

D S C 0 2 6 · F I N A L Y E A R D E S I G N P R O J E C T · 2 0 2 5 / 2 6

OSAT

An at-home wearable for sleep apnea screening

Leo Burness · F225661 · Loughborough University



Project Scope

01 **Brief overview**
Original Brief

02 **Design development**
Progress since Submission 2

03 **Prototypes**
Methods, purpose & final build

04 **User evaluation**
Methods, participants & findings

05 **DFM & commercial manufacture**
Volumes, materials, cost & retail

06 **Final design proposal**
Innovations & benefits

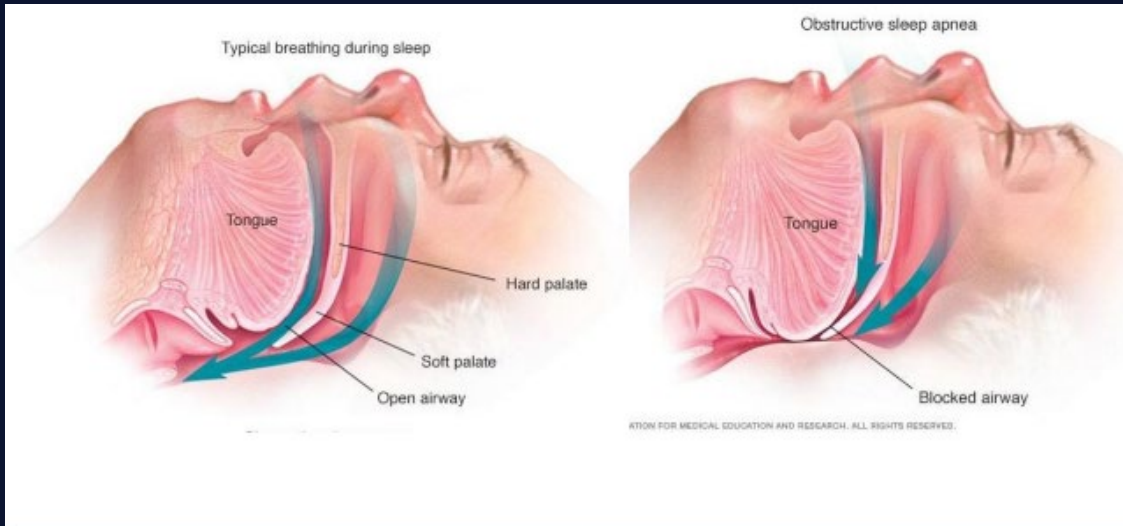
01

SECTION

Brief Overview

To address the non-adherence of CPAP machines by providing a comfortable and functional alternative.

Understanding the problem



Key Takeaways – The Core Problem

OSA occurs because the **upper airway** in your throat **collapses** during sleep.

Dual Failure: The collapse is due to two main issues:

- **Anatomy:** The airway is **structurally compromised** ("already a faulty straw").
- **Neuromuscular Control:** The muscle holding it open (the **Genioglossus** or "GG wires") is faulty.

2. The Key Finding: A Defective Reflex

• **The Experiment's Goal:** To see how the "GG wires" work when the airway is stressed.

• **The Result:** When the airway started to collapse, **healthy people's** GG muscle *reflexively pulled much harder and sustained the pull* to keep it open.

• **The Difference:** In people with **OSA**, this defensive reflex was **significantly weaker or broken**.

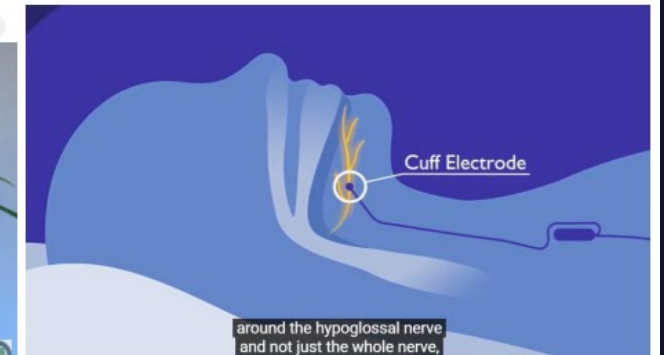
Competitive Landscape for OSA solutions



Hypoglossal Nerve Stimulation for Obstructive Sleep Apnea | David's Story



Oral Exercises to Help with Snoring and Sleep Apnea



Oral exercises to Help with Snoring and Sleep Apnea

<https://www.youtube.com/watch?v=bRE9FW99ZgM>

Hypoglossal Nerve Stimulation for OSA

<https://www.youtube.com/watch?v=3sKgSmMOvqo>



Brief – Addressing CPAP Adherence

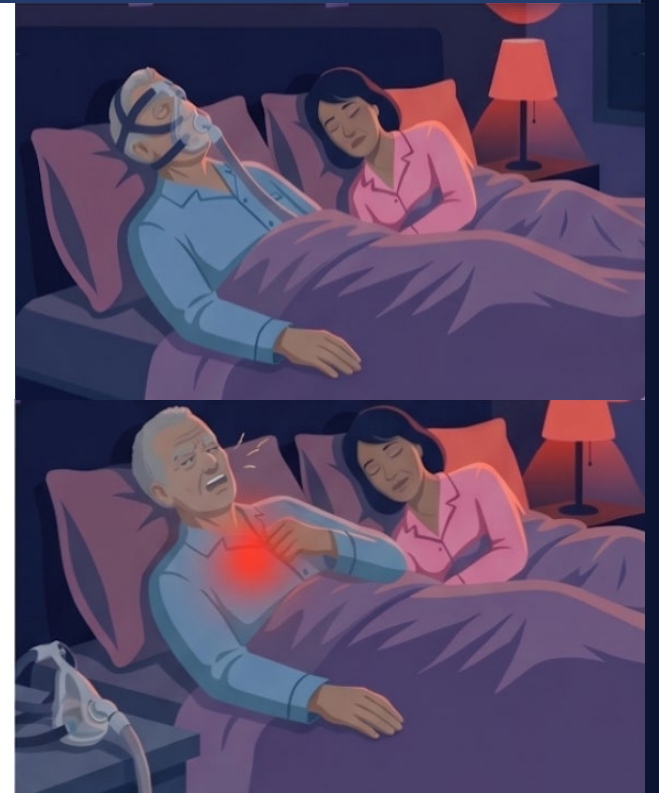
Create a new solution for Obstructive Sleep Apnea (OSA)

A more comfortable, **less invasive** alternative to **CPAP** therapy. The aim of my project is to improve user quality of sleep. I will address current issues around **discomfort, claustrophobia, noise** and **restricted movement** that are found with the CPAP device.

I am proposing a multimodal, non-invasive therapy device, that combines **Adaptive Sub-mental Electrical Muscle Stimulation** (EMS) **with Dynamic Cueing** to target failing muscles such as the Genioglossal muscle (tongue), that contribute to many of the symptoms and dangers posed by sleep apnoea. The device is designed **for CPAP-Intolerant and Mild-to-Moderate OSA patients**, and I will measure **success** by **improved sleep metrics** (e.g., AHI reduction) and **enhanced** user **comfort** and **mobility**, tracked via embedded physiological sensors (EEG, HR, etc.).

The core functions are:

- Prevent upper airway collapse
- Maximise comfort
- Cause minimal impact on sleep and patient welfare





Global scale

The Magnitude

OSA is a Global Pandemic: OSA affects almost 1 billion people globally*, with prevalence increasing due to aging populations and obesity. It's a significant public health issue.

The Risk

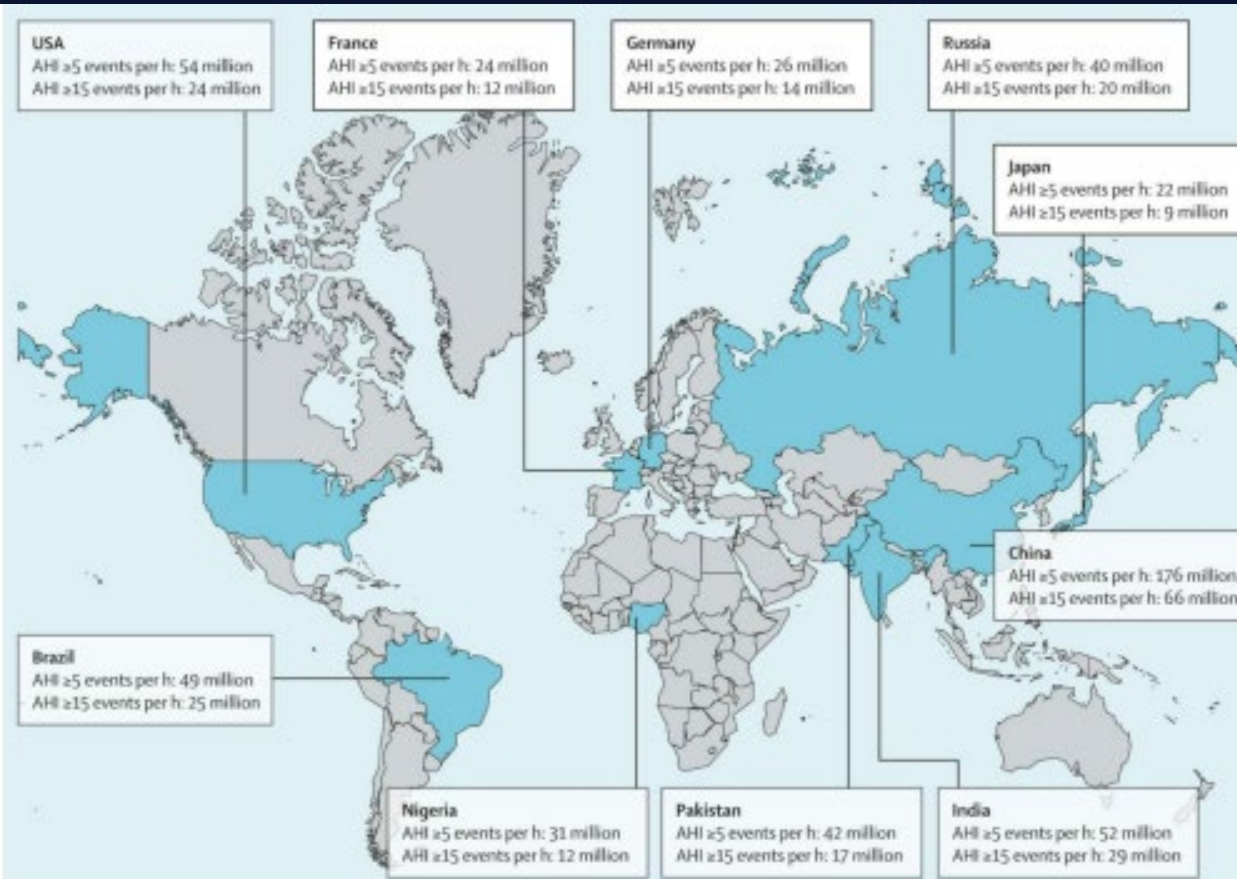
Untreated OSA is a Mortality Risk: Severe OSA is associated with a significantly increased risk of all-cause. It strongly increases the risk of hypertension, stroke, and cardiovascular events.

The Treatment Barrier

CPAP Adherence is the Systemic Failure: Despite being the standard treatment, non-adherence is widespread, reaching 83% in some reports. This under-treatment results in worsened health outcomes and increased healthcare costs.

The Design Opportunity

Current Masks are The Design Flaw: The problem is often not the science, but the poor patient interface. Barriers like claustrophobia (felt by 85% of full facemask users) and physical discomfort are primary factors that our design solution must address.



02

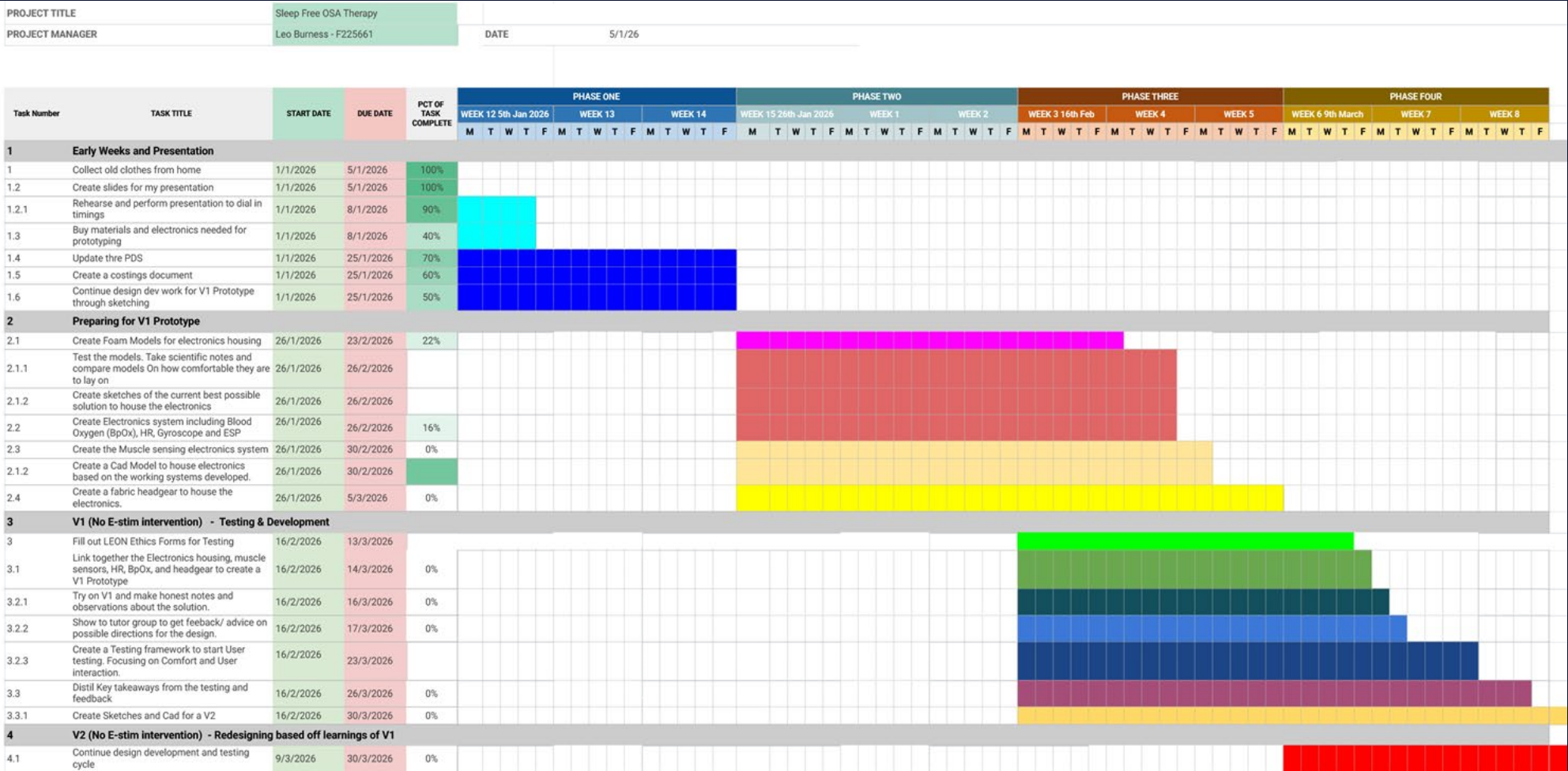
SECTION

Design Development

Progress since Submission 2 — what changed, and what drove it.



Gantt Chart



Section 2 · Design Development

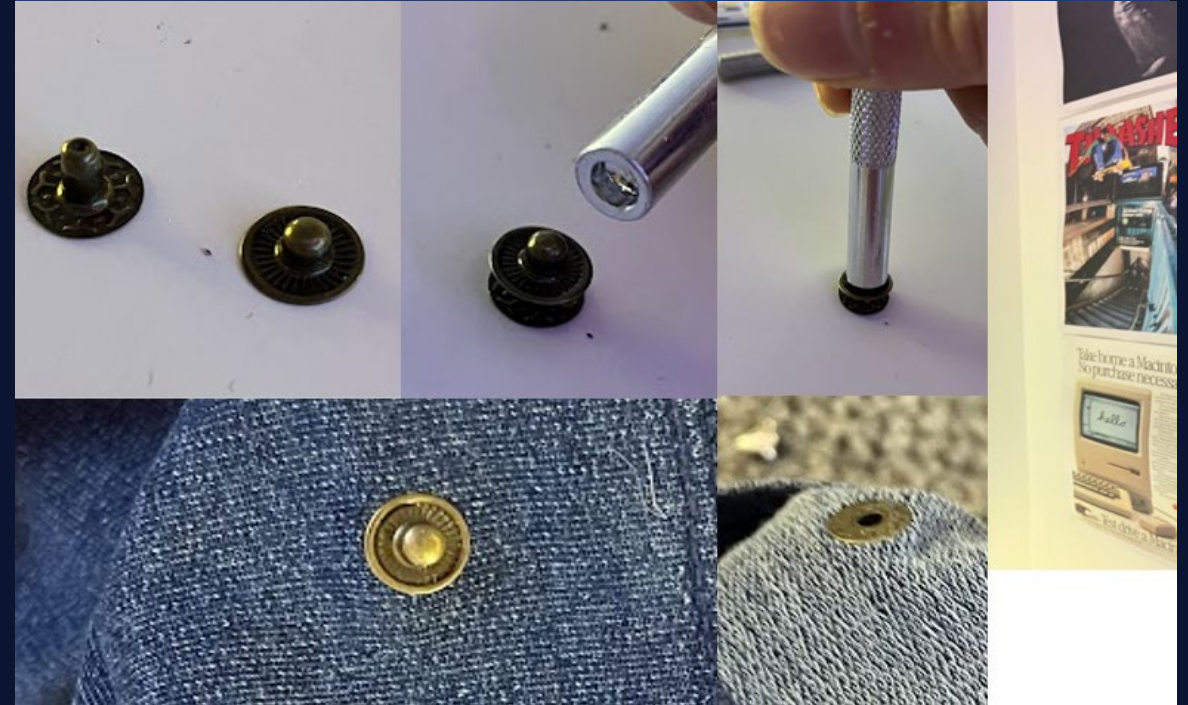
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Snap Buttons



Objective: Learn how snap buttons can act as connection point for electronics systems.



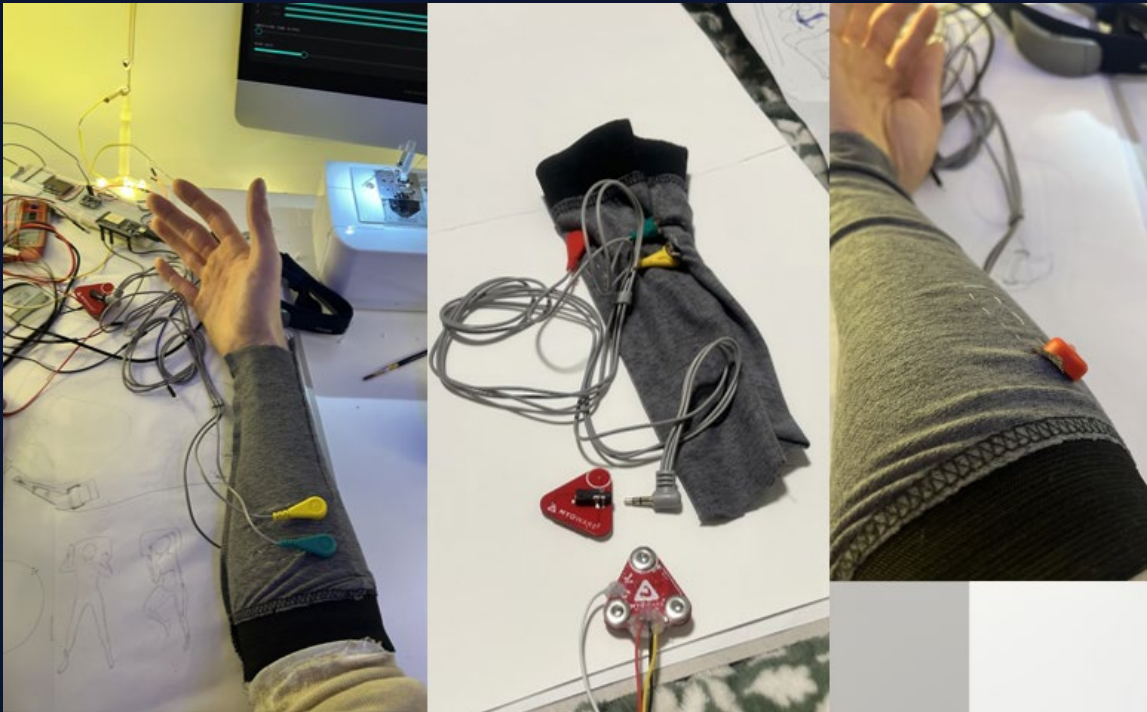


EMG Fabric Sleeve



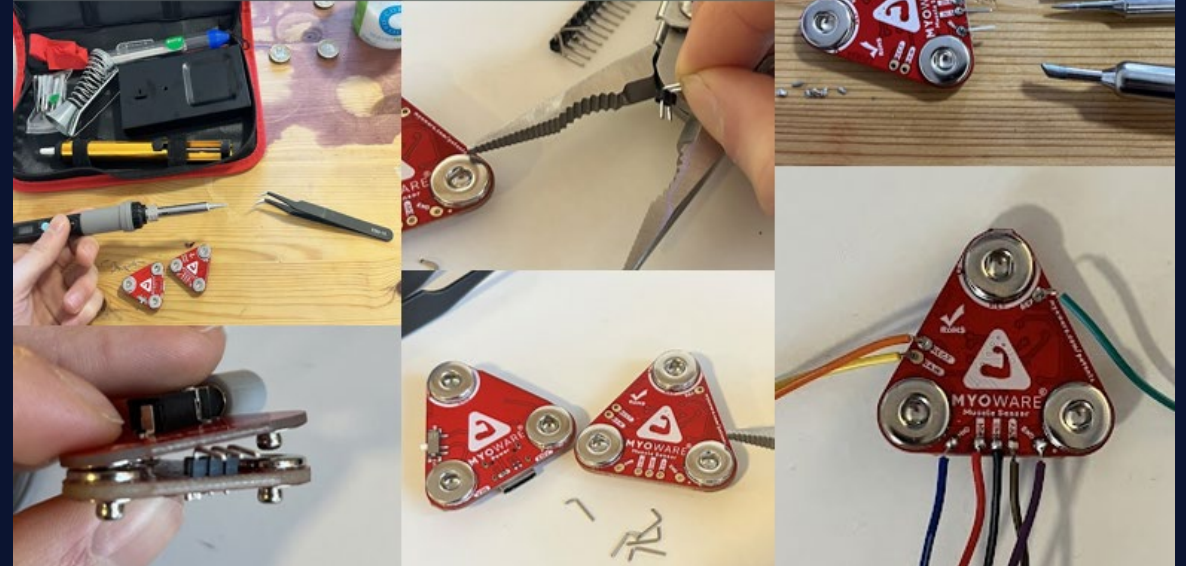


EMG Fabric Sleeve



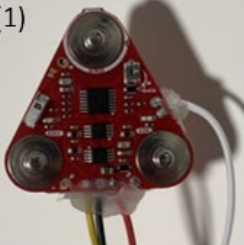
Myoware EMG sensor soldering

90 Degree pins were chosen at first for soldering, they didn't fit with the clipping mechanism, so were trimmed. I bought my own soldering iron and started soldering but the pins wouldn't solder well, so I went to the electronics lab.

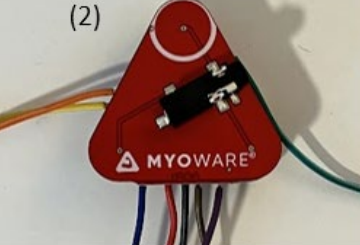


EMG Fabric Sleeve

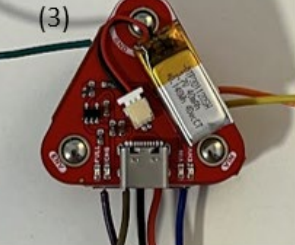
(1)



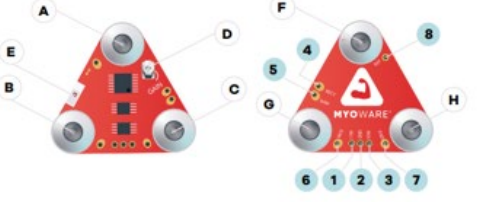
(2)



(3)



Sensor Parts



FRONT

BACK

A - Ground (GND) snap for shields

B - Envelope (ENV) output snap for shields

C - Input Voltage (VIN) snap for shields

D - Gain potentiometer (clockwise turn)

E - Reference electrode port (optional)

F - Reference electrode snap socket

G - Mid-muscle (MD) electrode snap socket

H - End-muscle (END) electrode snap socket

Primary Pins

1 - Input Voltage (VIN)

2 - Ground (GND)

3 - Envelope (ENV) output

Optional Pins

4 - Rectified (RECT) output

5 - Raw (RAW) output

6 - Mid-muscle (MD) electrode

7 - End-muscle (END) electrode

8 - Reference (REF) electrode

Raw EMG Output (RAW)



Rectified Output (RECT)



Envelope Output (ENV)



Power Shield (3) :

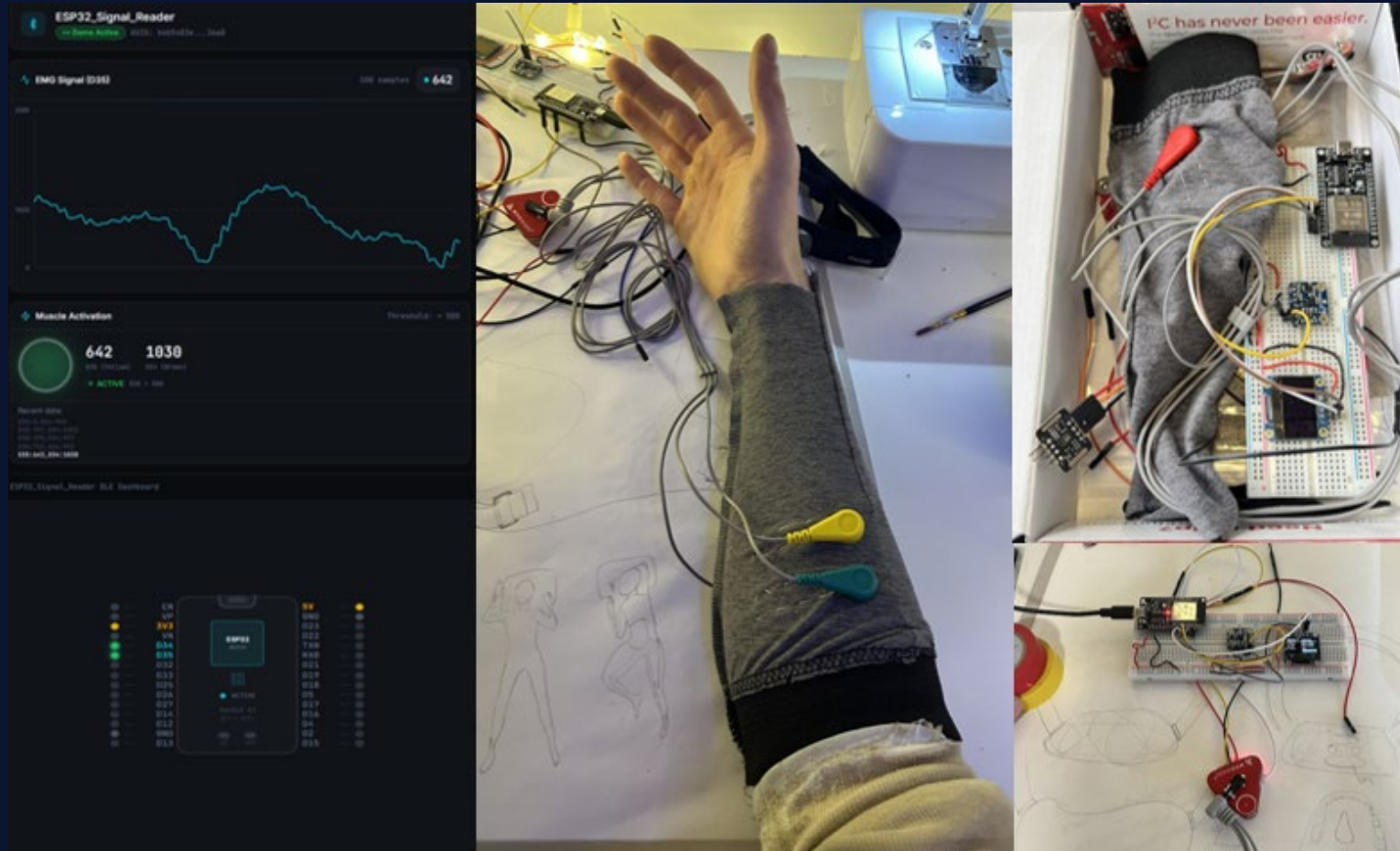
provides power to the sensor so it can process signals while disconnected from a separate power source like an Arduino.

Section 2 · Design Development

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EMG Fabric Sleeve

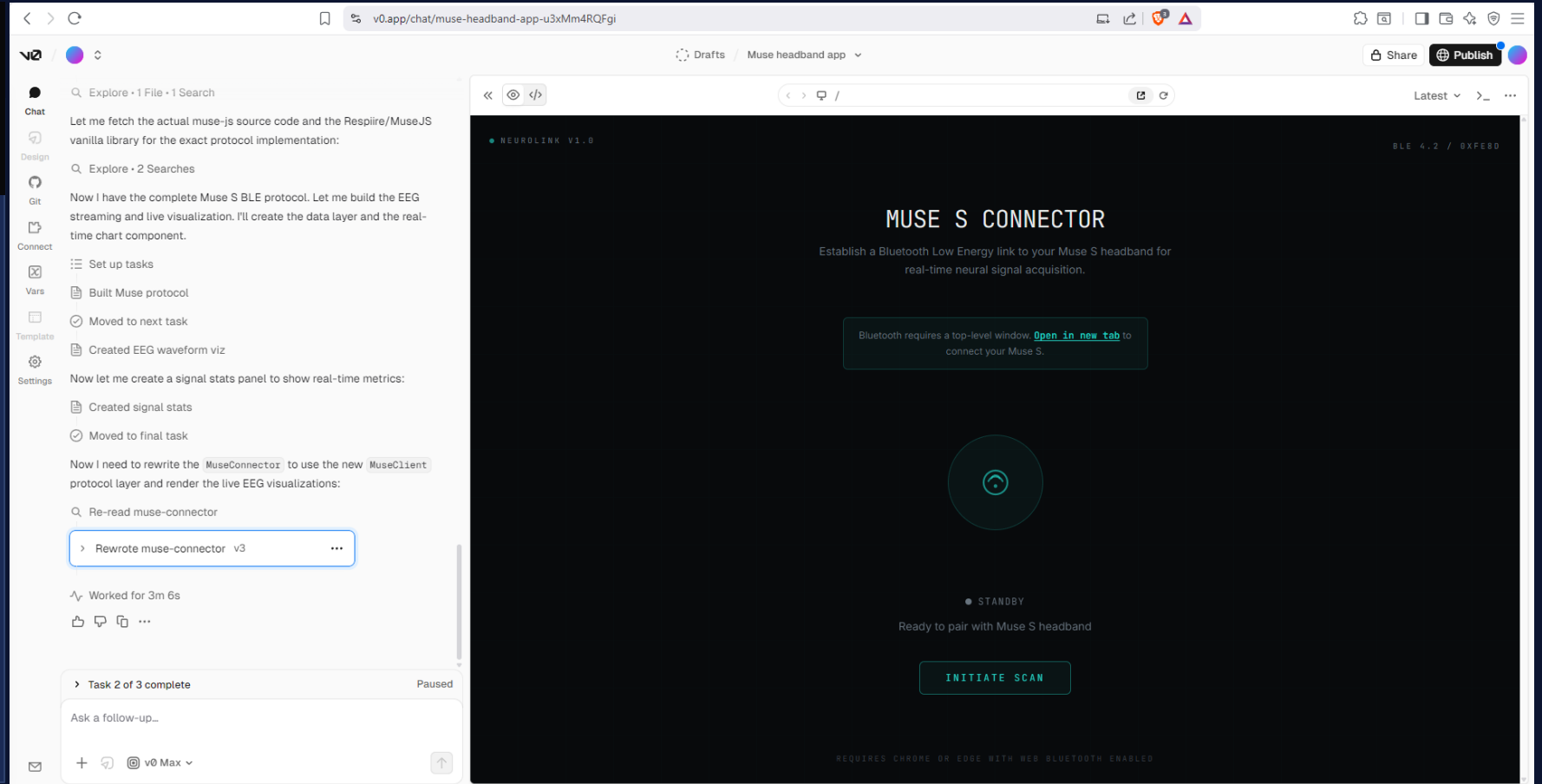




Agentic Vibe Coding

Open in 

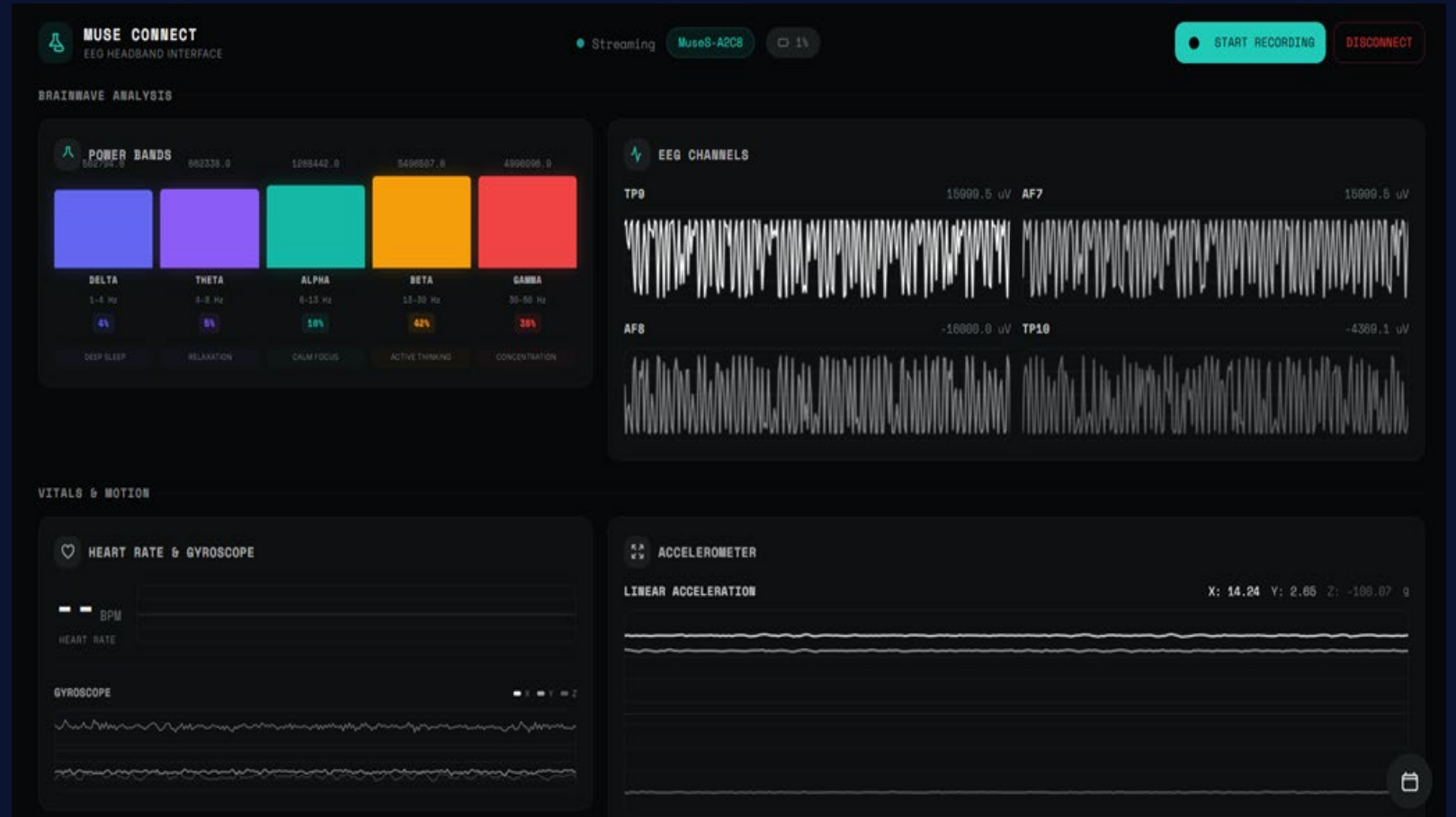
*Creating an app to
visualize and log
Brainwave, Heart rate
and positional data.*





Agentic Vibe Coding

Creating custom software to visualize electroencephalogram (EEG) wearable data. vO Vibe coded App for an acer laptop.

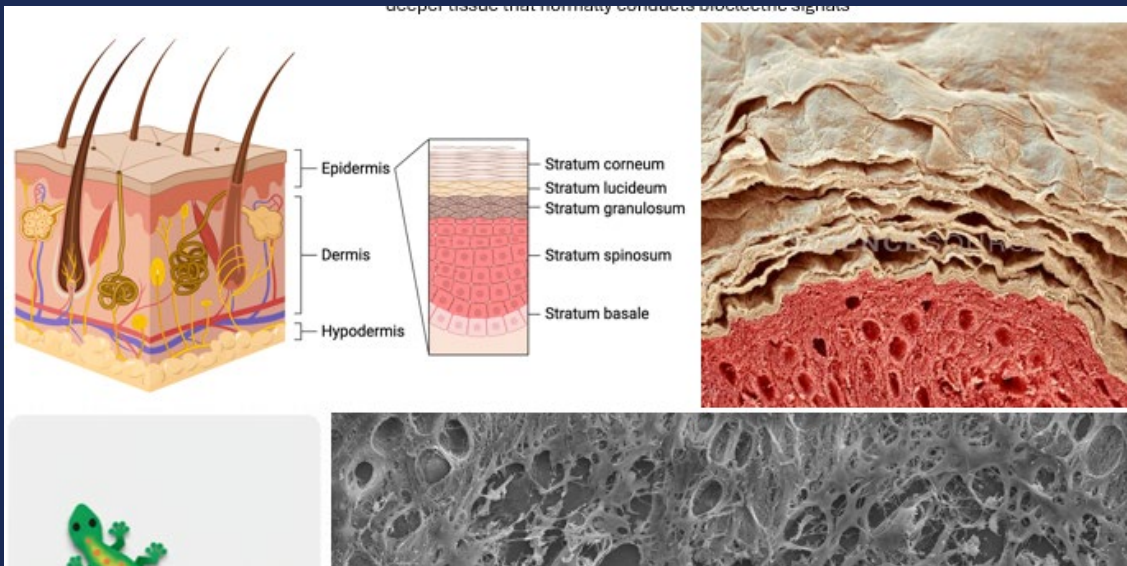


Dissecting an existing EEG Headband

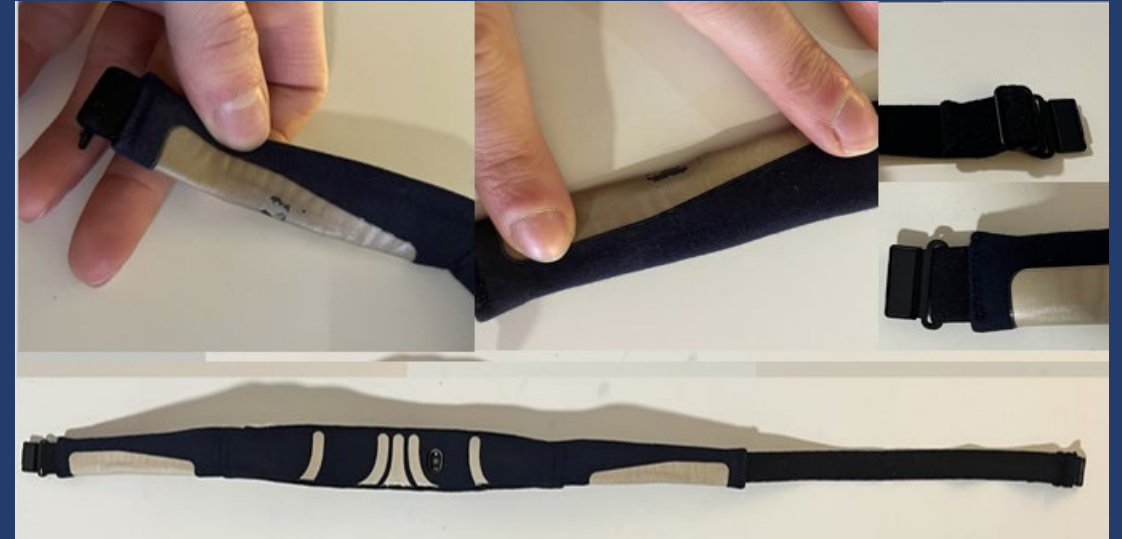




Understanding Physics of the skin



The stratum corneum (SC) is the outermost **skin layer**, composed of dead, keratinized cells called corneocytes embedded in a hydrophobic lipid bilayer of ceramides, cholesterol, and fatty acids. This structure creates high electrical resistance for three reasons: the lipid matrix repels **water** and ions, the densely packed architecture **leaves no open pathways for ionic current**, and the layer lacks the interstitial fluid found in deeper tissue that normally conducts bioelectric signals



Sweat gland ducts offer a **natural ionic bypass** through the SC, but sweat output is too physiologically variable to be a reliable conduction pathway. The silver fabric electrodes work when wet as the moisture fills the wrinkles of the skin fixing the surface area issue. **Water is a great conductor.**



EMG Pillow Development



Objective: Add a smaller sleeve as a reference electrode for the EMG set up and glue the silver fabric to the pillow. Reference is critical to obtain high quality signal.

Embroidered electrodes offer strong design control but produce a bumpier surface compared to the silver fabric tested previously. Silver alone is insufficient for conforming to skin microgeography; a screen-printed polymer layer could bridge this gap by moulding to the skin's natural surface valleys. Screen printing enables flexible electrode geometries and is an established research direction, though cost and development time must be carefully weighed against project scope.

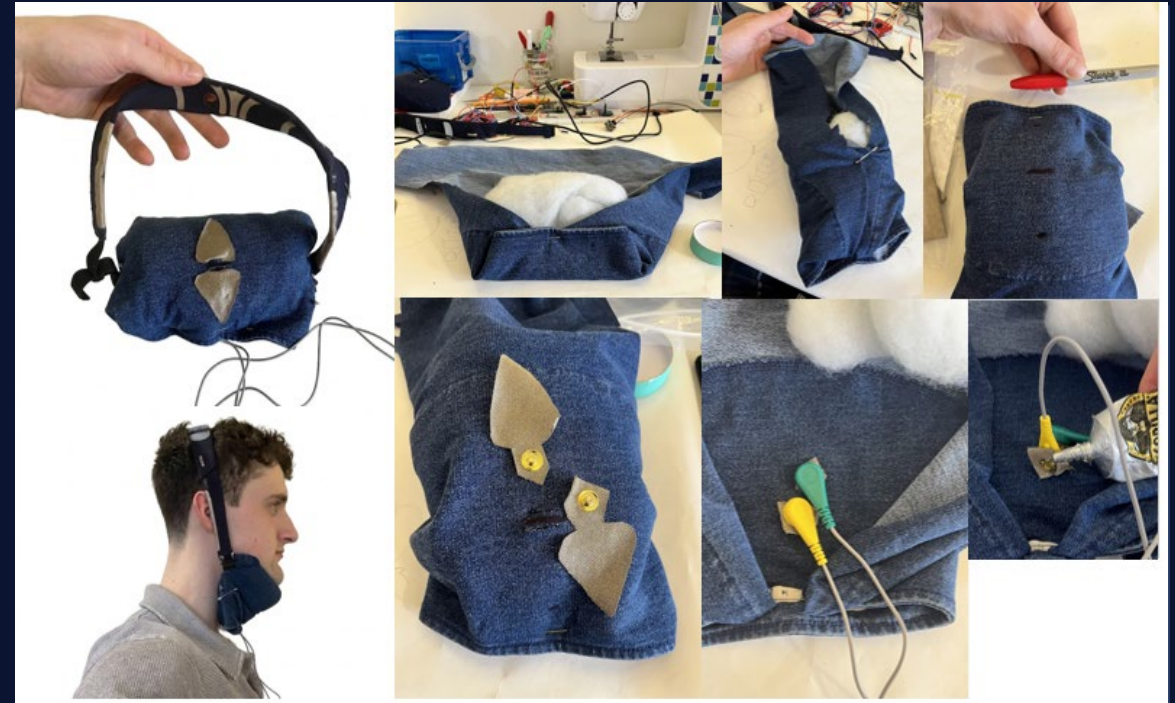




EMG Neck Pillow



Objective: Adapt electrode sleeve testing methods to measure submental genioglossus activity.



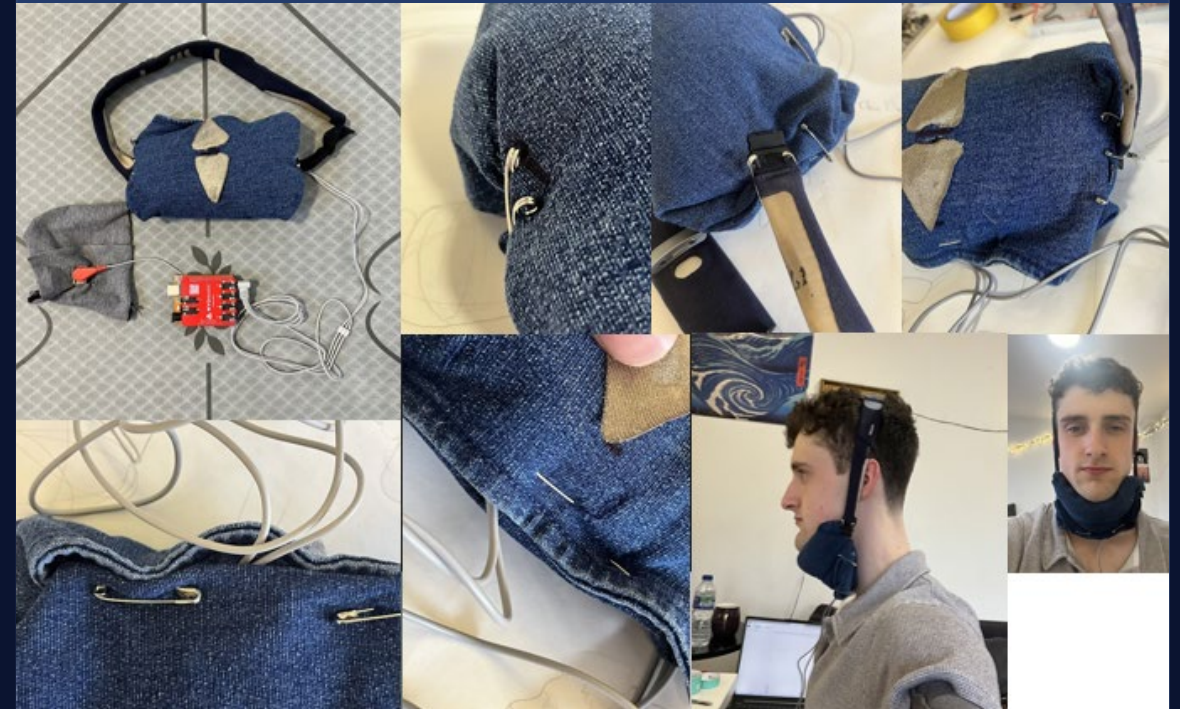
Utilized a safety-pin assembly for iterative sizing and adjustable fitting. **Electrode Integration:** Spade-shaped silver electrodes feature internalized wiring to protect connections. **Reliability:** Applied adhesive to secure electrode placement and prevent short circuiting during use.



Genioglossus EMG neck pillow



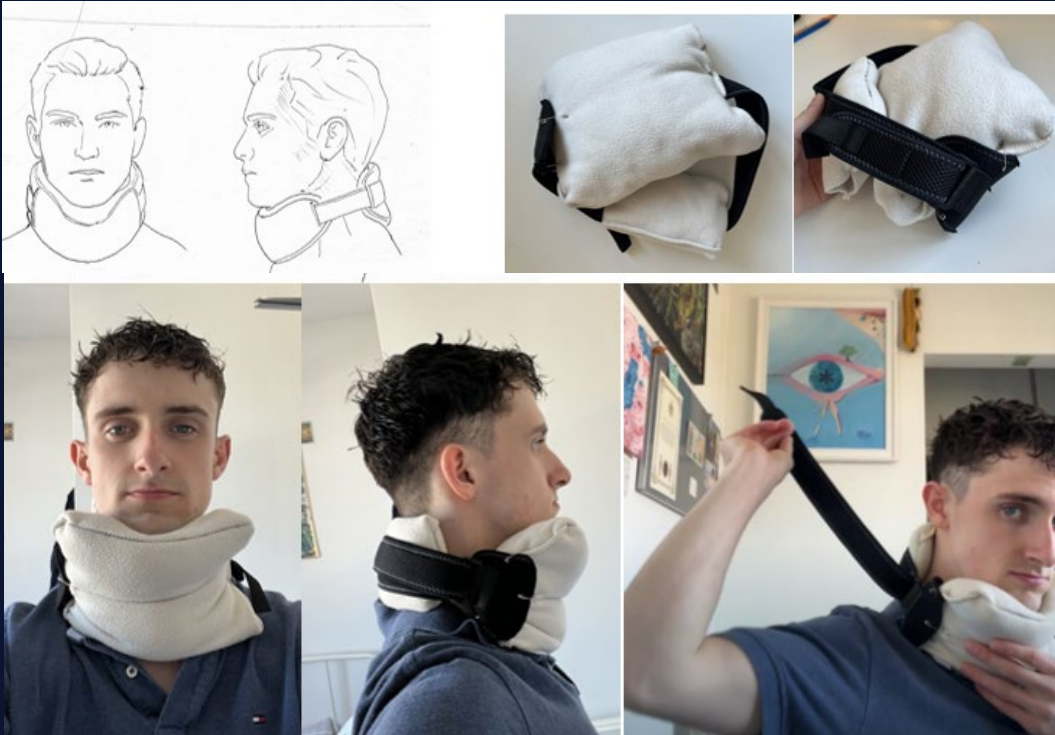
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Understanding Physics of the skin



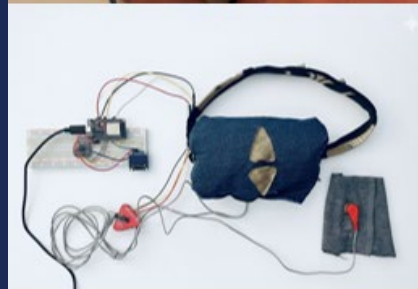
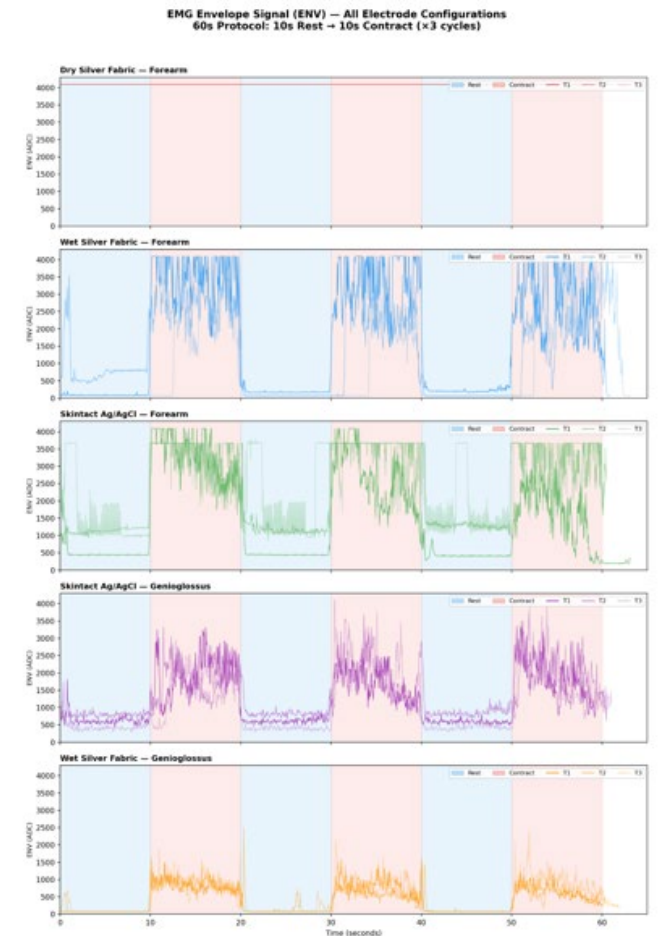
Above: Design the head straps away from the design to reduce claustrophobia. A travel friendly pillow.

Right: Testing signal fidelity for EMG signals on the forearm and genioglossus muscles.

Data Collection ENV Results

Envelope Time Series

These graphs show the envelope signal across all five configurations for the full 60-second protocol. Rest periods are shaded blue and contraction periods red. Each trial is overlaid with decreasing opacity (T1 darkest, T3 lightest).



EMG – Mic transition.

Electromyography → Microphone

3PCS INMP441 Omnidirectional Microphone Module I2S Interface MEMS High Precision Low Power Ultra Support ESP32 \$11.99

https://www.amazon.com/INMP441-Omnidirectional-Microphone-Interface-Precision/dp/B096B1F4CB/ref=sr_1_17?crid=13G3KMJA86ZV&df=eyJ2IjoiMSJ9.NVTOHB-Y9Qme_TBWYKAhtSg2Zn7Wxmp4n2VnydIRPueIsLeVFTD_TAKOma3p0S5nV8Jis+KQFRdri0Sk-cM9HWI_EFpp_Vzk_tXA8in4n1TObnBkk1-ePCbuXl1cfWQfCwO-46PqetYL2STQ_gVnGorshM-4DOP2x6Dy-XpB_PePiQCrN7PyW6gG1S.dlb_tag=se&keywords=INMP441+3pc&qid=1774875867&prefix=irm-p441+3pc%2Caps%2C2018&sr=8-1

After Realising silver fabric EMG electrodes required water to maintain a meaningful signal, I changed my thinking to monitoring the sound of the breath through microphones.

Audio processing will provide the necessary insights into airway patency for diagnosis and profile modelling.

A digital twin of the patient created by the ai to monitor states of being.



Microphone testing

INMP441
I2S microphone

ESP32
Dev module

VDD — 3.3V — 3V3

GND — GND — GND

SD — SD — D32

WS — WS — D25

SCK — SCK — D26

L/R — — = GND (tied on board)

— I2S bus —

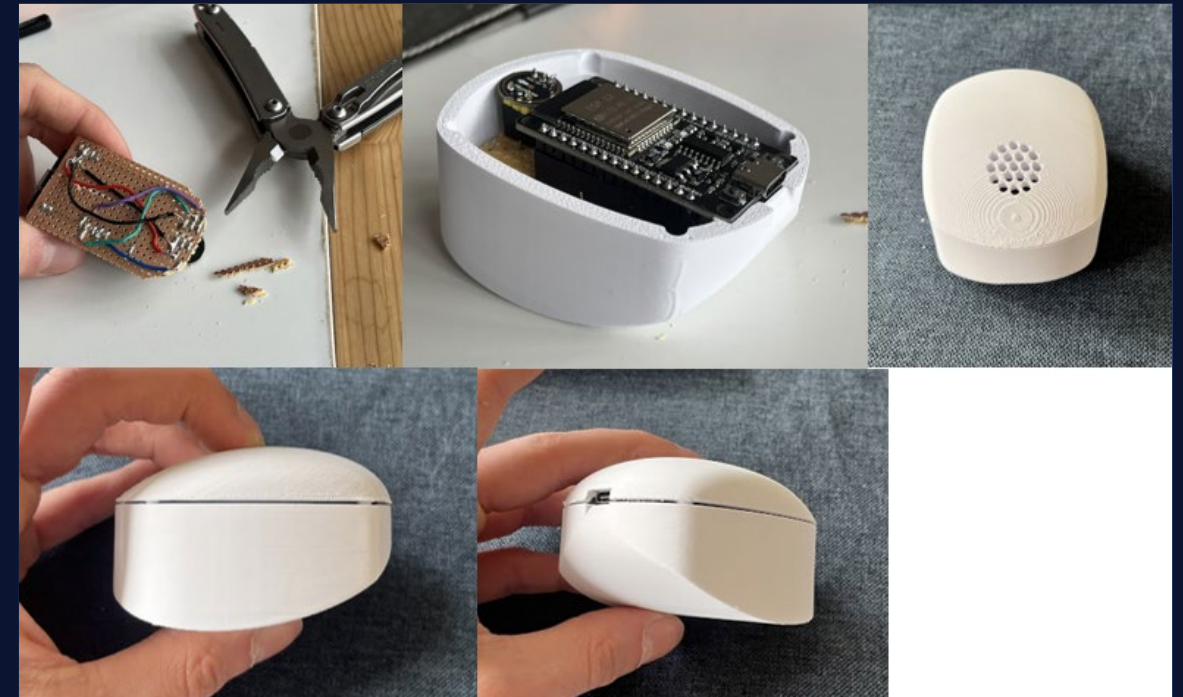
● 3.3V power ● GND ● SD (data in) ● WS (word select) ● SCK (bit clock)

5 wires · L/R bridged to GND on board · left channel confirmed

System Diagram generated via Claude. Sonnet 4.6 Extended ✓
(Prompt on next page)

SD, WS, and SCK are mapped to GPIO pins D32, D25, and D26. Selected for their I2S compatibility whilst avoiding ESP32 strapping pins. The L/R pin is pulled to GND on the board, configuring the microphone to transmit on the left channel. The perfboard has been manually scored to isolate the required traces. Successful I2S audio transmission was subsequently confirmed via serial monitor, validating the physical implementation.

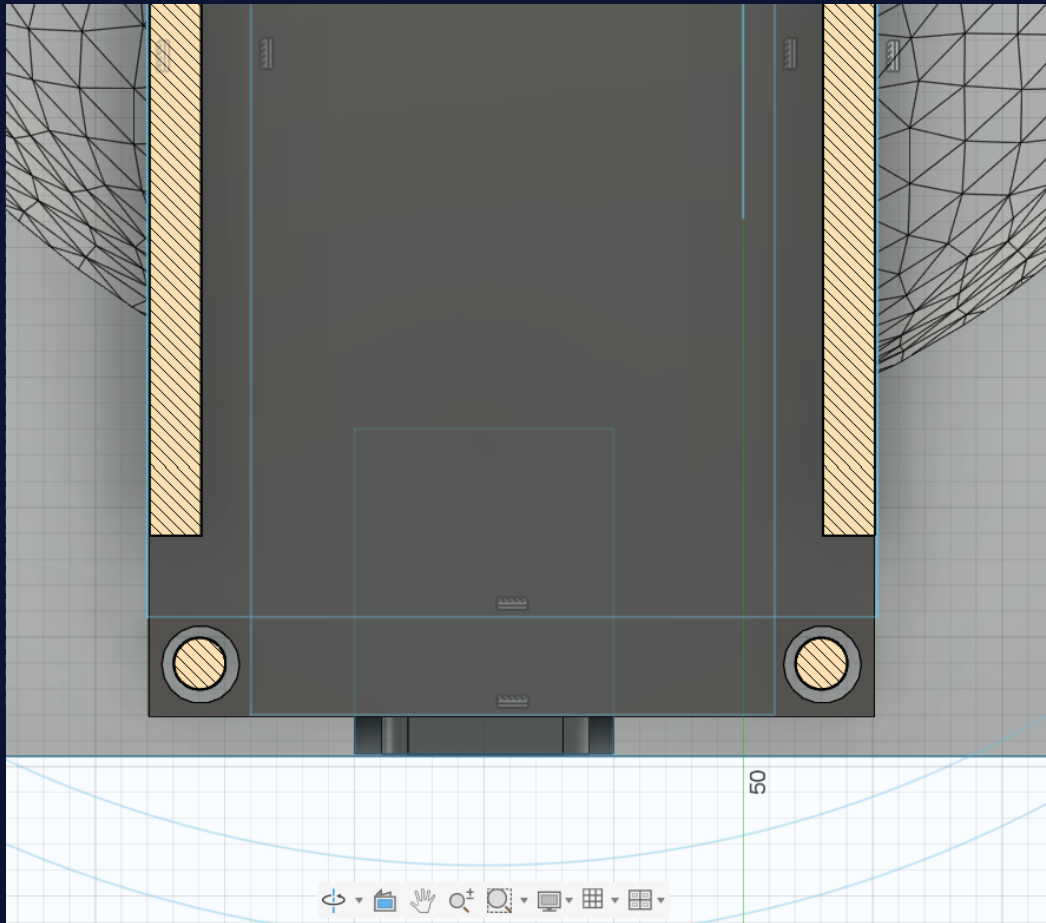
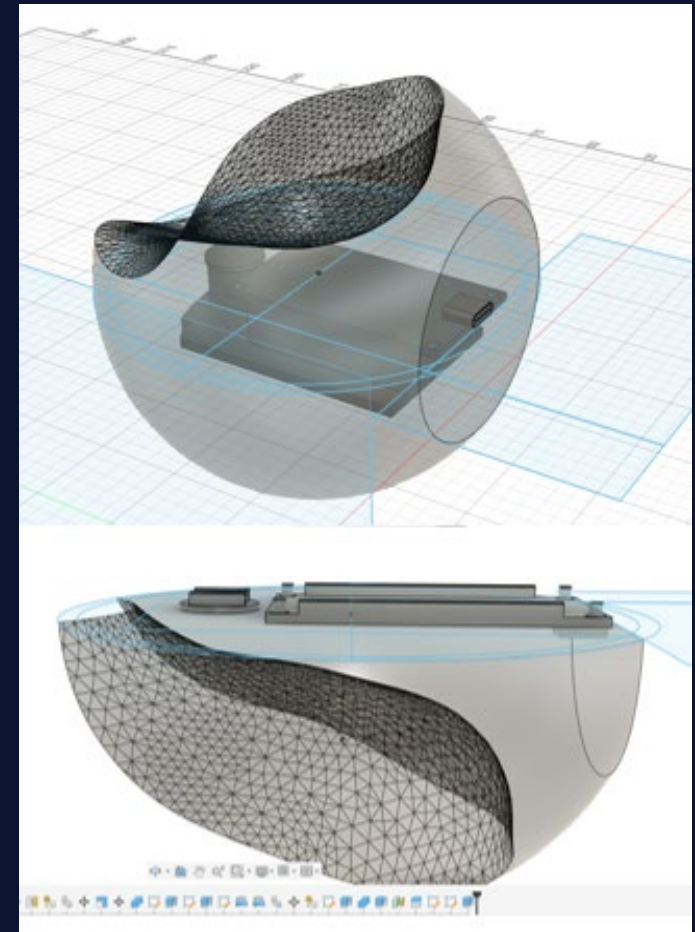
ESP32-Devkit V1 testing with perf-boards and 3D printing. Claude helping structure and code the system.



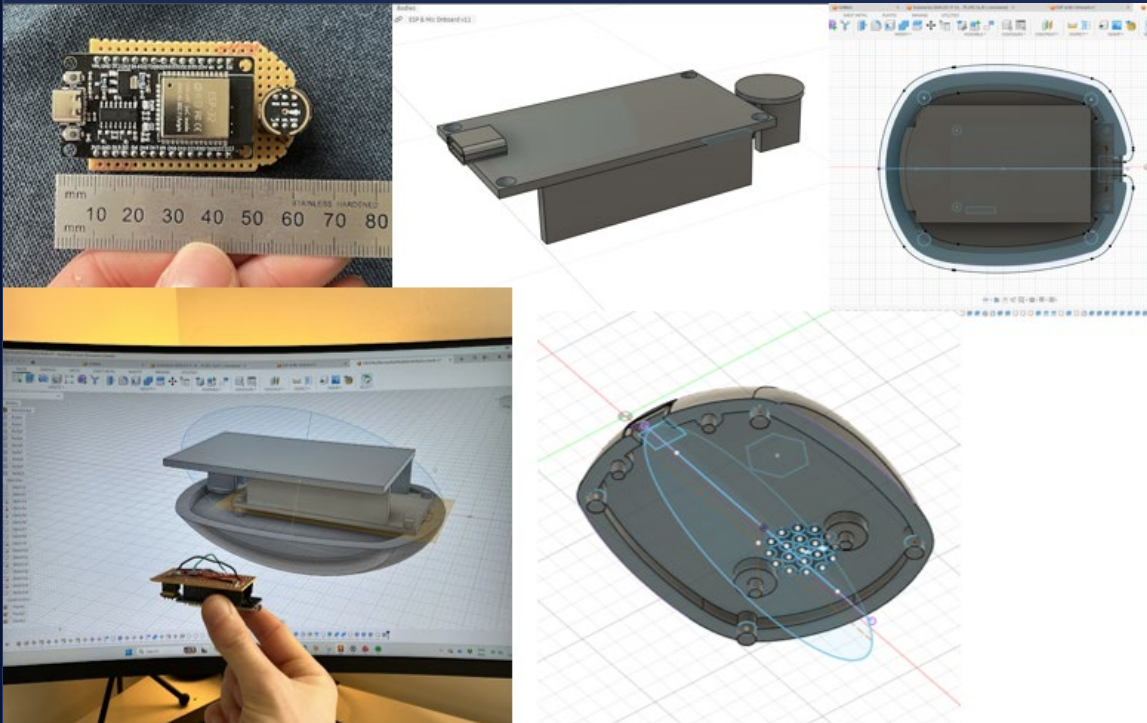
Trimming and sanding the parts to enable a clean fit.



Microphone testing



Microphone testing



Create a plastic housing for me to test my Microphone set up.

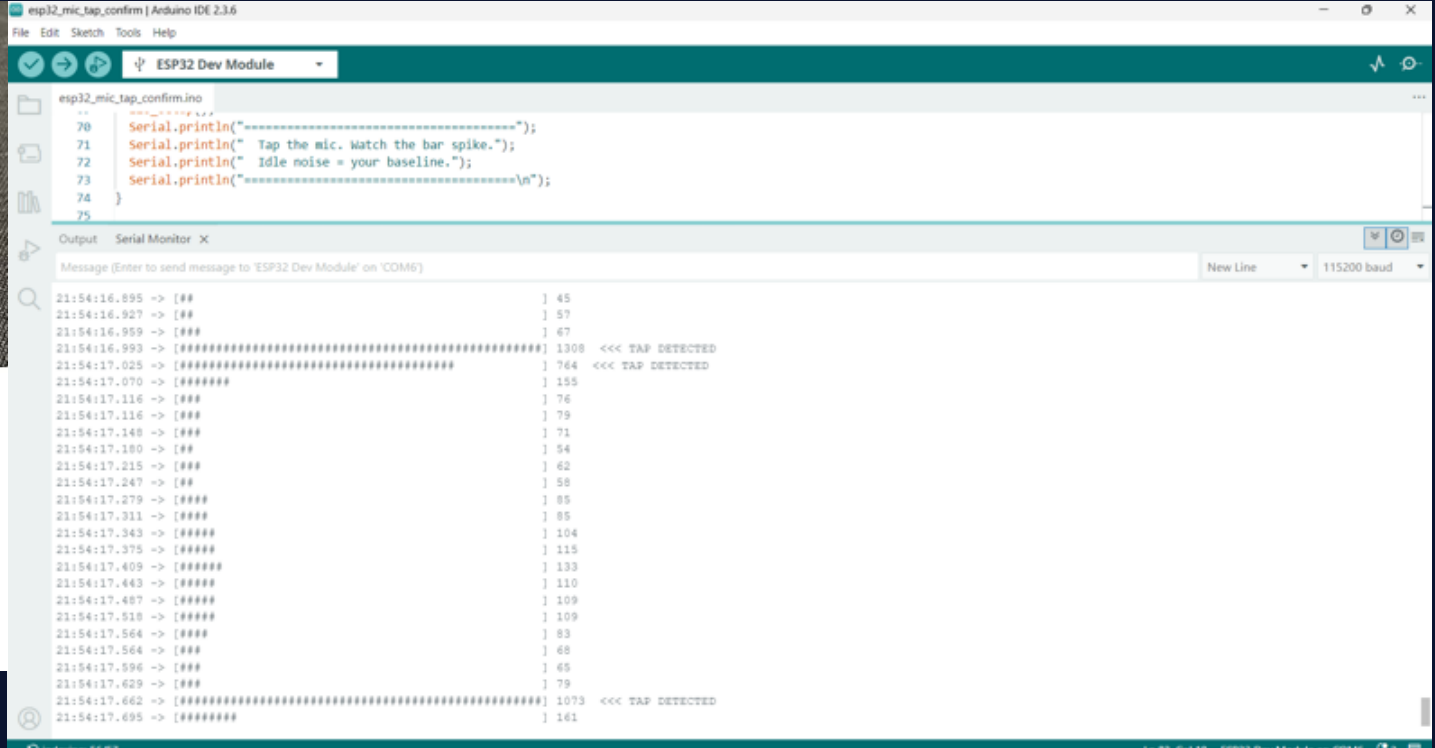


Reflection on process:

Print warping caused **misalignment** between the push-fit pin holes and the ESP32 footprint, requiring manual **post-processing** with a **scalpel** and **file** to achieve an **acceptable fit**. This identified a critical tolerance gap in the CAD model. Future iterations will incorporate **2mm** of **additional clearance** into the mounting geometry to eliminate fit-up issues without manual intervention. For this **prototype stage**, functionality is **uncompromised** and **apnea detection testing** can proceed as intended. However, as the design evolves to integrate **headstraps** and a chin cap assembly, precise dimensional **tolerancing** will become a hard requirement — any fit failure at that stage would affect wearability, positional accuracy of the microphone, and ultimately the clinical validity of the captured data.



Microphone testing



```
esp32_mic_confirm.ino
70 Serial.println("=====");
71 Serial.println(" Tap the mic. Watch the bar spike.");
72 Serial.println(" Idle noise = your baseline.");
73 Serial.println("=====\\n");
74 }
75

Output Serial Monitor X
Message (Enter to send message to 'ESP32 Dev Module' on 'COM6')
New Line 115200 baud

21:54:16.895 -> [###] 45
21:54:16.927 -> [###] 57
21:54:16.959 -> [###] 67
21:54:16.993 -> [#####] 1308 <<< TAP DETECTED
21:54:17.025 -> [#####] 764 <<< TAP DETECTED
21:54:17.070 -> [#####] 155
21:54:17.116 -> [###] 76
21:54:17.116 -> [###] 79
21:54:17.148 -> [###] 71
21:54:17.180 -> [###] 54
21:54:17.215 -> [###] 62
21:54:17.247 -> [###] 58
21:54:17.279 -> [#####] 85
21:54:17.311 -> [#####] 85
21:54:17.343 -> [#####] 104
21:54:17.375 -> [#####] 115
21:54:17.409 -> [#####] 133
21:54:17.443 -> [#####] 110
21:54:17.487 -> [#####] 109
21:54:17.518 -> [#####] 109
21:54:17.564 -> [#####] 83
21:54:17.564 -> [#####] 68
21:54:17.596 -> [#####] 65
21:54:17.629 -> [#####] 79
21:54:17.662 -> [#####] 1073 <<< TAP DETECTED
21:54:17.695 -> [#####] 161
```

Here I am using the serial monitor to visualise the audio data being processed by the INPP mic. I am testing using a volume threshold to trigger a "Tap Detected" message to the serial monitor.

This proved to me the Mic was connected correctly, allowing me to start exploring more complicated signal processing capabilities that achieve higher accuracy tracking of breathing patterns

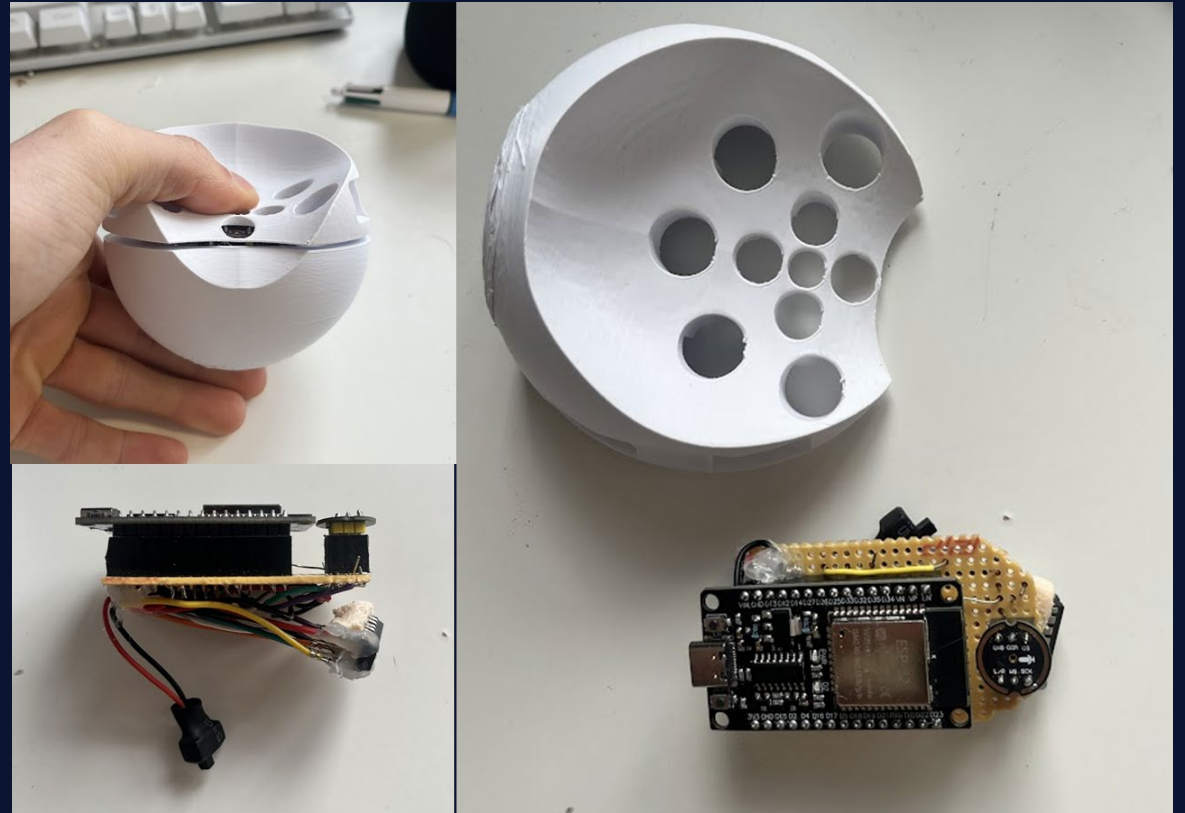
03

SECTION

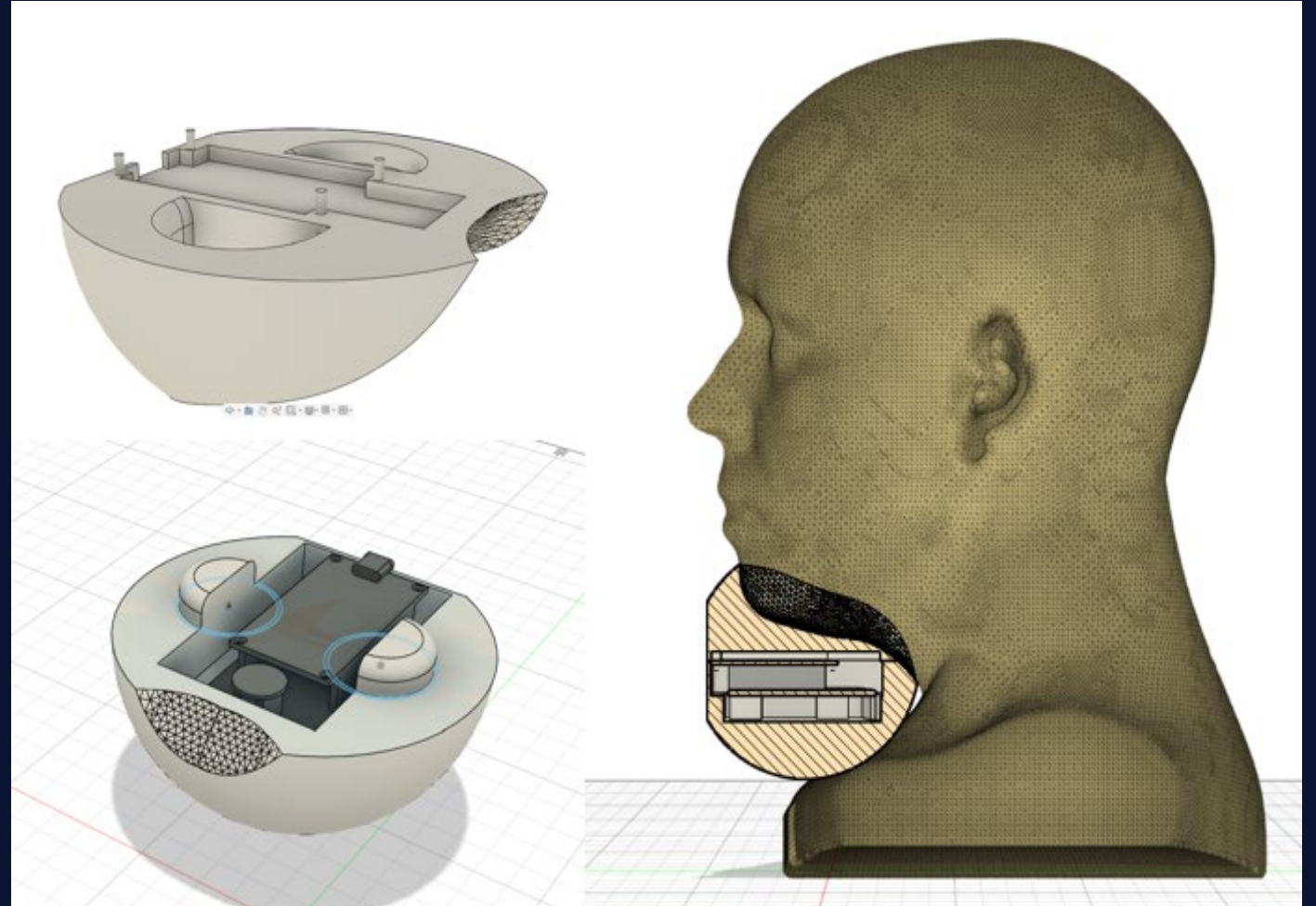
Prototyping in Semester 2

What was made, how, and why — from early studies to the final build.

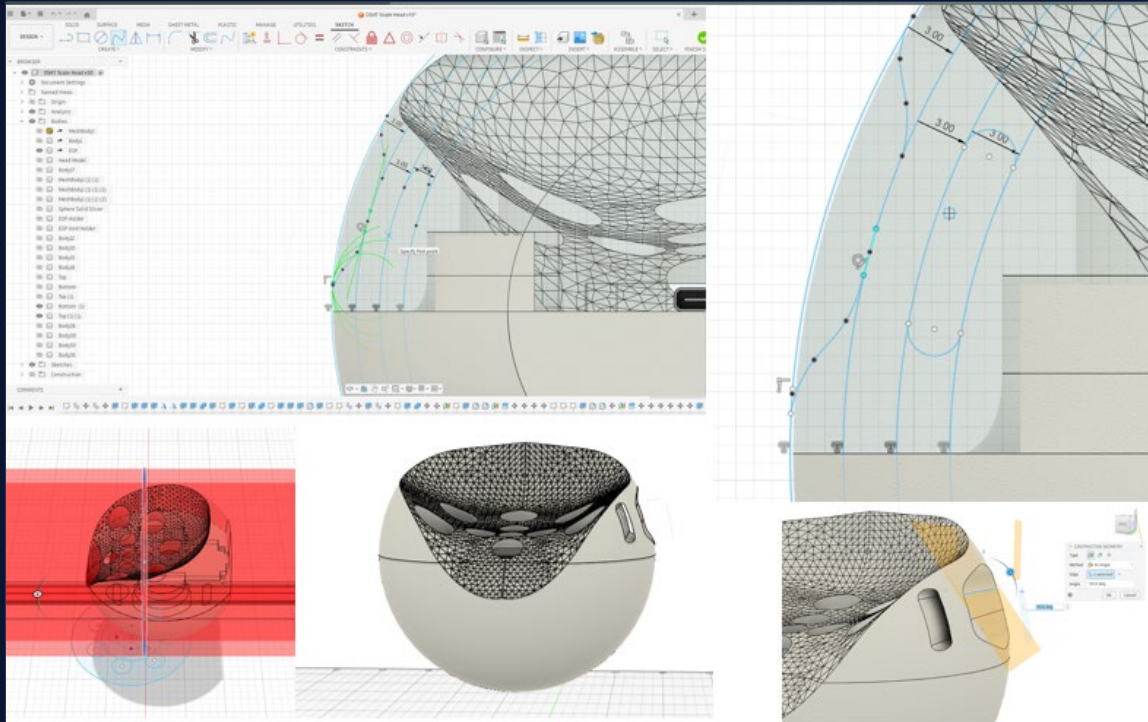
Microphone testing



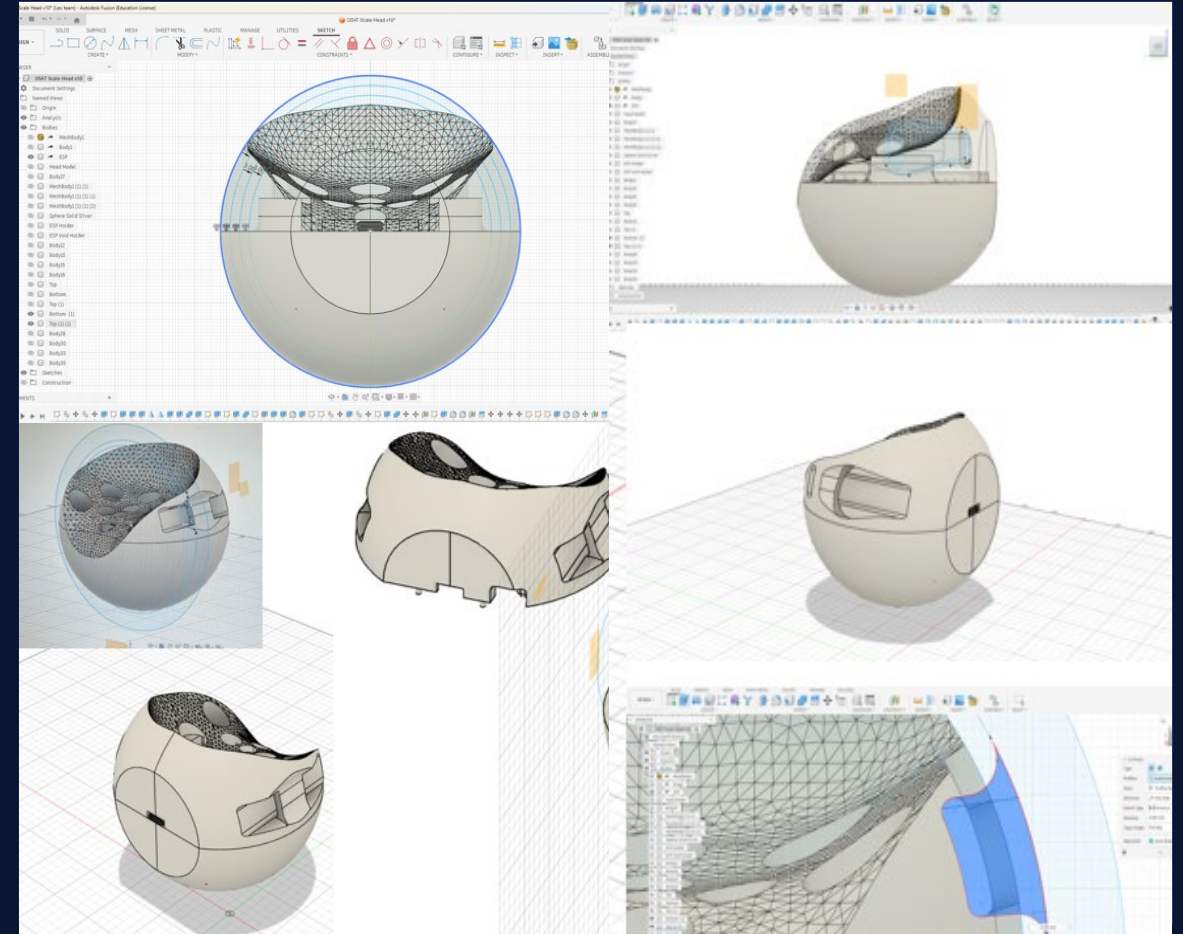
Microphone testing



Microphone testing



Create a plastic housing for me to test my Microphone set up.

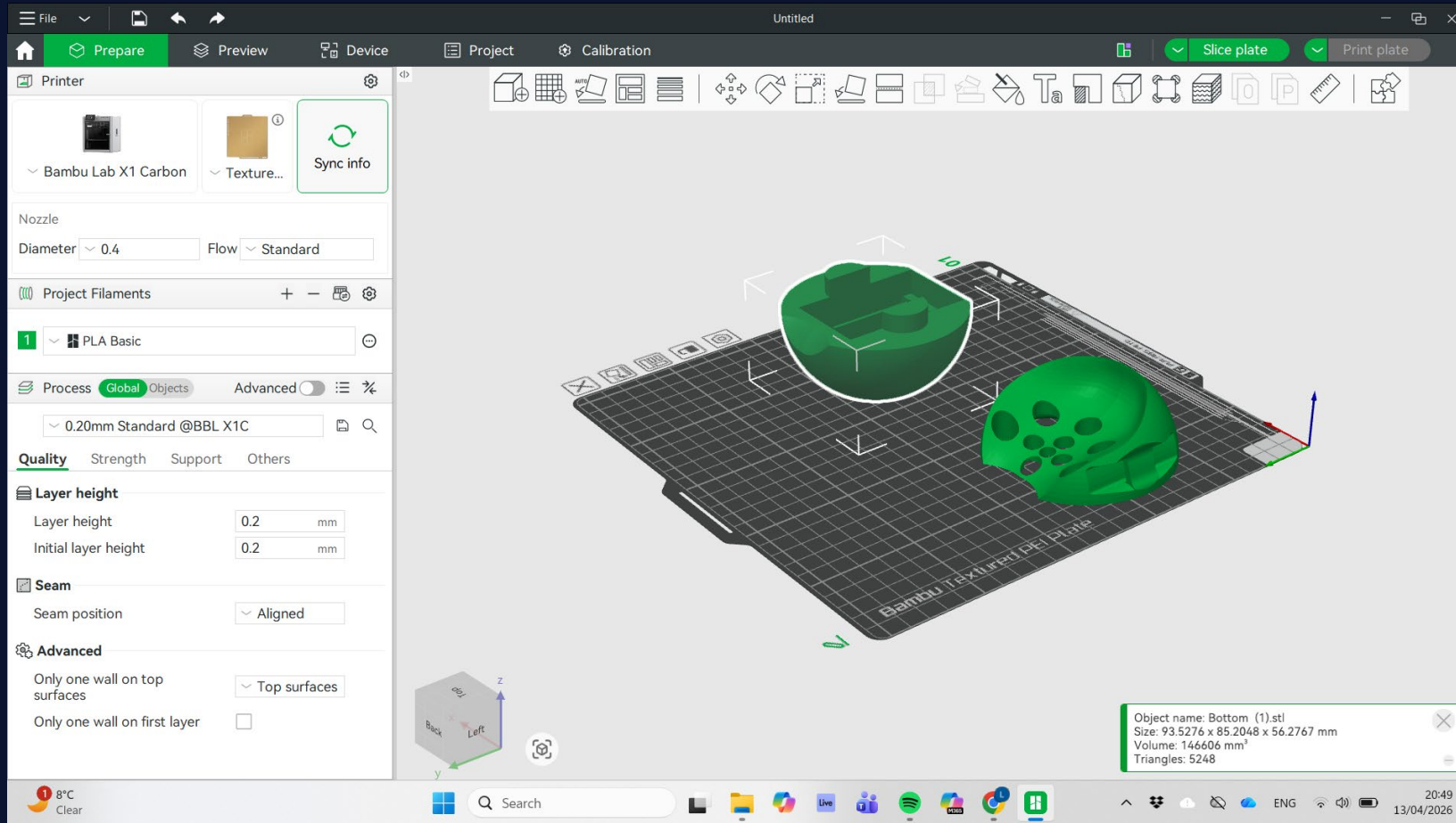
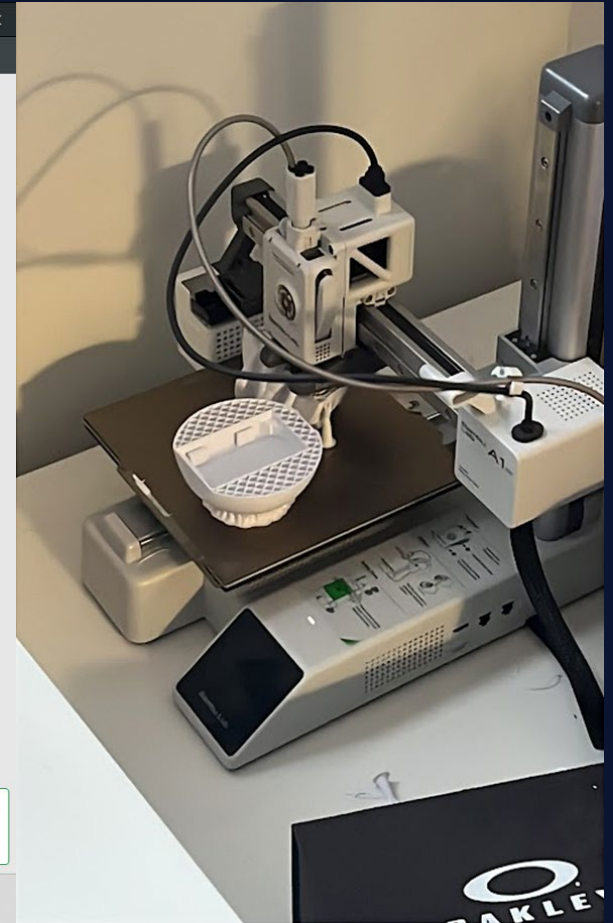


3D Printing

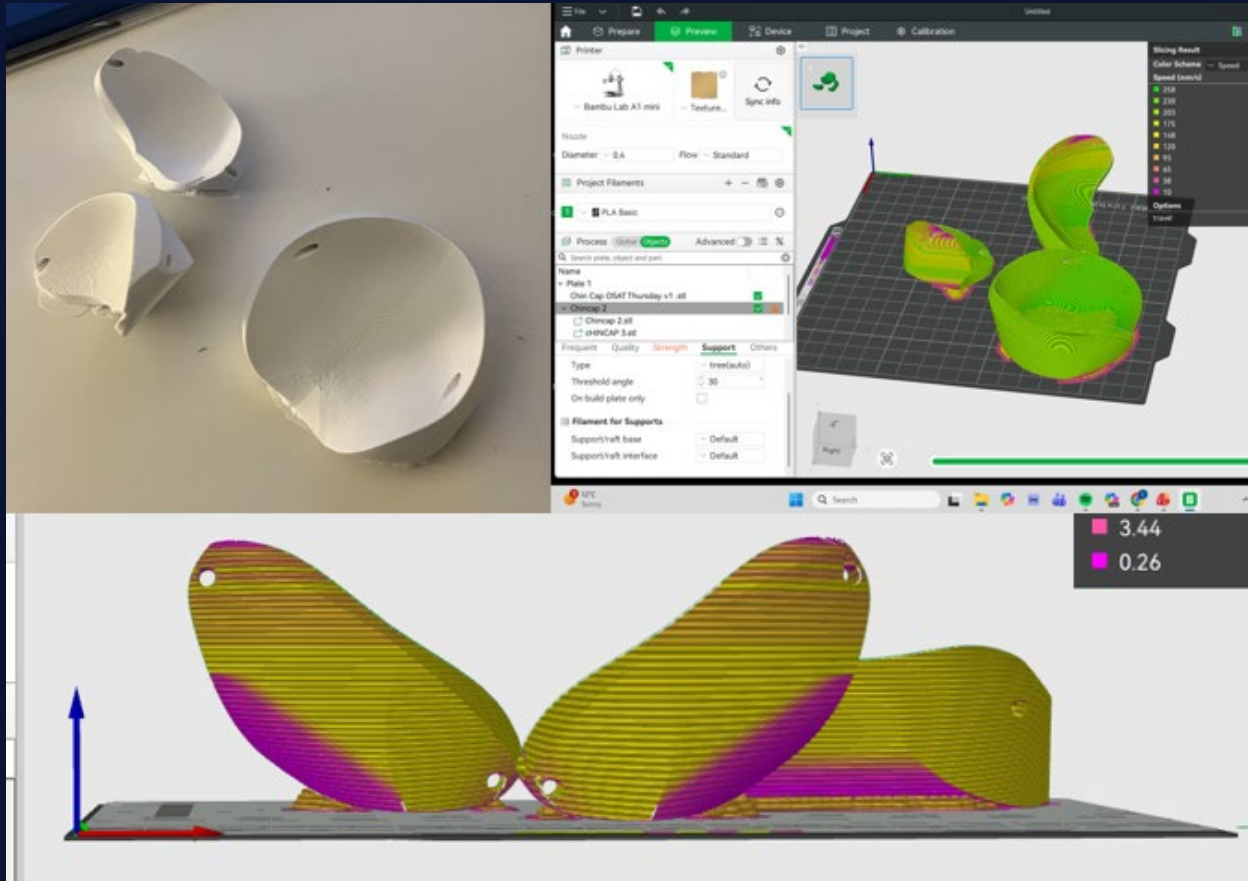


Explore housing for my Sensor Hub

3D Printing



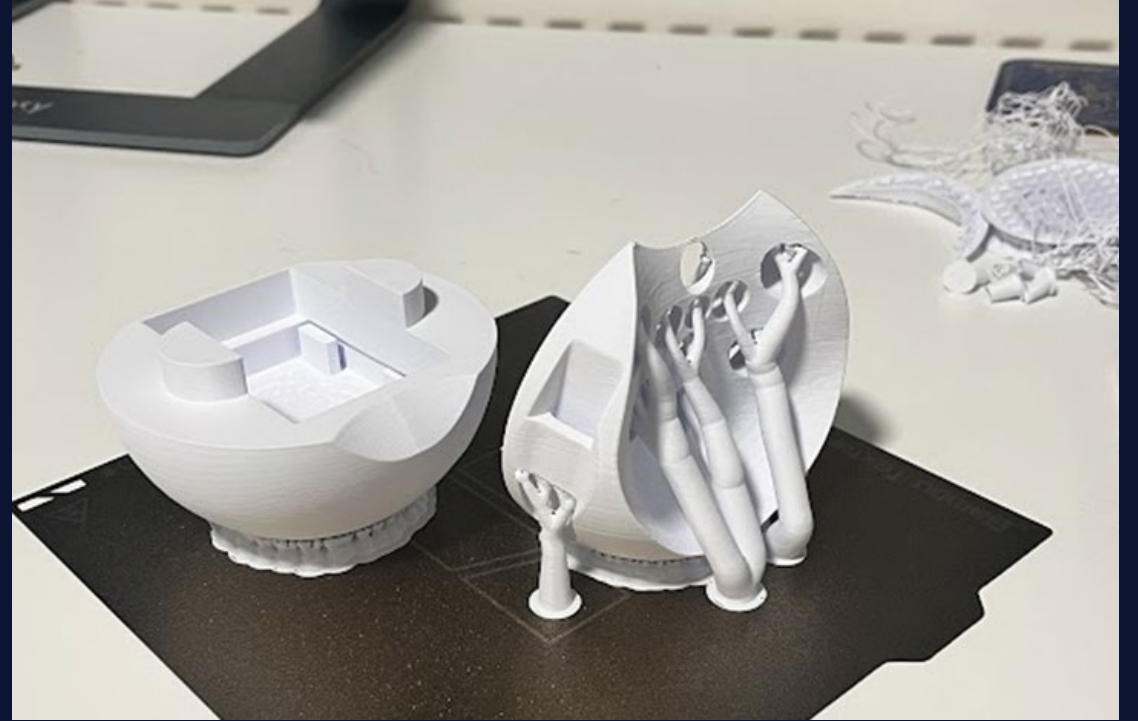
Prototyping



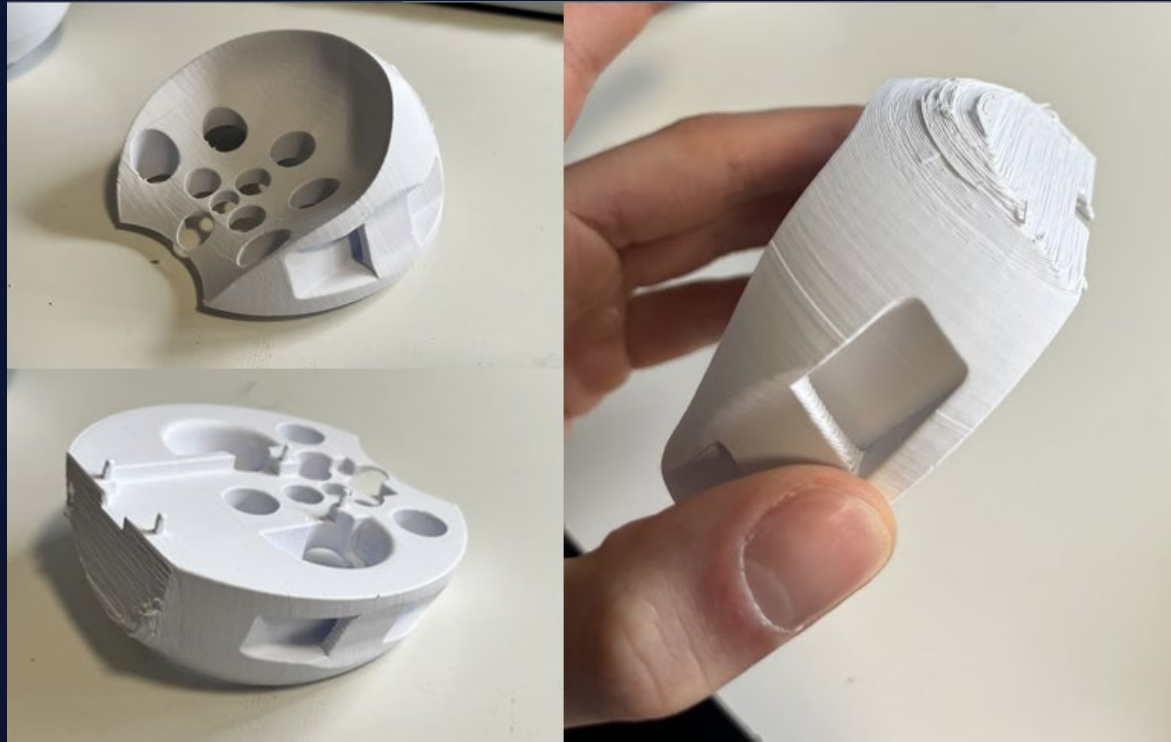
3D Printing



Explore housing for my Sensor Hub



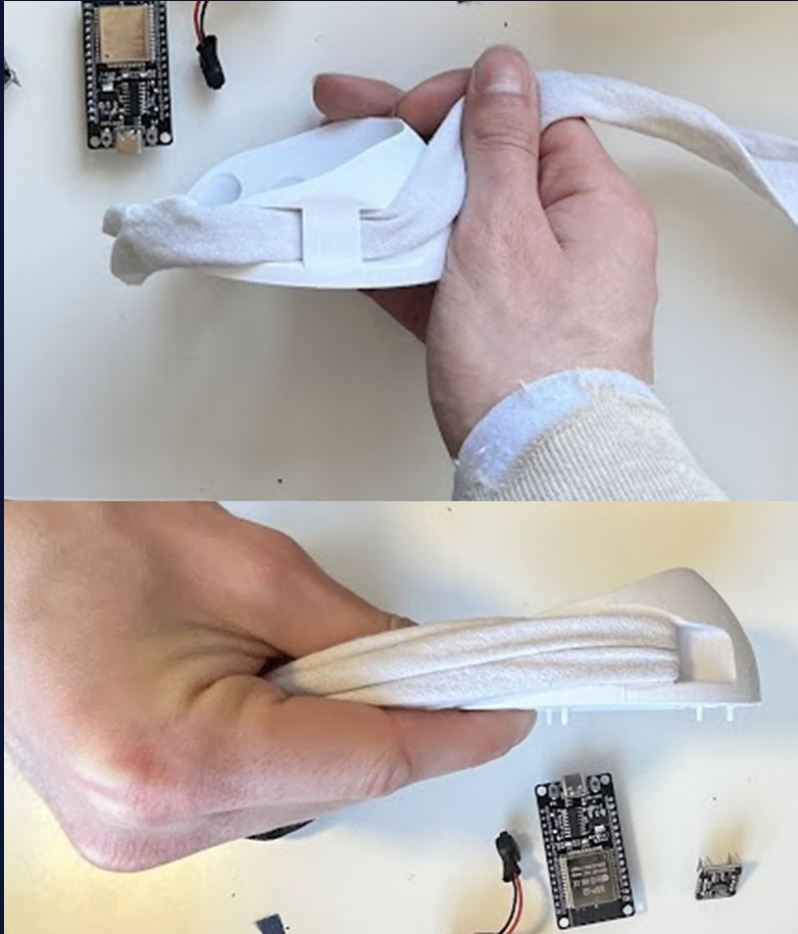
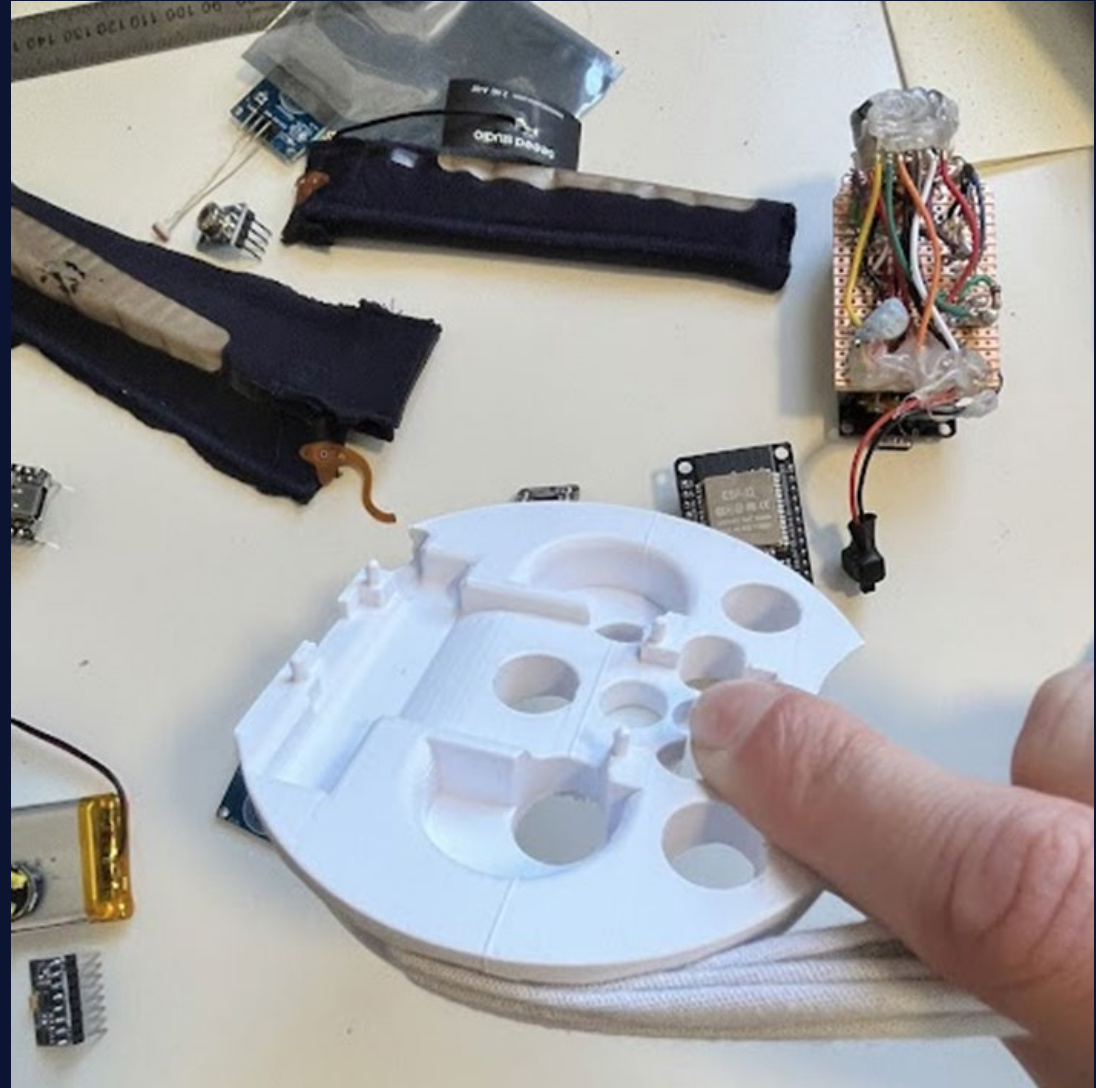
3D Printing



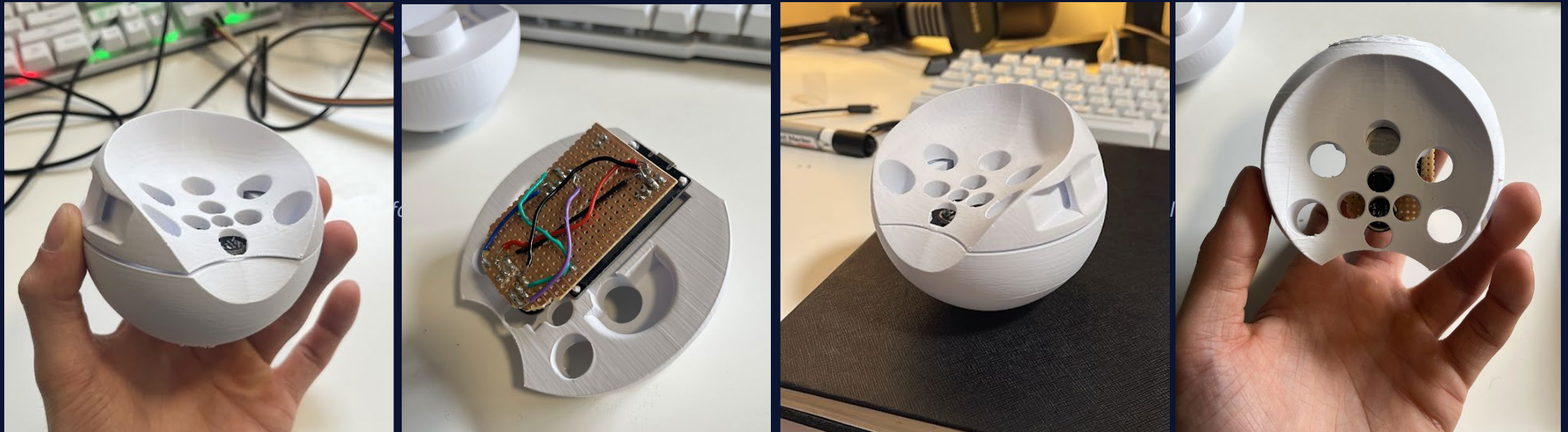
Explore housing for my Sensor Hub



3D Printing



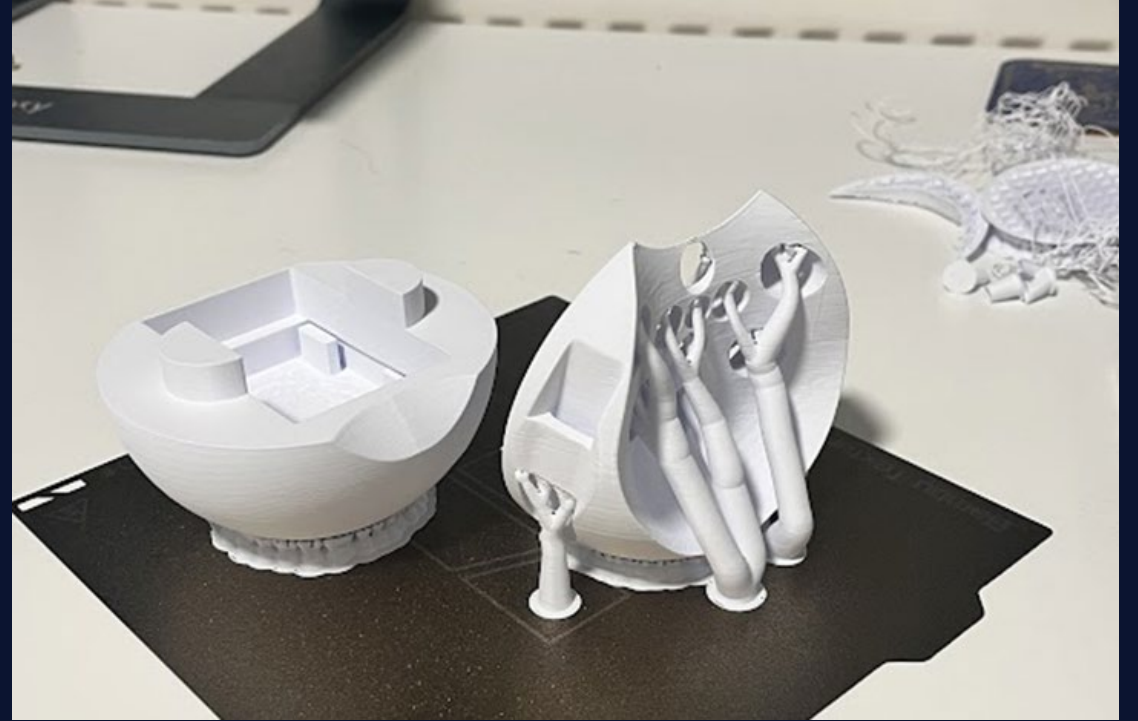
Sensor Hub



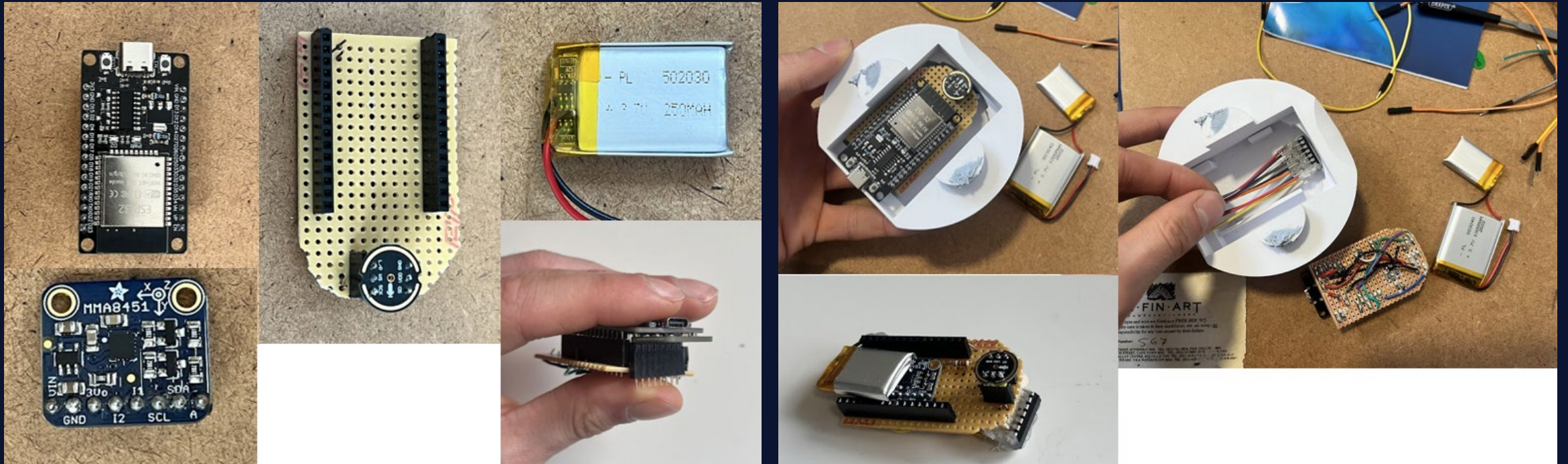
3D Printing



Explore housing for my Sensor Hub



3D Printing

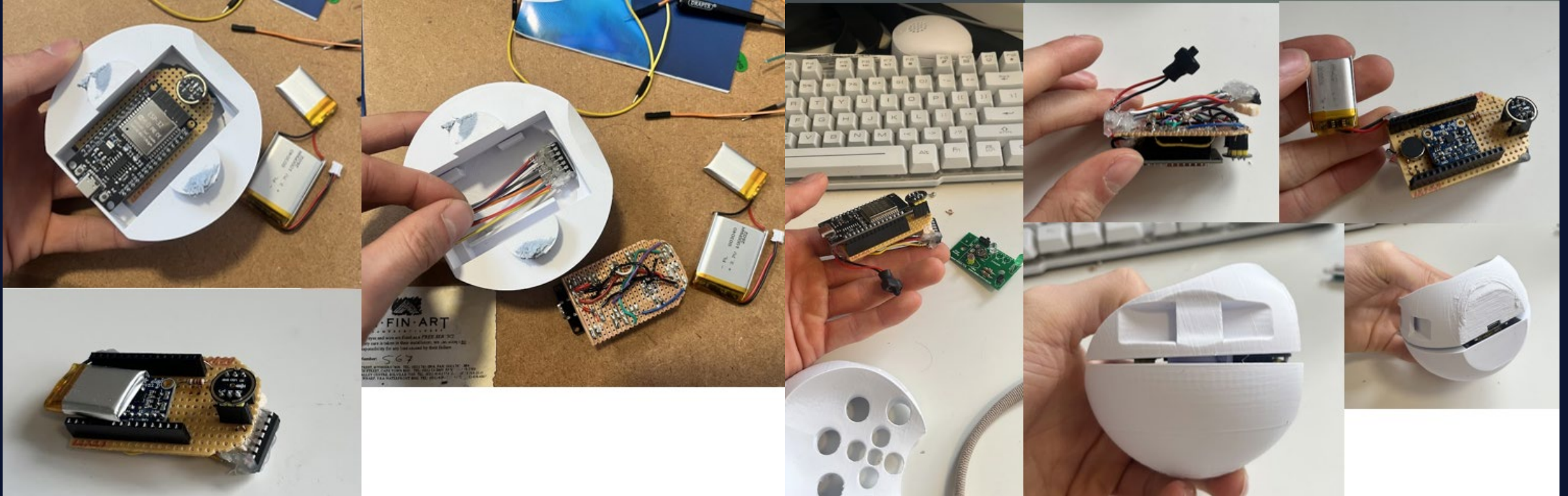


Explore housing for my Sensor Hub

3D Printing



3D Printing



Explore housing for my Sensor Hub

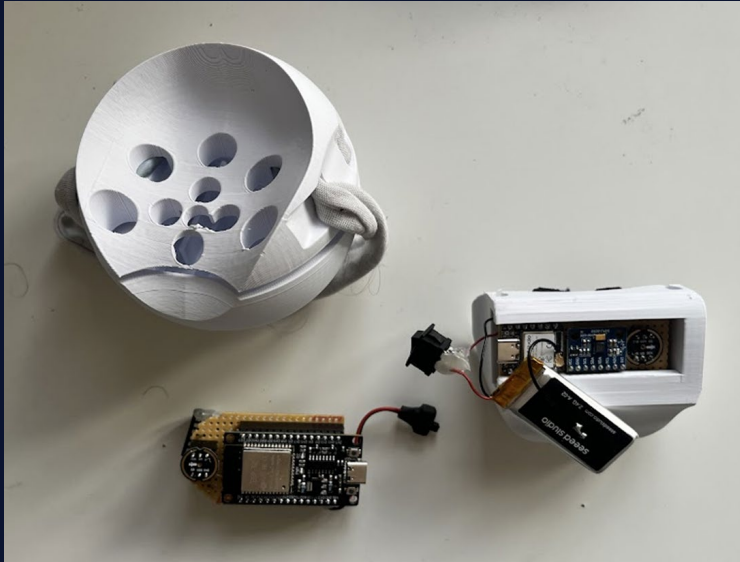
3D Printing



Explore housing for my Sensor Hub



Design Pivots



Updated Design

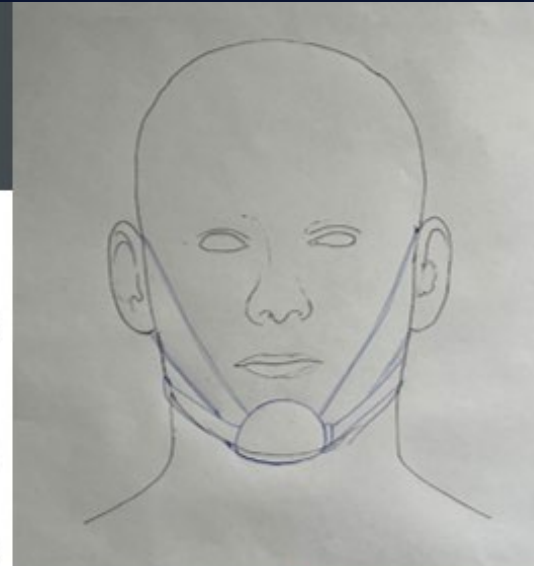
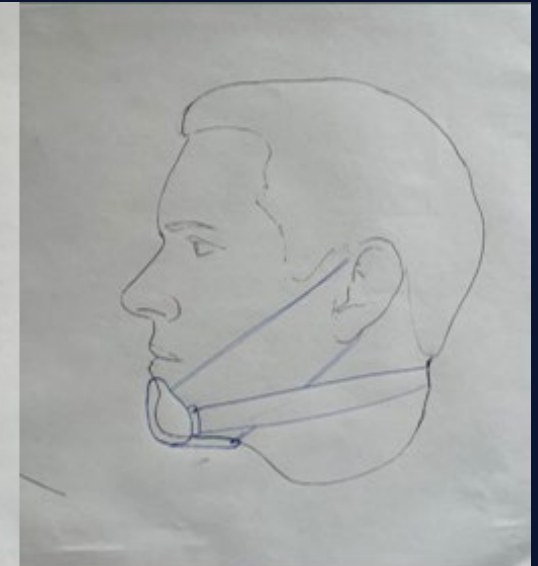
What I've changed and why:

After consulting with ergonomics experts Prof. Mike Fray and Prof. Simon Hodder, I pivoted the design to solve for **stability** and **heat regulation**.

By using the **chin** as a **fixed anchor** point, I eliminated the risk of the device shifting to incorrect neck areas. Additionally, I moved away from a bulky "neck pillow" style to improve thermal management and prevent the device from twisting overnight, which would lead to misplaced EMS.

The electronics will be placed in the chin cap and reach underneath the chin to the submental triangle where they will deliver the EMS.

Google Gemini Prompt: Generate me an image of a man wearing this product. it is a plastic cap with straps attached to it. The middle of the cap is made from plastic and the straps are neoprene. Show this from the angles found in the drawings. Professional lighting.



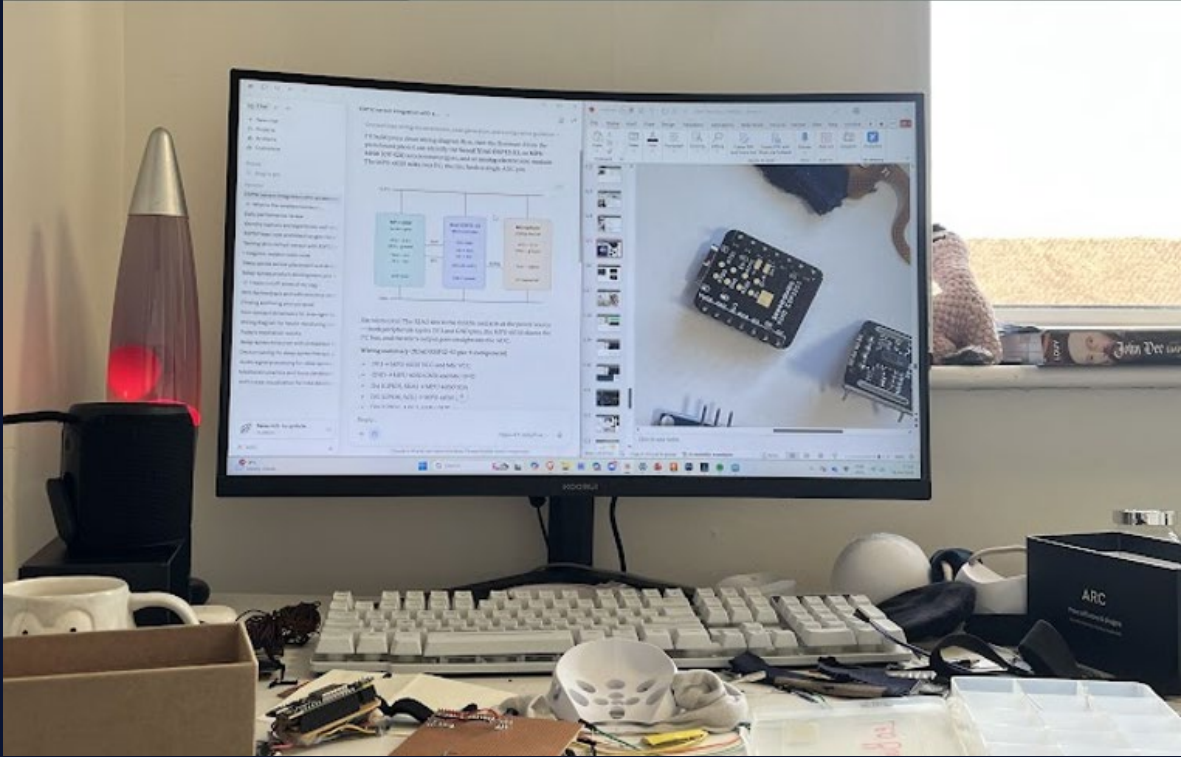
PRECISION JAW-SUPPORT HARNESS



Prototyping

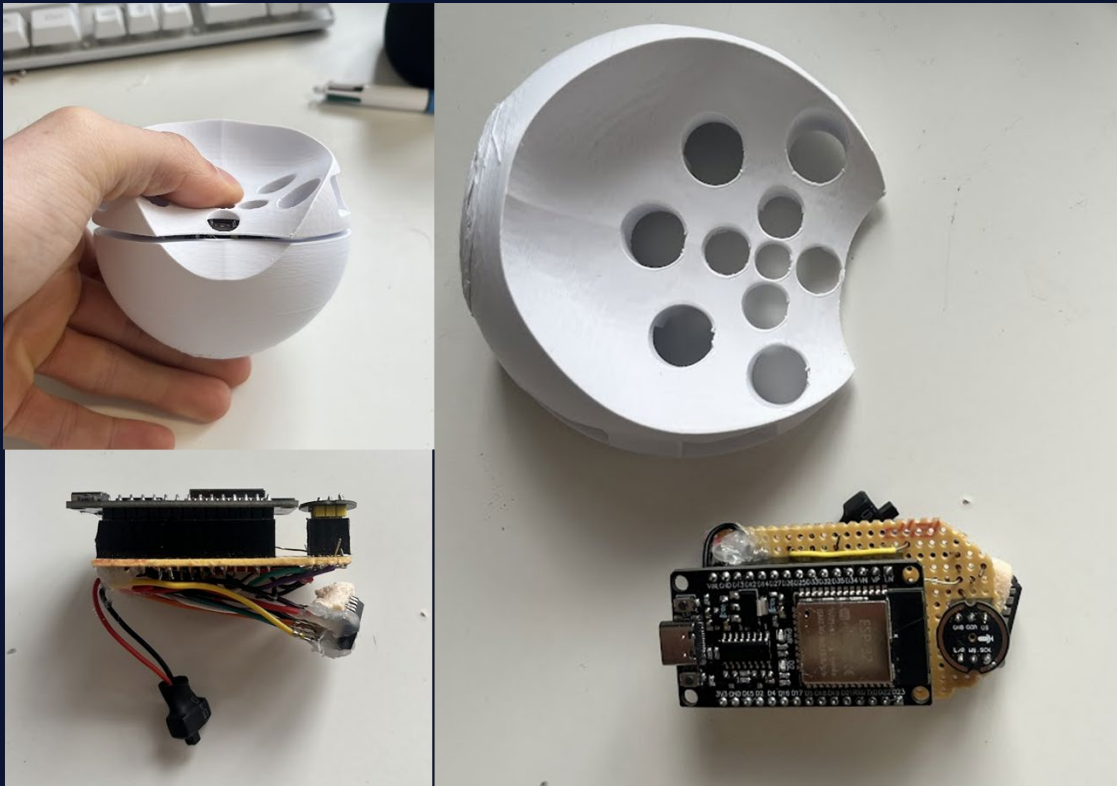


Prototyping



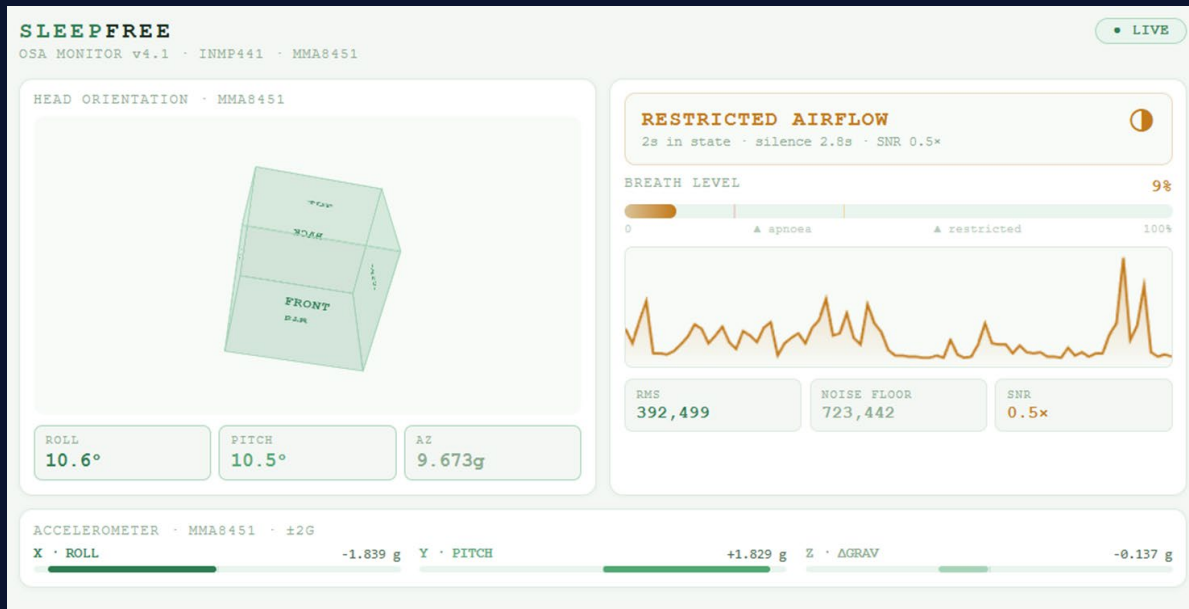


Live Mic/ Positional Data Visualisation



TAM: 936M adults 30–69 globally (Benjafield et al., Lancet Respir Med 2019) · Aware SAM ~50M.

Data Visualisation.

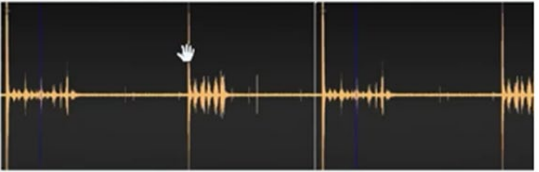


What Does Sleep Apnea Sound Like?
Snoring vs. Sleep Apnea?

(Real sounds explained!)
(And How to Snore Less)

80% of people with sleep apnea snore
50% of people who snore have sleep apnea

Dylan Petkus, MD

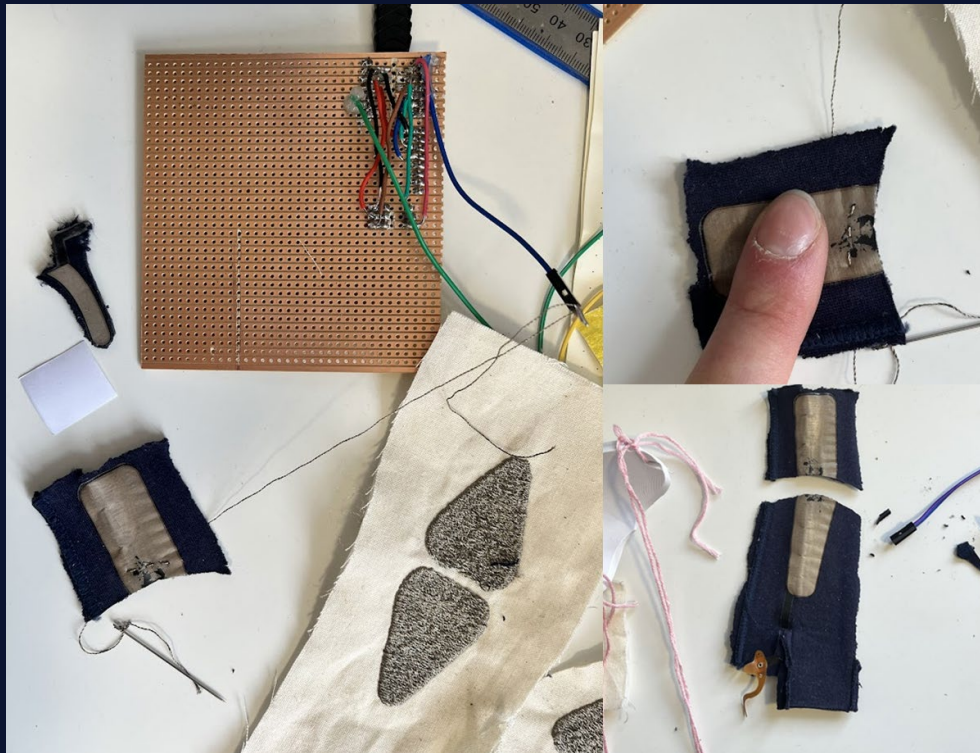
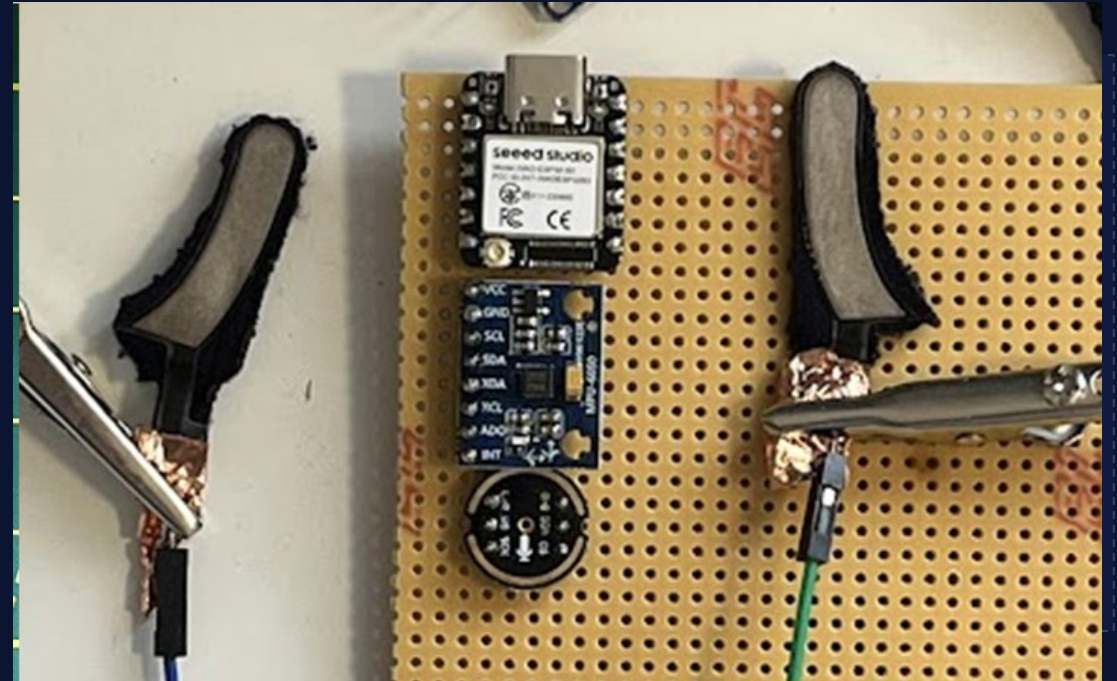



Here we see the audio pattern of snoring (Above) and sleep apnea (Below). Snoring is frequent and constant spikes, whereas sleep apnea has long gaps of silence where the airway is blocked, followed by a loud unblocking when the airway does start to open slightly again.

What To Do

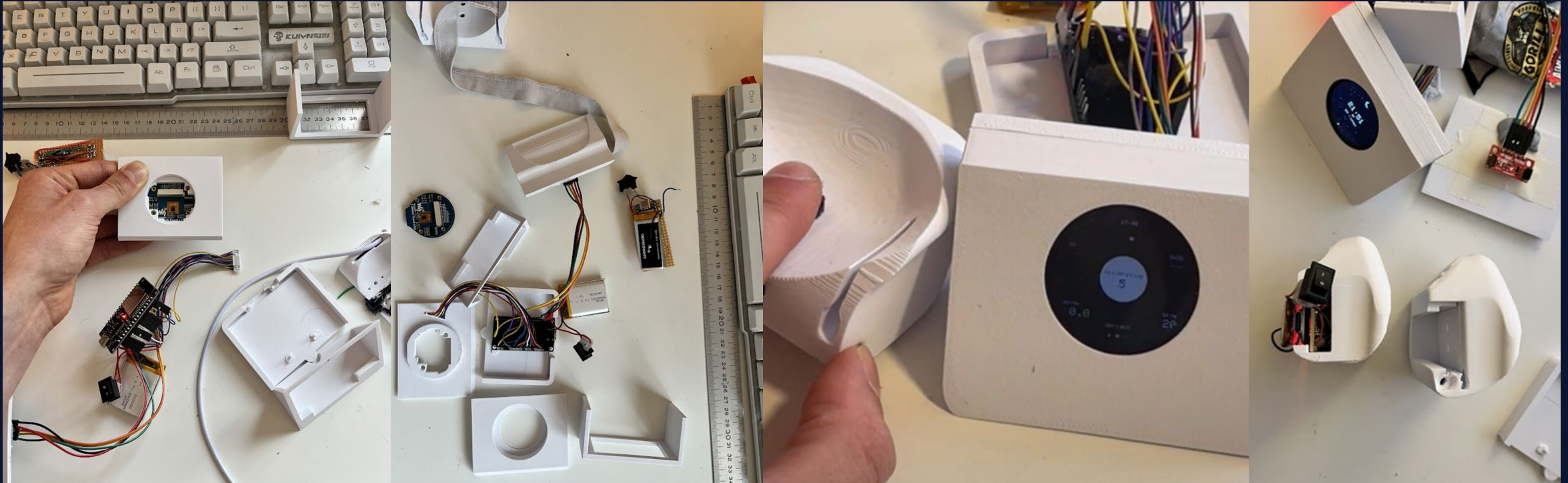
1. Measure with Snorelabs
2. Decide and Act (Nasal breathing, mouth tape, positional therapy)
3. Re-measure!

Prototyping





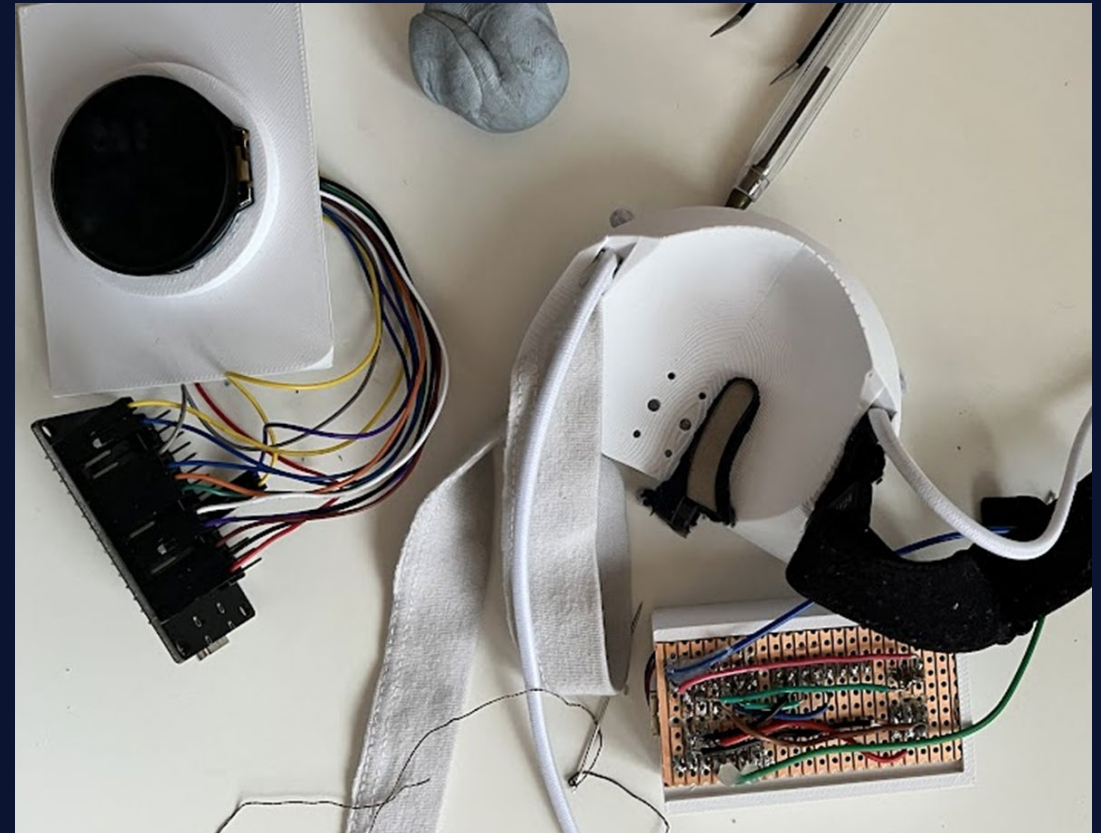
Progression of prototypes



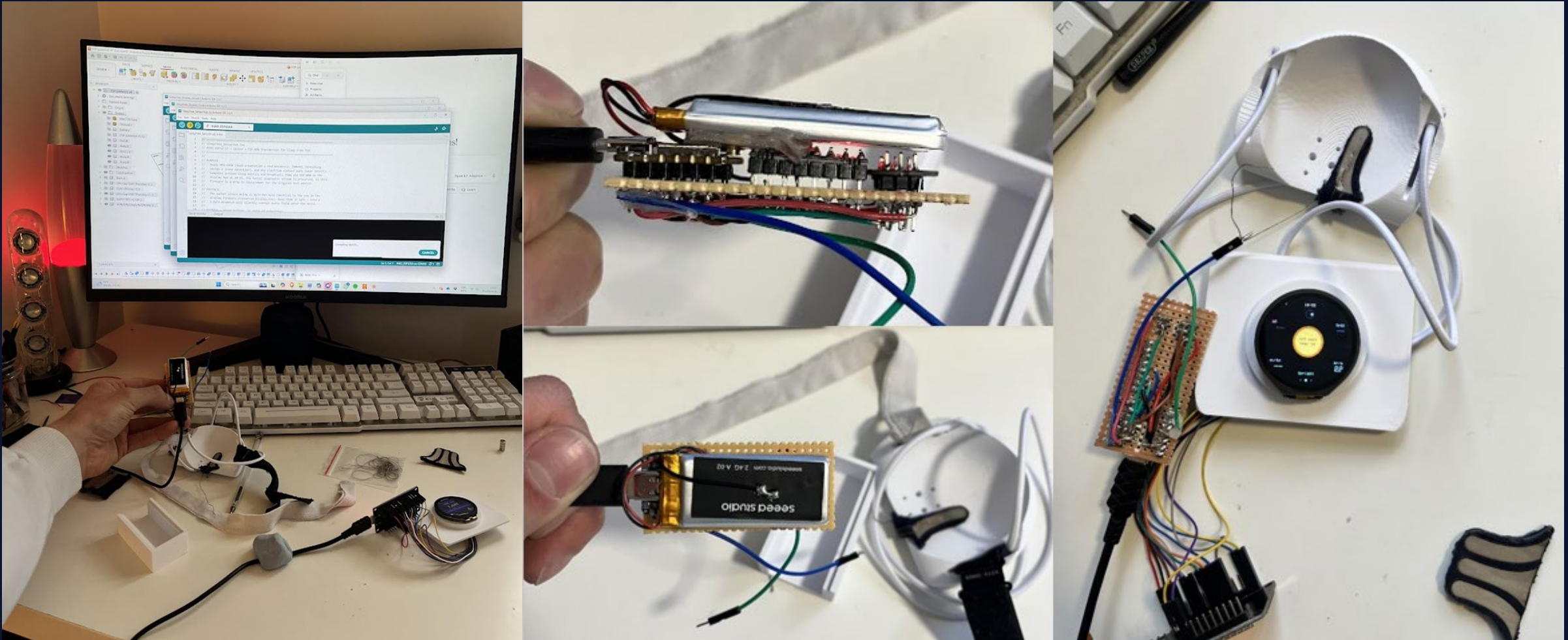
Each prototype tied to a specific design question. Folio carries the photo evidence.



Progression of prototypes



Progression of prototypes





Progression of prototypes



Final prototype

Here we see some experimentation for different display models. Clocks, Live Biometric displays, a calibration mode. A microphone mode to record.



Progression of prototypes

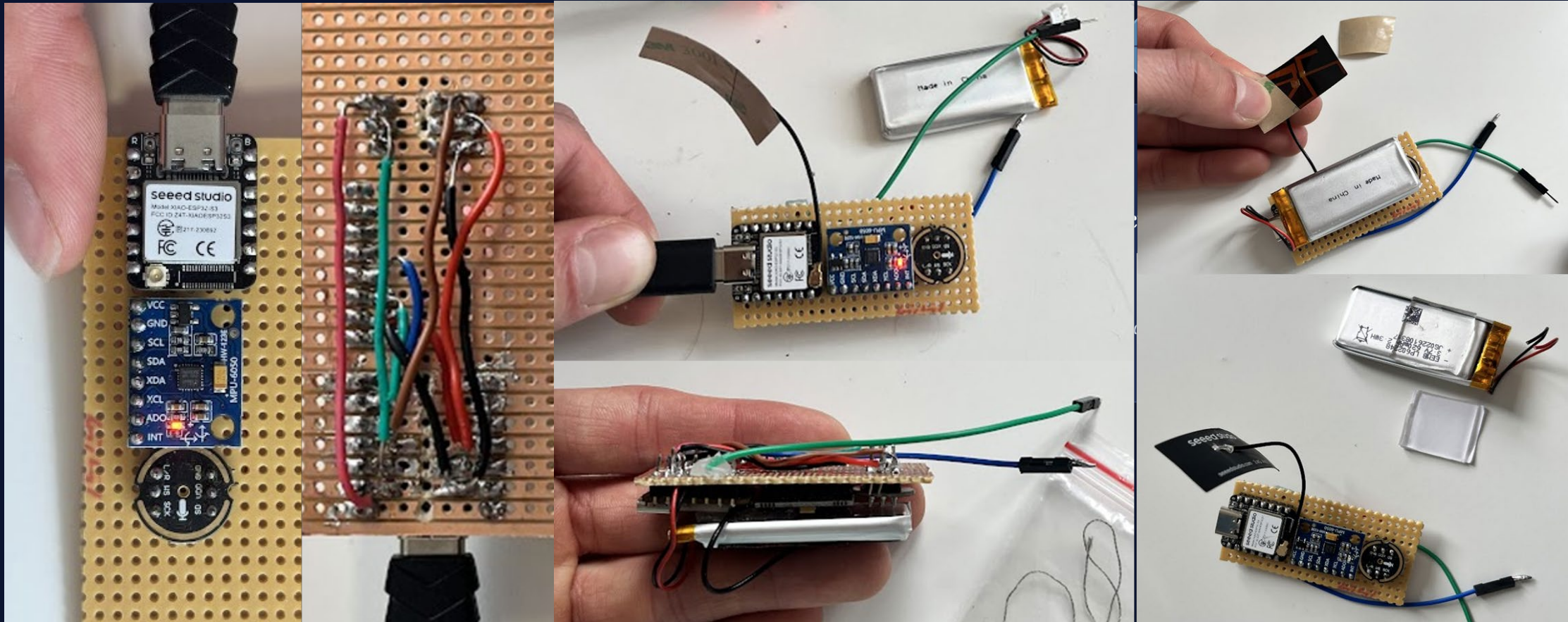


OLED Touchscreen

*Here Im.
creating a fitting for the screen.
Modifying small details to ensure
a snug fit.*

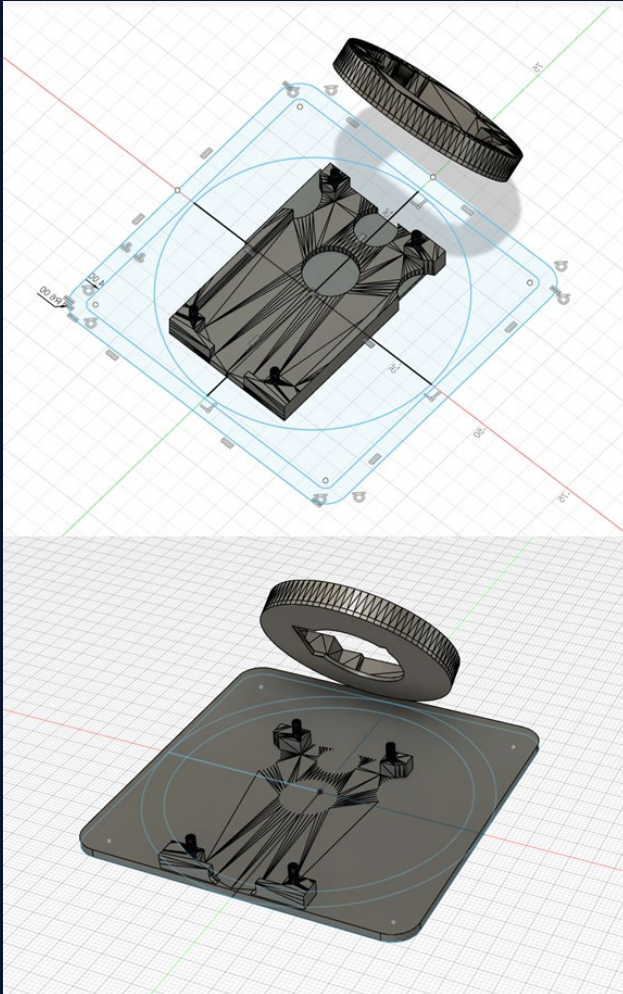
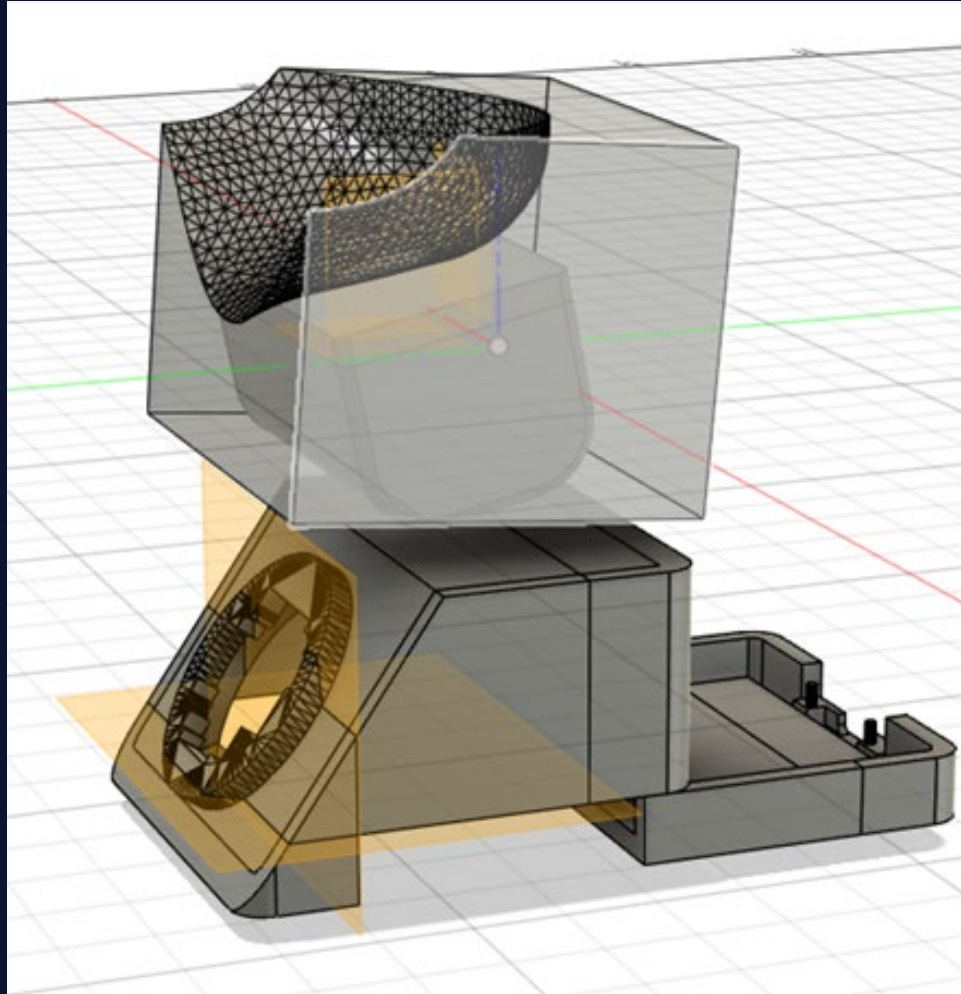
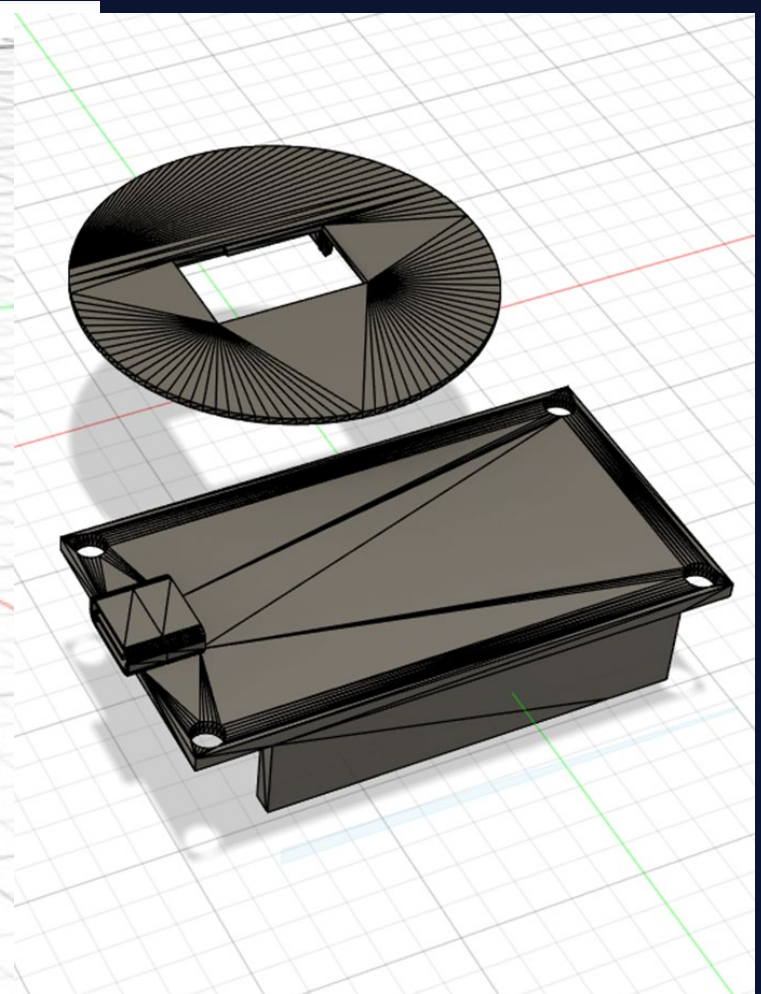


Progression of prototypes



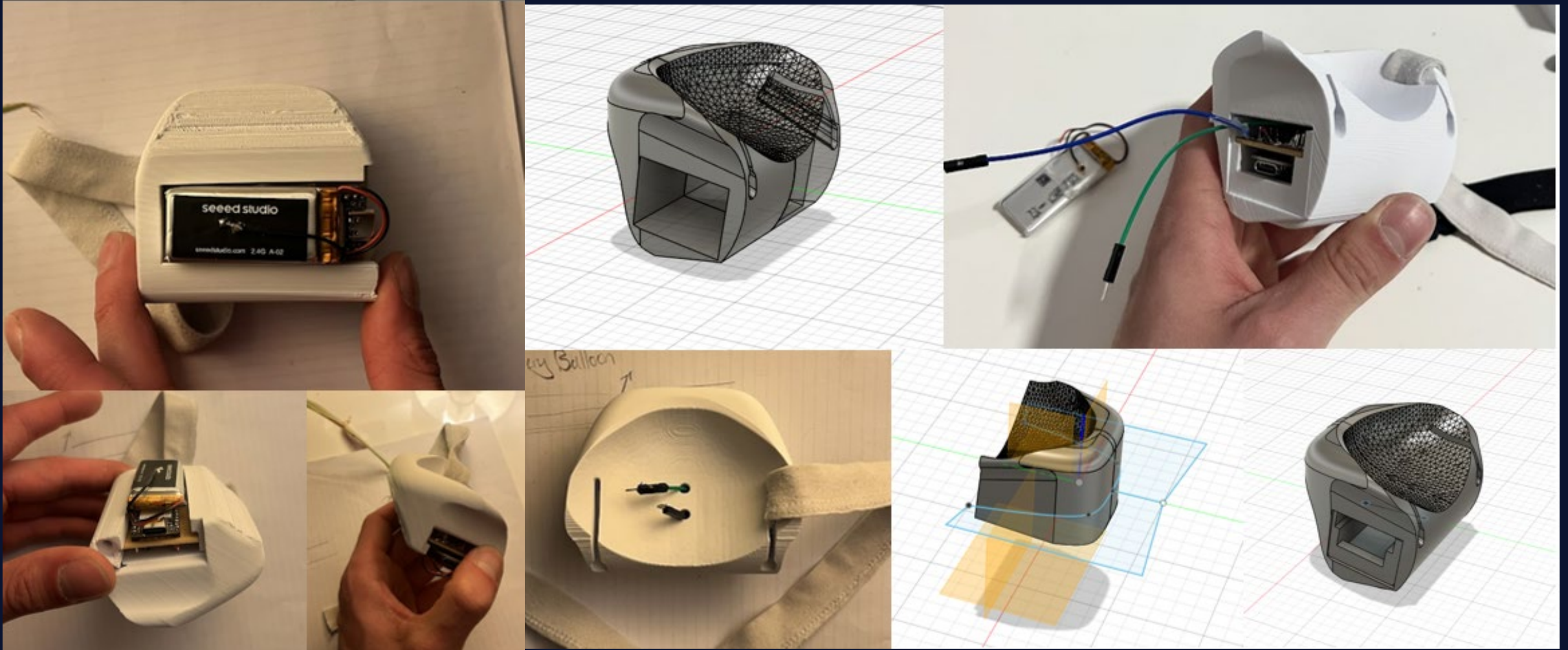


Progression of prototypes



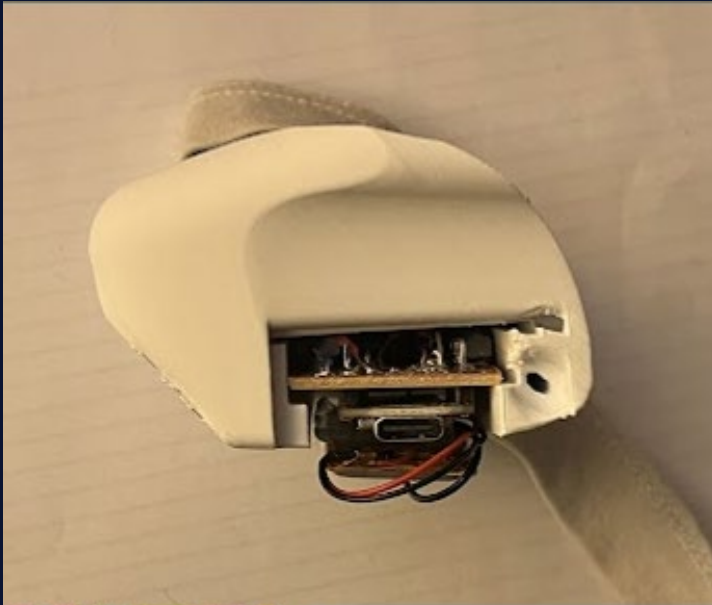
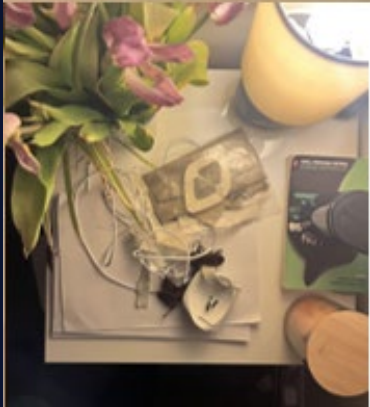
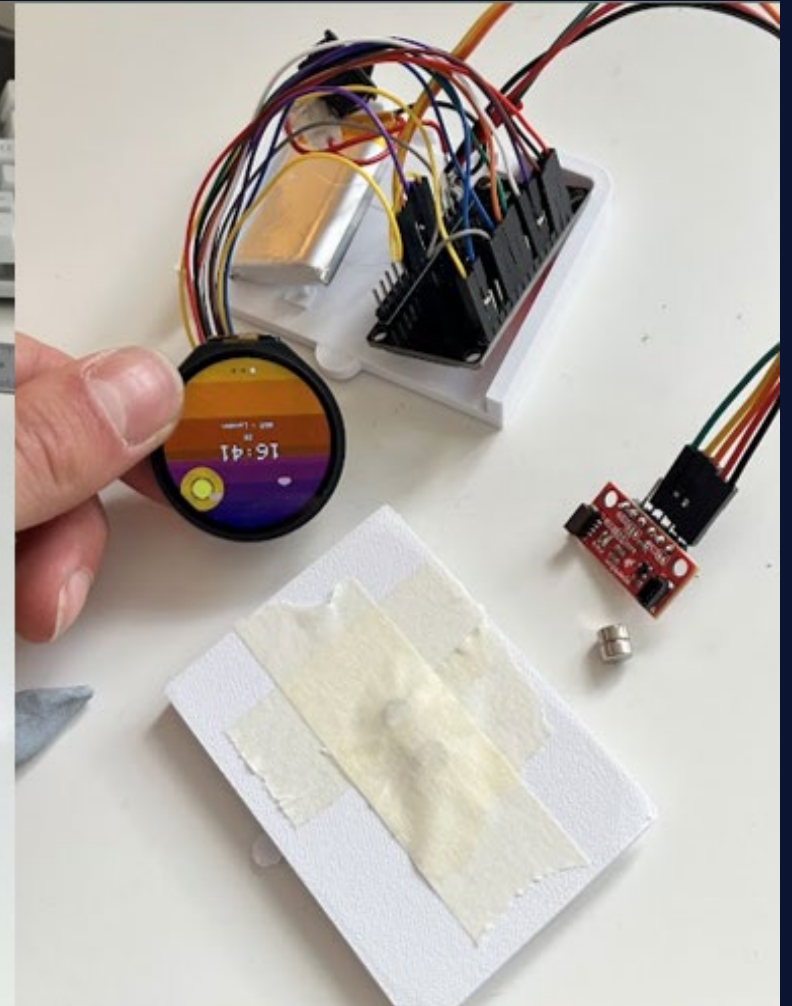


Progression of prototypes



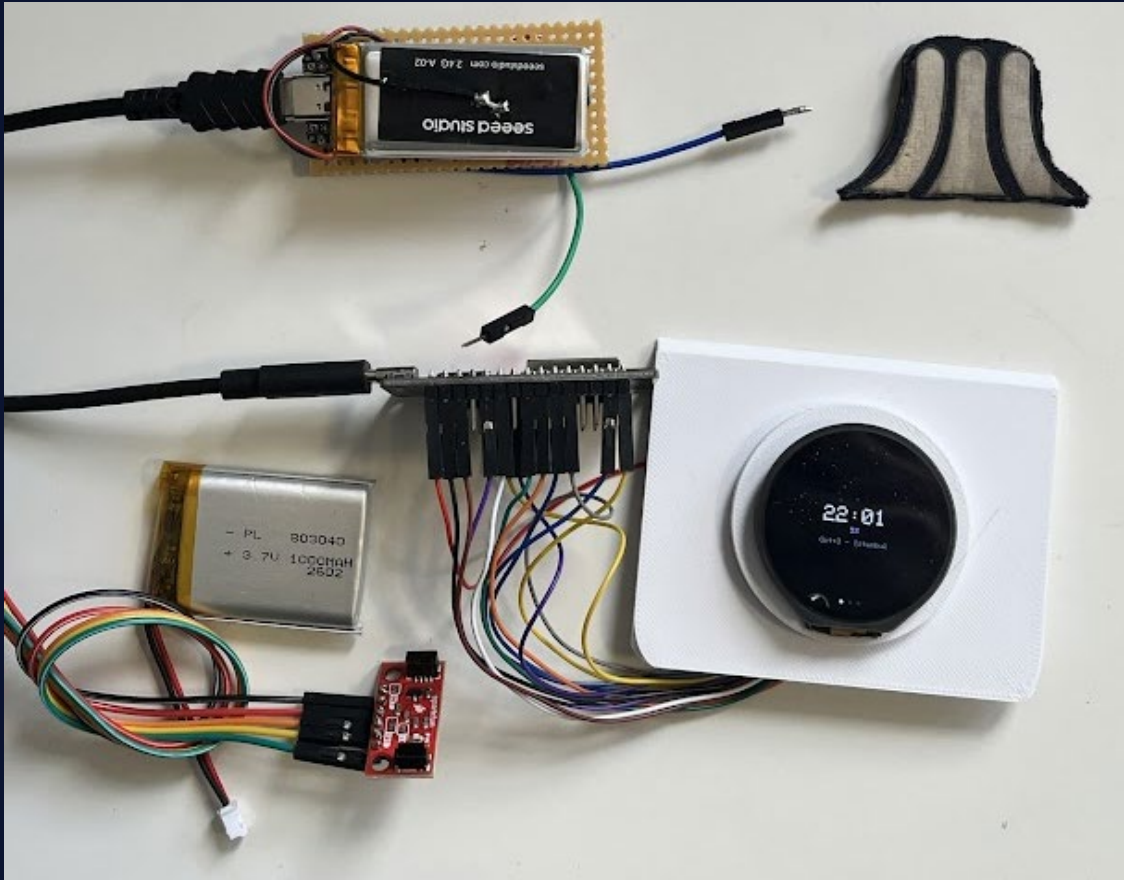
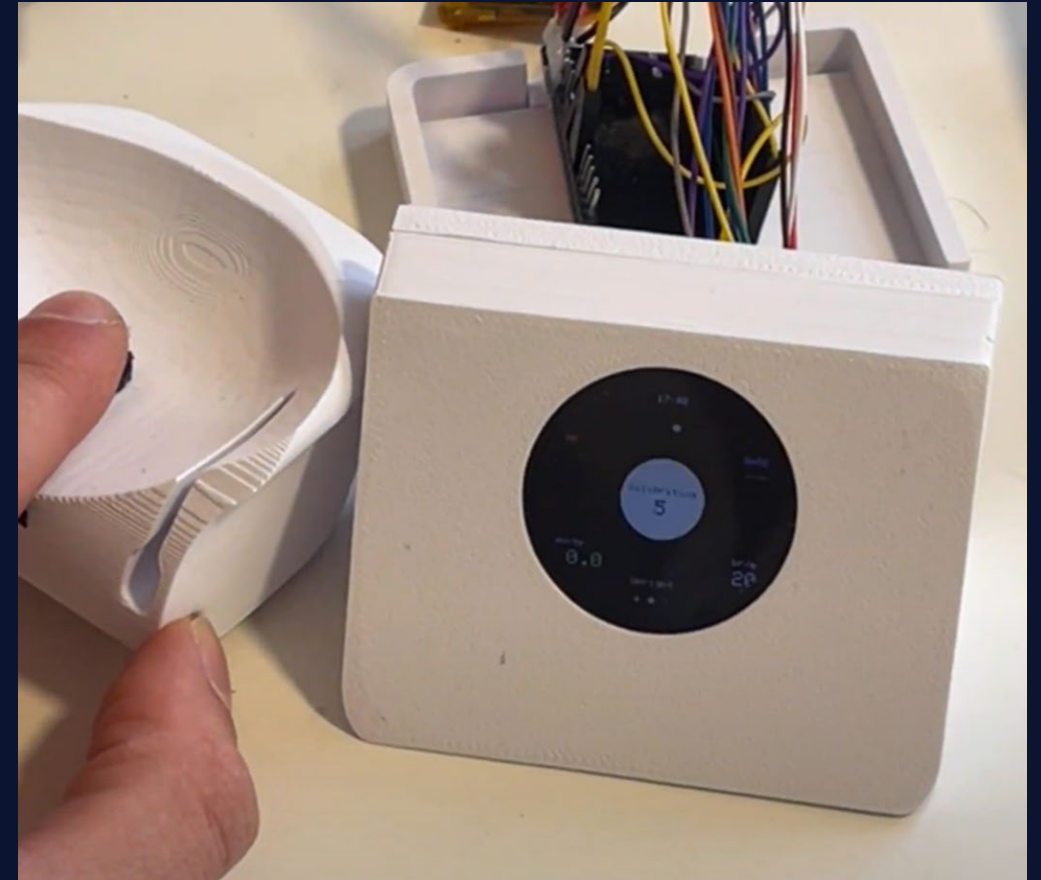


Progression of prototypes





Progression of prototypes

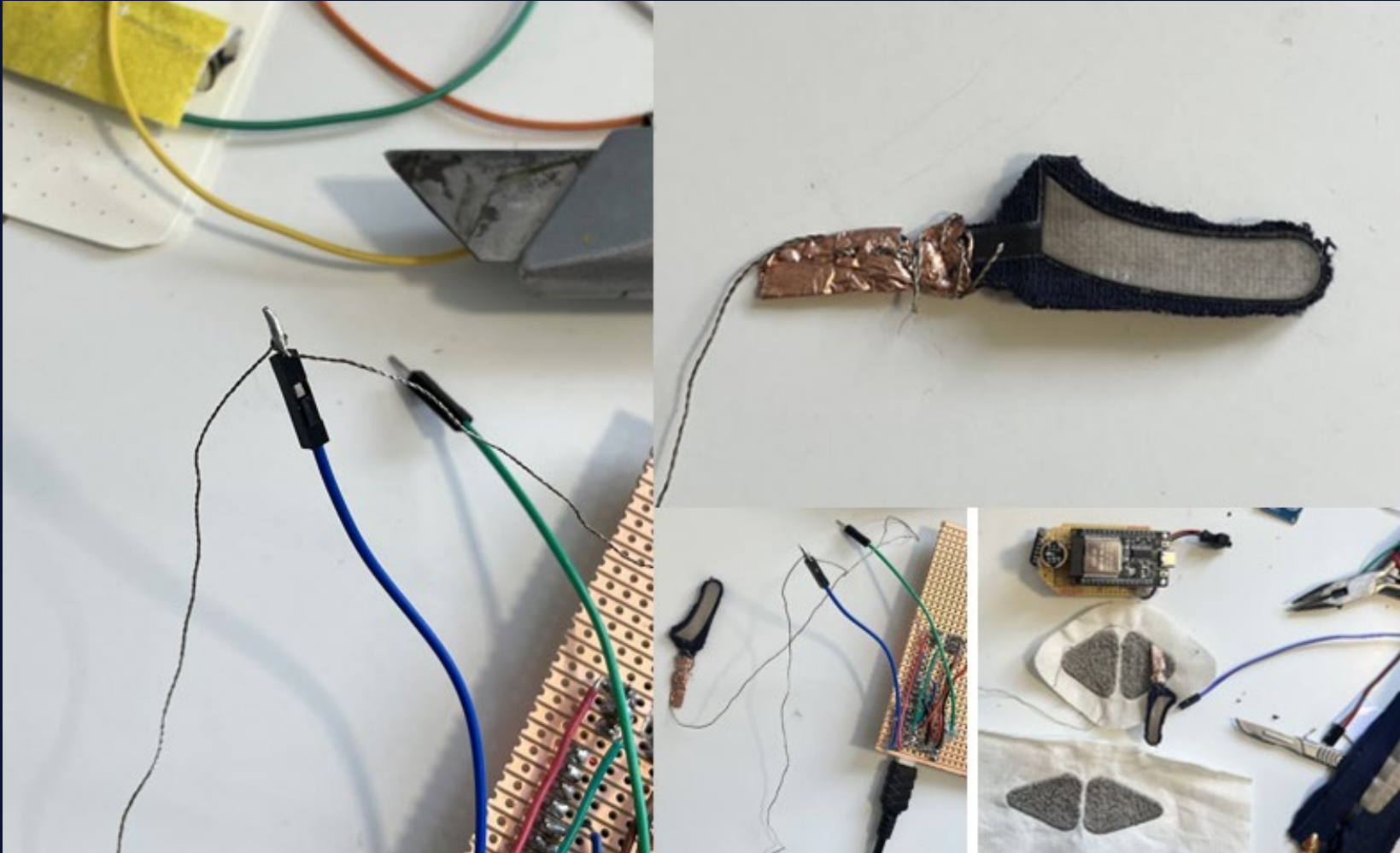


Progression of prototypes

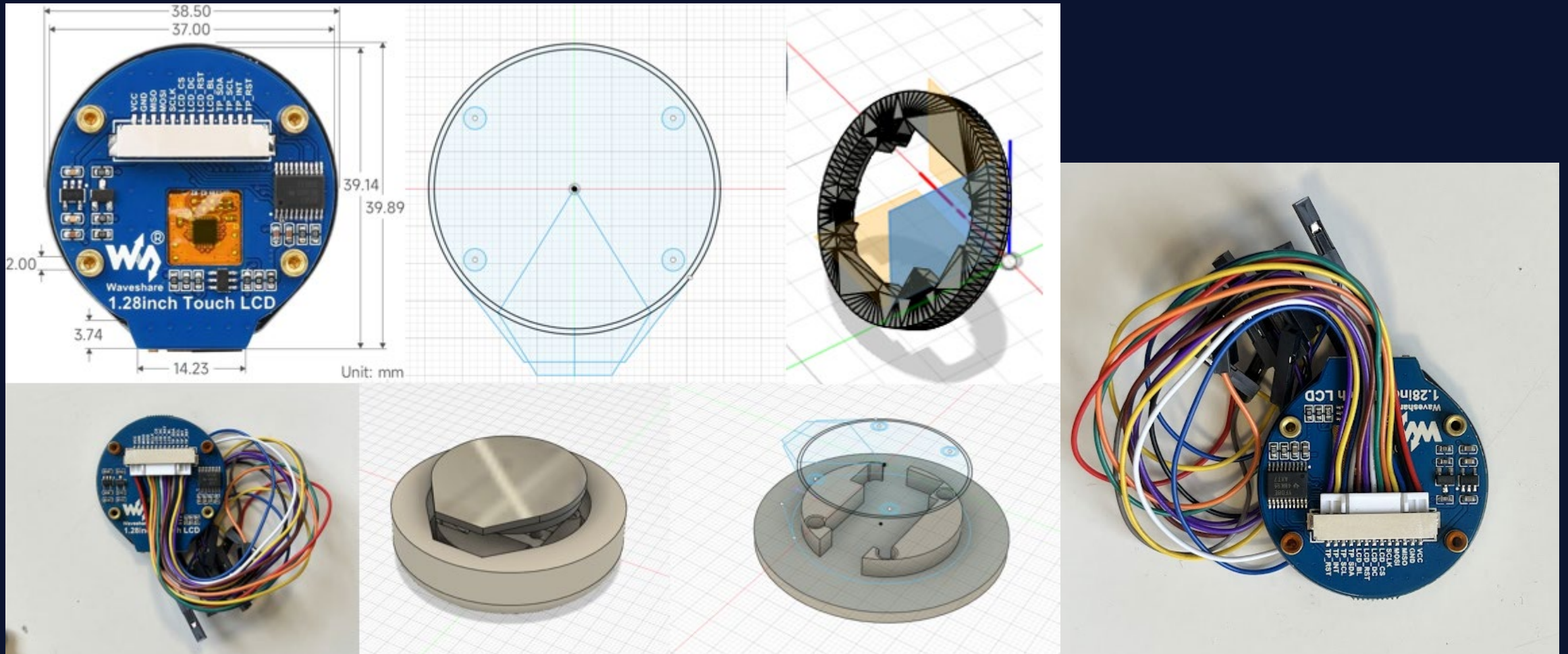




Progression of prototypes



Progression of prototypes



Prototyping



Screen Display





Progression of prototypes



P5

Final prototype

End-to-end demonstrator



Progression of prototypes



P3



P5



04

SECTION

User Evaluation & Testing

How we tested, who took part, and what we learned.



Methods & participants

User Testing

Ergonomics

Averages & reoccurring themes

Not comfortable for sleeping on the front.
Hair gets in the way of straps, gets tangled and caught.

Prototype Number	Comfort/ 10	Time taken to wear	Stability after 10 rolls on bed	Comments
1	6	6	3 – slipped	Slipping down the neck
2	4	4	4 – stayed on due to size but not securely	Tangled in hair and pushing Adam's apple
3	7	9	8 – didn't move	Nice and tight against chin but not in a claustrophobic way. Getting itchy against the plastic.
4	2	5	0 – Fell during testing	Sharp edges pushing against jawline, too tight. Slipping. Didn't feel correctly shaped.
5	7	2	0 – Slips down neck	Chincap not 100% secure against submental area





Methods & participants



User Testing

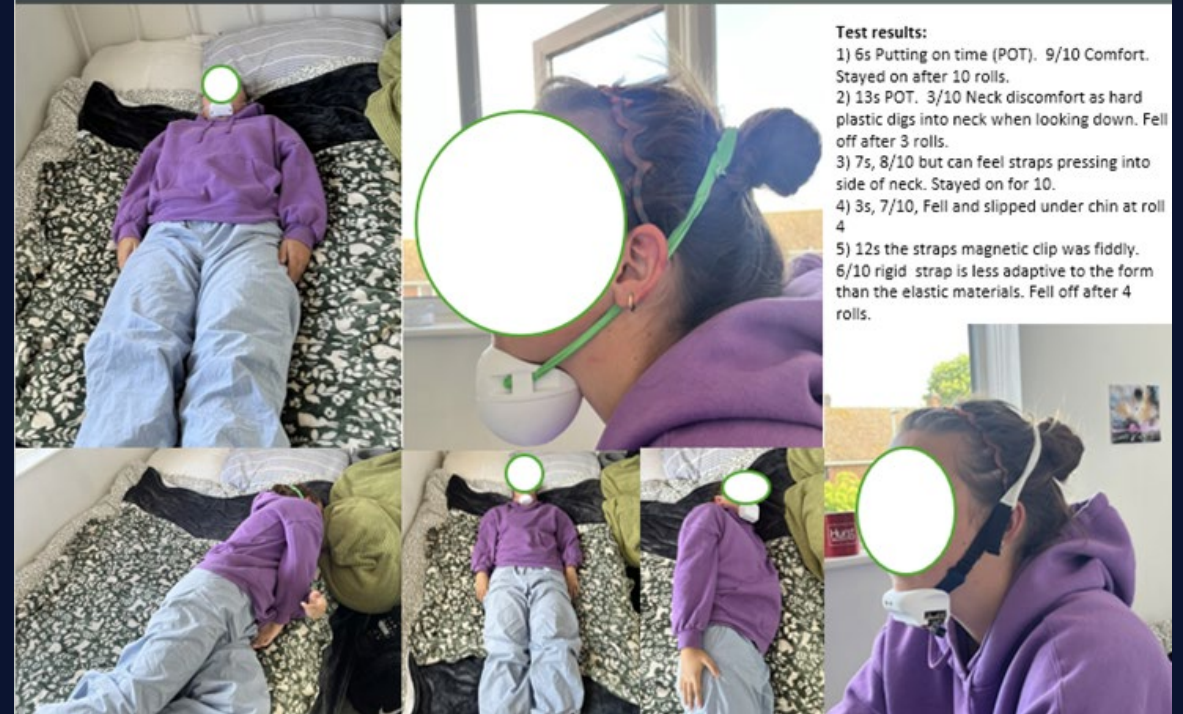
Ergonomics

Insights from testing

Elastic straps are favourable as they distribute the forces more evenly than the rigid straps. Shrinking the electronics housing as much as possible is important as the bulkier heavier models were described as less comfy.

Test results:

- 1) 6s Putting on time (POT). 9/10 Comfort. Stayed on after 10 rolls.
- 2) 13s POT. 3/10 Neck discomfort as hard plastic digs into neck when looking down. Fell off after 3 rolls.
- 3) 7s, 8/10 but can feel straps pressing into side of neck. Stayed on for 10.
- 4) 3s, 7/10, Fell and slipped under chin at roll 4
- 5) 12s the straps magnetic clip was fiddly.
- 6/10 rigid strap is less adaptive to the form than the elastic materials. Fell off after 4 rolls.





User Testing



User testing





User Testing





Methods & participants





What it does — and what it does not

	Prototype Number	Comfort/ 10	Time taken to wear	Stability after 10 rolls on bed	Comments
	1	9	1	0 – slipped onto mouth	Very comfortable on the chin but <u>barely</u> noticeable
	2	5 – over time the product becomes very uncomfortable	4.3	9 Solid stability – seems there is a trade-off occurring between comfort and stability.	Not noticed how to divide the head strap at the back to create the halo support mechanism.
	3	6 Less elastic more uncomfortable. But the <u>chincap</u> is comfortable.	4.6	The single strap configurations <u>have a tendency to slip and fall.</u>	When the tension is pulled through the plastic <u>chincaps</u> nearer the front of the chin the product remains more stable and isn't moved by neck pressing into it so much. The force must concentrate through the anchor point of the chin and not be pulling to hard against the squishy bits of the neck.
	4	2	7.7	9	Secure but deeply uncomfortable as chin didn't fit inside.
	5	5 – loose but not annoying	5	6 – Device is falling down the neck.	Slight sharp digging into neck but barely noticeable.



Prototyping





Chin Pillow





Key findings

WORKED

Comfort & fit

The Neon Green elastic straps had the best overall comfort as they are the most adaptive to everyones head shape. the straps must be pulling through the front of the chin

WORKED

Small Chin Pillow

A soft pillow at the chin is much more comfortable than hard plastic.

MIXED

Many designs fell off

The design must remain in the submental triangle to prevent interference with other key nerve layouts within the neck.

NEXT

Embedding electronics

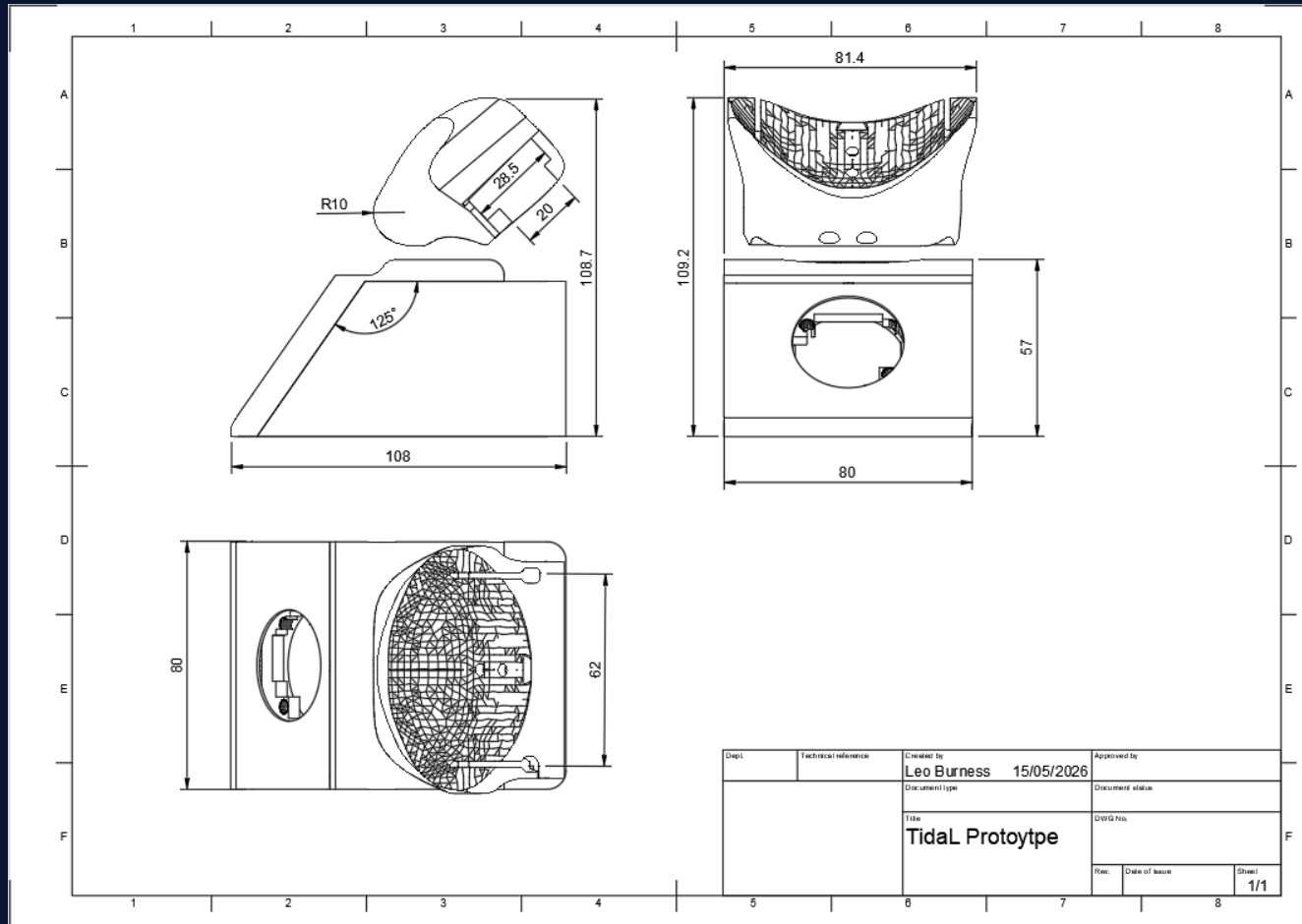
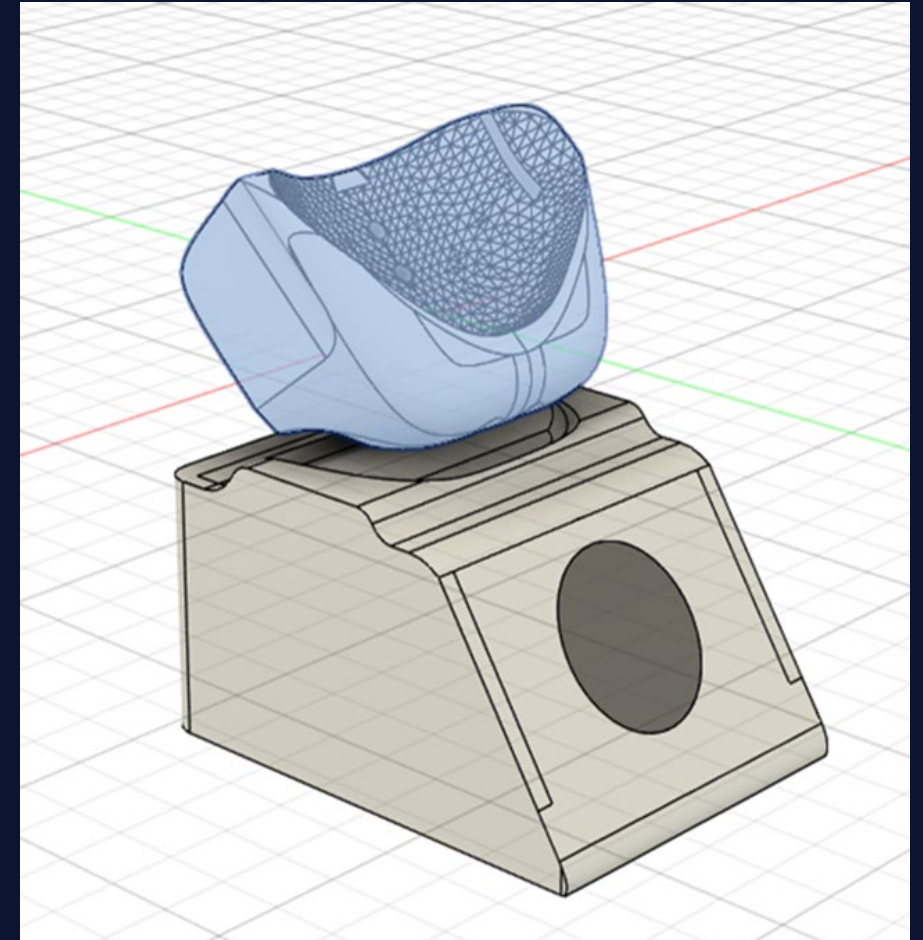
05

SECTION

Design for Manufacture

*Commercial production — volumes, materials, processes,
costing.*

Materials & processes





Bill of Materials and cost build-up

Cost line	10,000 / yr	100,000 / yr	1,000,000 / yr
Headwear sub-total	£32.65	£16.47	£8.99
Bedside dock sub-total	£30.35	£15.30	£8.36
System COGS (factory gate)	£63.00	£31.77	£17.35

5.4 Bill of Materials and cost build-up

Cost is modelled per the Marshall lecture's direct + indirect + tooling-amortised framework, taken from OSAT_Cost_Model.xlsx. Headline tier table:

Per-line breakdown at the 100k tier:

Cost line (£/unit, 100k)	Headwear	Bedside dock	System total
Injection-moulded shells	0.55	0.90	1.45
Tooling amortised	0.30	0.20	0.50
PCBA (4-layer, SMT, test)	8.50	4.50	13.00
1.28" round LCD + CST816S touch	—	5.20	5.20
LiPo 600 mAh + protection	1.55	—	1.55
USB-C 5V/1A wall PSU	—	1.80	1.80
Vibration motor (haptic)	0.42	—	0.42
Strap + textile electrode assembly	2.10	—	2.10
Final assembly + EOL test (labour)	1.50	0.80	2.30
Cabling + dock contacts	—	0.30	0.30
Packaging (shared box, insert, manual)	0.55	0.55	1.10
Indirect overhead allocation	0.60	0.60	1.20
Other NRE amortised (cert, EMC, fixture)	0.40	0.45	0.85
Sub-total COGS, 100k tier	£16.47	£15.30	£31.77

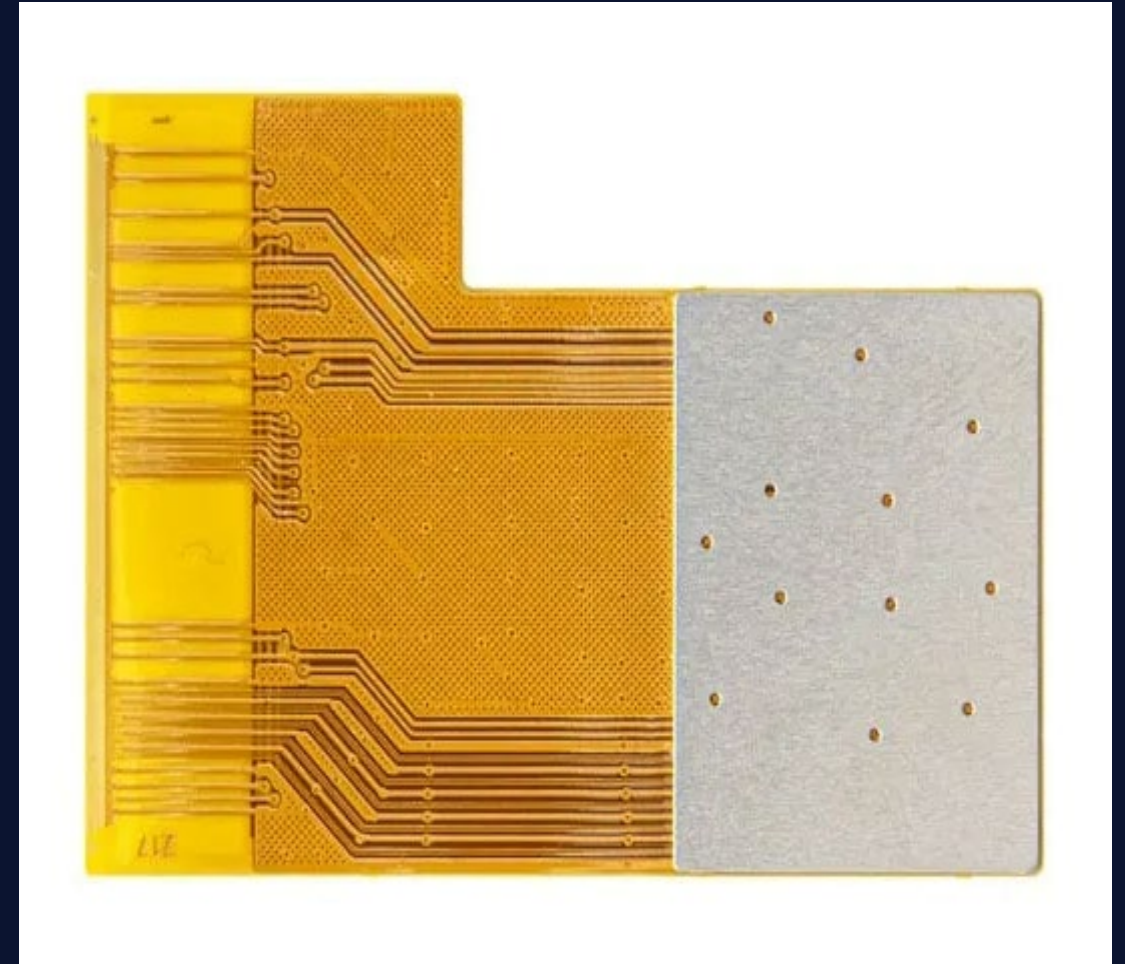


5.1 Commercial manufacturing strategy

Tidal is a two-device consumer wearable produced through three production routes: injection moulding for the rigid plastic enclosures (chin-cap, electronics housing and bedside dock shell), cut-and-sew with sonic-welded edges for the textile strap and conductive-fabric electrode pad, and contract SMT for both PCBAs. Production is dimensioned against three volume tiers — 10,000 units/yr (launch), 100,000 units/yr (primary commercial design point) and 1,000,000 units/yr (mature-market upside) — and the parts and tool architectures below are sized for the 100k tier unless otherwise stated.

The 100k tier is defended from market analysis rather than chosen as a round number. The global TAM for adult OSA is 936 million (Benjafield et al., Lancet Respir Med 2019); restricted to plausibly-served geographies and the ~20% aware of their condition, the aware serviceable market is ~50 million people. 100k units/yr is roughly 0.2% of that aware SAM — a defensible Year 2–3 retail and direct-to-consumer scale, in the same order of magnitude as the published volumes for the Belun Ring and the Withings Sleep Analyzer.

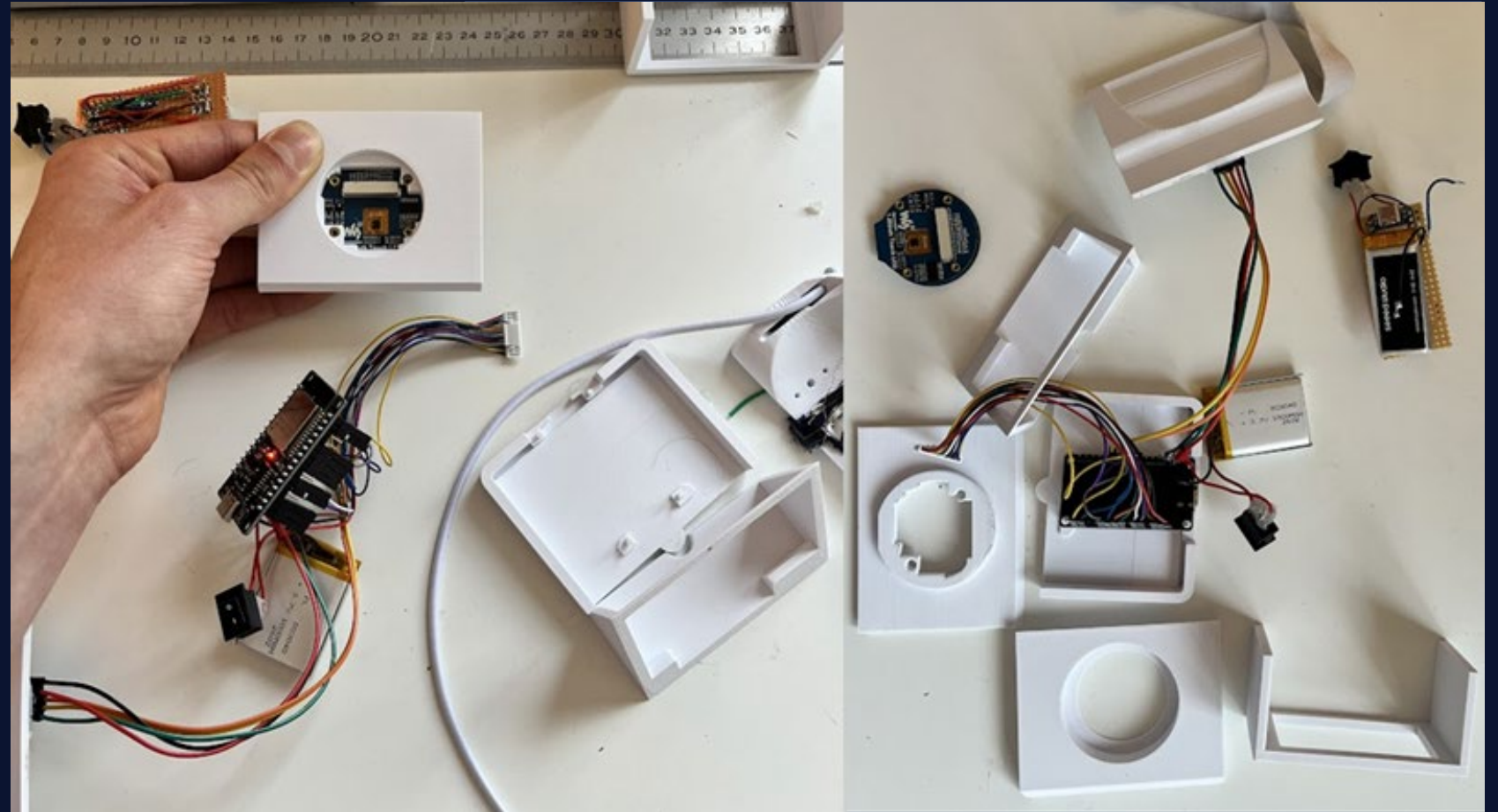
V1 is positioned as a consumer wellness product (snore monitoring and sleep-quality feedback), not a regulated medical device. This avoids the £150–500k of NRE and 12–18 month Notified Body lead time of a Class IIa MDR submission. The **V2+** therapeutic configuration is explicitly framed as a future regulated route under UK MHRA Class IIa; V1 deliberately preserves that pathway by using clinically-grounded sensor specifications (INMP441 acoustic capture; AD8232 biopotential AFE; 4-layer mixed-signal PCB stack-up) so the same hardware family can later carry a regulated claim without an architectural reset.





5.7 DFM reflections and simplifications

Three consolidations were carried through the DFM cycle: elimination of the MyoWare carrier (replaced with a discrete AD8232 AFE on the headwear PCBA, removing £6–10 of BOM at any volume); replacement of four service screws with a circumferential snap-fit on the chin-cap (removing the screws and ~20 s of assembly time); and relocation of the microphone aperture to the parting line (cutting ~£15k from the 100k-tier tool quote). The B&D part-count index for the headwear improves from 0.36 as-prototyped to 0.57 as-designed-for-manufacture, approaching the B&D theoretical minimum after one further over-moulding consolidation. DFM thinking has removed mass, parts and cost from a design that had been over-engineered for hand prototyping — not constrained the industrial design.



06

SECTION

Final Design Proposal

The product, what it does, and how it does it.

OSAT — the final design





OSAT — the final design



OSAT — the final design

