Projected Cost P.P
	[Based on UK wages]									
China (Dongguan)	N/A		27000	€ 66,420.00	€ 66,420.00	N/A	£2.05	N/A	C	
UK	N/A		27000	€ 965,790.00	€ 965,790.00	N/A	£47.69	£35.77	C	
China (Dongguan)	N/A		27000	€ 87,750.00	€ 87,750.00	N/A	£2.70	N/A	A	
UK	N/A		27000	€ 949,590.00	€ 949,590.00	N/A	£46.89	£35.17	A	
China (Dongguan)	N/A		54000	€ 51,300.00	€ 51,300.00	N/A	£0.79	N/A	B	
UK	N/A		54000	€ 301,050.00	€ 301,050.00	N/A	£14.86	£11.15	B	
China (Dongguan)	N/A		108000	€ 96,120.00	€ 96,120.00	N/A	£0.74	N/A	B	
UK	N/A		108000	€ 344,250.00	€ 344,250.00	N/A	£17.00	£12.75	B	
China (Dongguan)	N/A		27000	€ 102,600.00	€ 102,600.00	N/A	£3.20	N/A	B	
UK	N/A		27000	€ 2,243,970.00	€ 2,243,970.00	N/A	£110.81	£83.11	C	
China (Dongguan)	N/A		27000	€ 270,000.00	€ 270,000.00	N/A	£10.00	N/A	C	
China (Dongguan)	N/A		IN PROGRESS						C	£1.50
UK	N/A		IN PROGRESS						C	£49.50
China (Dongguan)	N/A		IN PROGRESS						C	£0.80
UK	N/A		IN PROGRESS						B	£26.40
China (Dongguan)	N/A		IN PROGRESS						B	£0.80
UK	N/A		IN PROGRESS							£26.40
China (Hangzhou, Zhejiang)	£896		9000	£6,374.00	£19,122.00	N/A	£0.71	N/A	D	
China (Shenzen)	N/A		27000	£21,060.00	£21,060.00	N/A	£0.78	N/A	D	
UK	N/A		400	£216.00	£14,580.00	N/A	£0.54	N/A	D	
China (Shenzen)	N/A		81000	£1,620.00	£1,620.00	N/A	£0.02	N/A	D	
China (Whenzhou)	N/A		5000	$800	£4,800.00	N/A	$0.16	N/A	A	
China (Dongguan)	N/A		27000	£924.25	£924.25	N/A	£0.03	N/A	A	
China (Whenzhou)	N/A		5000	$800	£4,800.00	N/A	$0.16	N/A	B	
China (Dongguan)	N/A		27000	£924.25	£924.25	N/A	£0.03	N/A	B	
China (Dongguan)	N/A		54000	$1080	$1080	N/A	£0.02	N/A	B	
UK	N/A		20000	£17,335.00	£26,002.50	£0.87	£0.72	N/A	B	
UK	N/A		20000	£20,290.00	£30,435.00	£1.01	£0.31	N/A	B	
China (Dongguan)	N/A		27000	£16,380.00	£16,380.00	£0.34	£0.24	N/A	B	
UK	N/A		20000	£10,115	£15,173	£0.91	£0.82	N/A	C	
UK	N/A		20000	£10,500	£15,750	£0.67	£0.30	N/A	C	
China (Dongguan)	N/A		27000	Costed in WC-REV 1: Q3	Costed in WC-REV 1: Q3	£0.47	£0.10	N/A	C	
UK	N/A		IN PROGRESS					N/A	C	
UK	N/A		100 meters	£9.79	£812.57	N/A	£0.03	N/A	B	
China (Whenzhou)	N/A		27000	£6,210.00	£6,210.00	£0.26	£0.23	N/A	A	
UK	N/A		20000	£23,400.00	£35,100.00	£1.33	£1.17	N/A	A	
UK	N/A		20000	£8,000.00	£12,000.00	£0.55	£0.40	N/A	A	
China (Whenzhou)	N/A		27000	£7,560.00	£7,560.00	£0.31	$0.28	N/A	C	
UK	N/A		20000	£23,600.00	£35,400.00	£1.29	£1.18	N/A	C	
UK	N/A		20000	£8,000.00	£12,000.00	£0.91	£0.40	N/A	C	
UK, Kent	N/A		1000+	£1.76 (1 pack)	£23,760.00	N/A	£0.11	N/A	B	
Not Disclosed	N/A		8000+	£0.12 (1 pack)	£3,240.00	N/A	£0.02	N/A	B	
Not Disclosed	N/A		10000+	£1,700.00	£27,540.00	N/A	£0.17	N/A	B	
UK	N/A		>100m	£251.99	£20,412.00	N/A	£0.12	N/A	A&B	
UK	N/A		>100m	Already expended	Already expended	N/A	£0.08	N/A	B	
UK	N/A		>100m	Already expended	Already expended	N/A	£0.51	N/A	B	
Not Disclosed	N/A		2000	£147.95	£15,876.00	N/A	£0.07	N/A	C	
Not Disclosed	N/A		400	£77.87	£42,049.80	N/A	£0.19	N/A	A	
Not Disclosed	N/A		1000	£113.40	£6,123.60	N/A	£0.11	N/A	B	
Not Disclosed	N/A		20	£5.50	£29,700.00	N/A	£0.28	N/A	C	
Not Disclosed	N/A		10000	£96	£288.00	N/A	£0.01	N/A	C	

Appendix O – Engineering Drawings



Appendix P – Final Design

PCB Casing – Bottom View:

Changes:

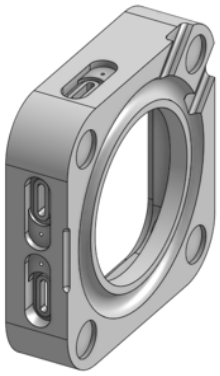
- This part has been changed significantly to accommodate for manufacturing requirements.
- An 'o-ring' groove has been added and the mounting bosses have been reduced in height to accommodate for a shock absorbing material.



PCB Casing – Isometric View:

Changes:

- Additional ports have been added for the microphone alongside a bespoke casing to ensure the device is waterproof.



Waterproof Casing:

Changes:

The cut-through grooves allow the wires to trail from the motor and battery.



Waterproof Casing:

Changes:

- The underside of the waterproof casing shows the groove intended for the bespoke battery pack.



Battery Casing:

- No existing design exists for three-coin cell batteries to lie next to each other.
- A common issue with coin cell batteries is that they short-circuit, so a non-conductive material must be used.



Base Casing – Bottom View

- Laser engraved company/product name and routed slots for rubber mounting.



Base Casing – Top View w/rubber gasket:

- Like the top casing, the base requires a gasket to protect the users' fingers.
- The gasket is mounted via the 4 triangular shapes around the edge of the part.



Base Casing:

Changes:

- Like the waterproof casing, the base casing has a groove milled for the battery casing.



Shock absorbing material: [NEW]

This component will absorb the shock generated from the vibration motor to stop a feedback cycle.



Light Casing – Front View:

This casing creates a waterproof seal and a section in the side of the product for light to emit through.



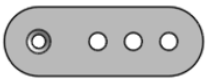
Light Casing – Back View:



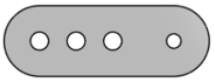
Microphone Casing – Front View:

Like the light casing, a layer of water-resistant speaker fabric will be placed in between it and the PCB casing.

A o-ring will be placed in the groove on its other side to create a waterproof seal.



Microphone Casing – Back View:



Silicone Dampener:

Allows the vibration motor to be active without making excessive noise or causing a feedback loop.



Silicone Dampener:

Top half of the silicone dampener, the vibration motor sits inside of this casing as a tight tolerance.



Strap [1]:

Base strap allows the user to attach the product to their arm.



Top Gasket:

The top gasket protects the user's fingers when opening the product.



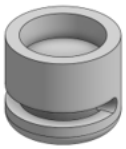
Base Gasket:

Acts in the same way as the Top Gasket.



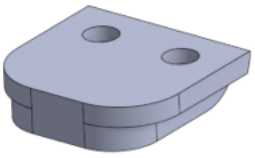
Magnet Clip:

Secures to the second strap and acts as a fastener. The magnet would be secured using ECO Epoxy



Base Insert:

This component acts as a quick release coupling, allowing the user to easily remove the strap.



PMMA [RED/CLEAR]:

The design has two sets of acrylic screens to ensure waterproofing is maintained.

