VOICE ACTIVATED SKI AIRBAGS

60% human deployment failure in current designs...

Wind Noise Cancellation using Alango and Google APIs

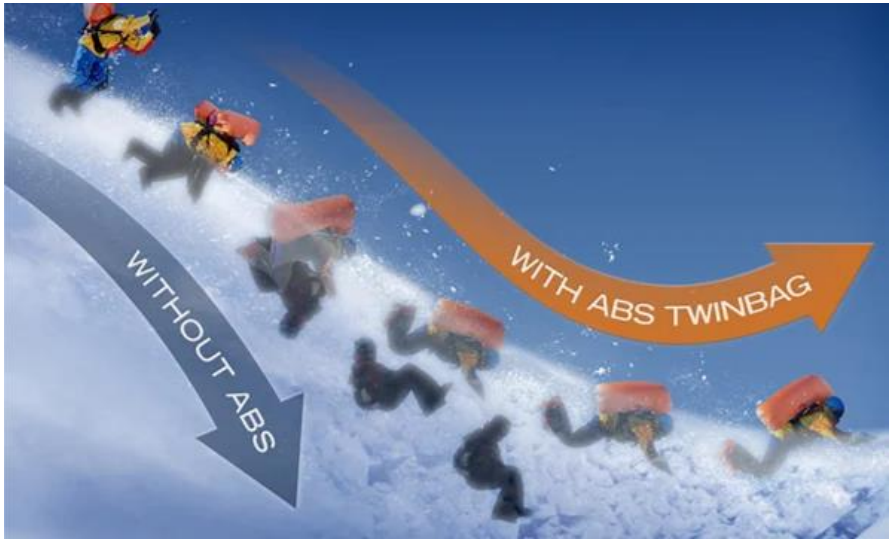
High Torque Servo Motor Deploys Airbag

Y-Connection for Manual Override

Non-Invasive Balaclava Integration

Dual-Channel Microphones for Enhanced Speech Separation

Alex Alexiev, Harry Chin, Hamza Dugmag, Willis Guo, Daniel Zhuang



Current airbags are **difficult to deploy**.

01. OPPORTUNITY

Design a **hands-free** airbag trigger mechanism to facilitate activation.

USER ERROR

60% of non-successful airbag deployments are **caused by human deployment failure** (Haegeli et al., 2014).

USER PANIC

In avalanche scenarios, the fight-or-flight response **impairs decision-making** and **fine motor skills** (Moyer, 2019).

DfXs and Objectives

USABILITY

Airbag is easy to deploy for the user.

User motion is not compromised.

RELIABILITY

Few dependencies and points of failure.

Accurately detects avalanches.

EFFICIENCY

Airbag deploys very quickly.

Does not consume a lot of power.

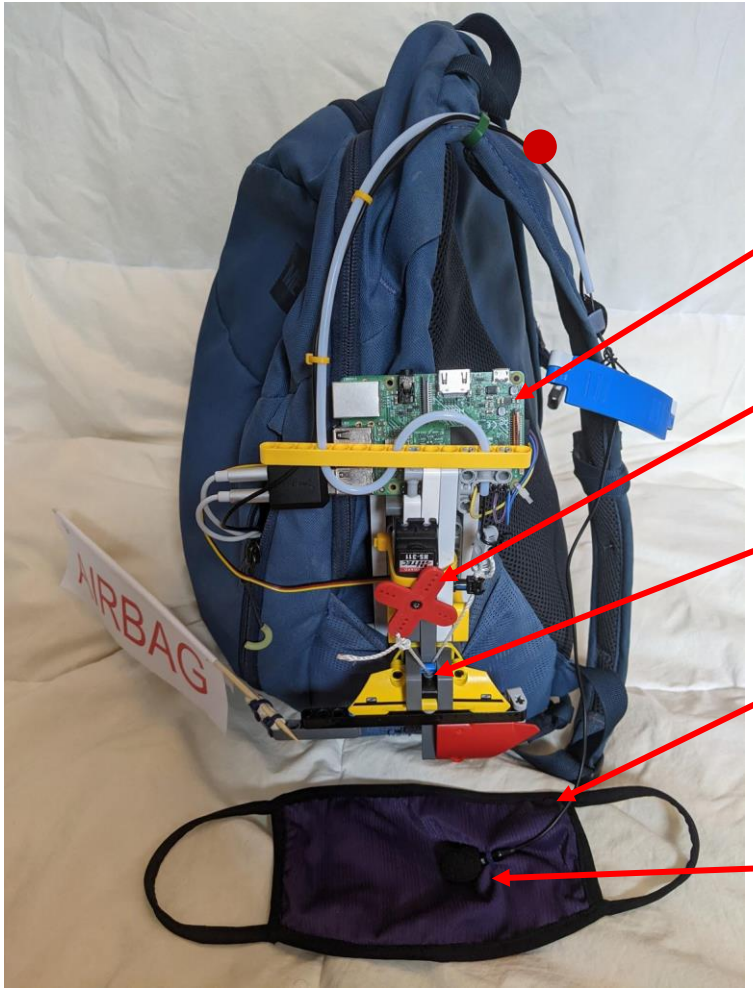
02. DESIGN

VoiceEvo

2s Deployment Time

70+ Hour Battery Life

95% Detection Accuracy



Note: Components are located inside the backpack and the cables exit the strap at

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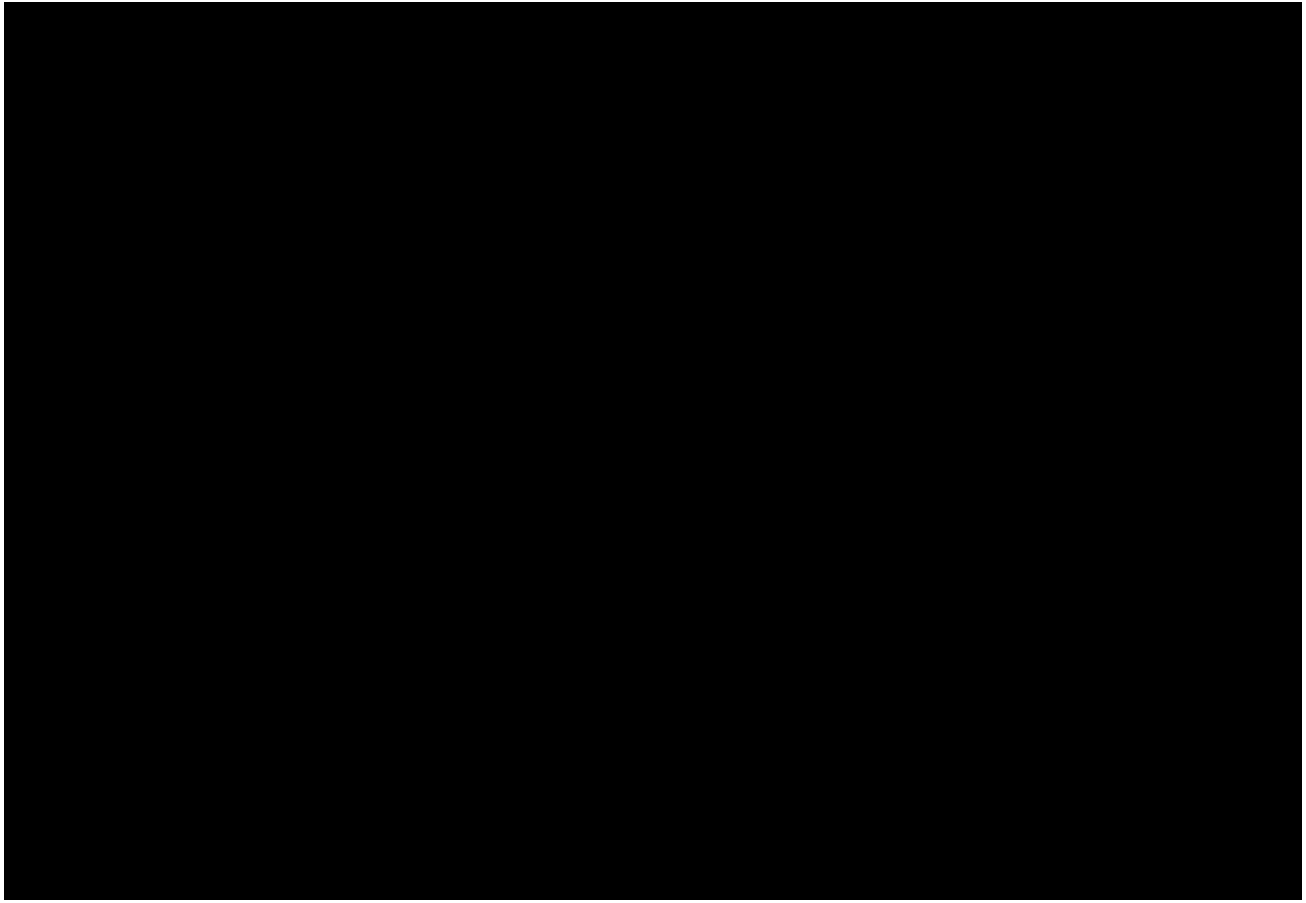
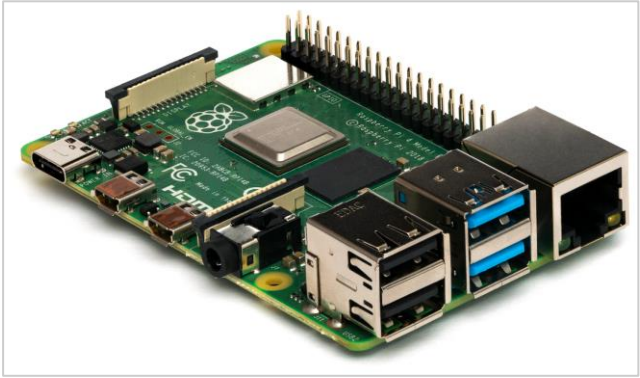
Dual-Channel Microphones + **Foam Windscreen** for Enhanced Speech Separation



Demo

Current Implementation

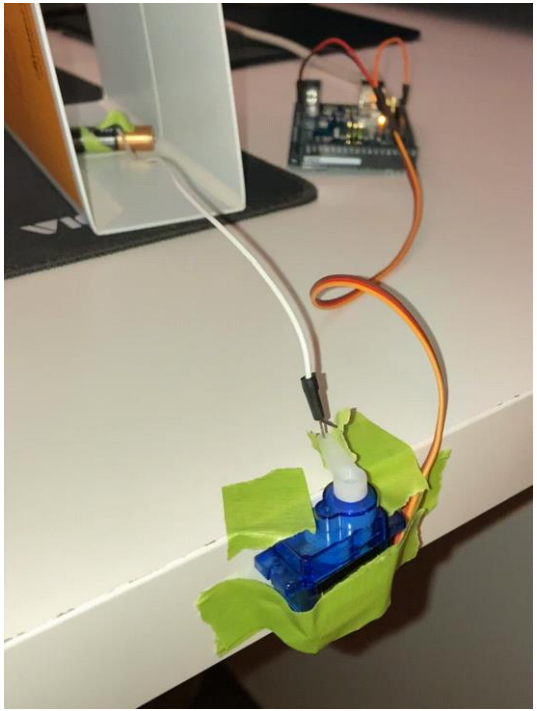
```
def callback(recognizer, audio):
    try:
        value = r.recognize_google(audio)
        if is_keyword(value):
            deploy_airbag()

stop_listening = r.listen_in_background(m, callback)
```



Python SpeechRecognition library recognizes a hotword, triggering the development of the airbag.

Raspberry Pi interfaces with microphones and servo motor

Automated Servo Triggering



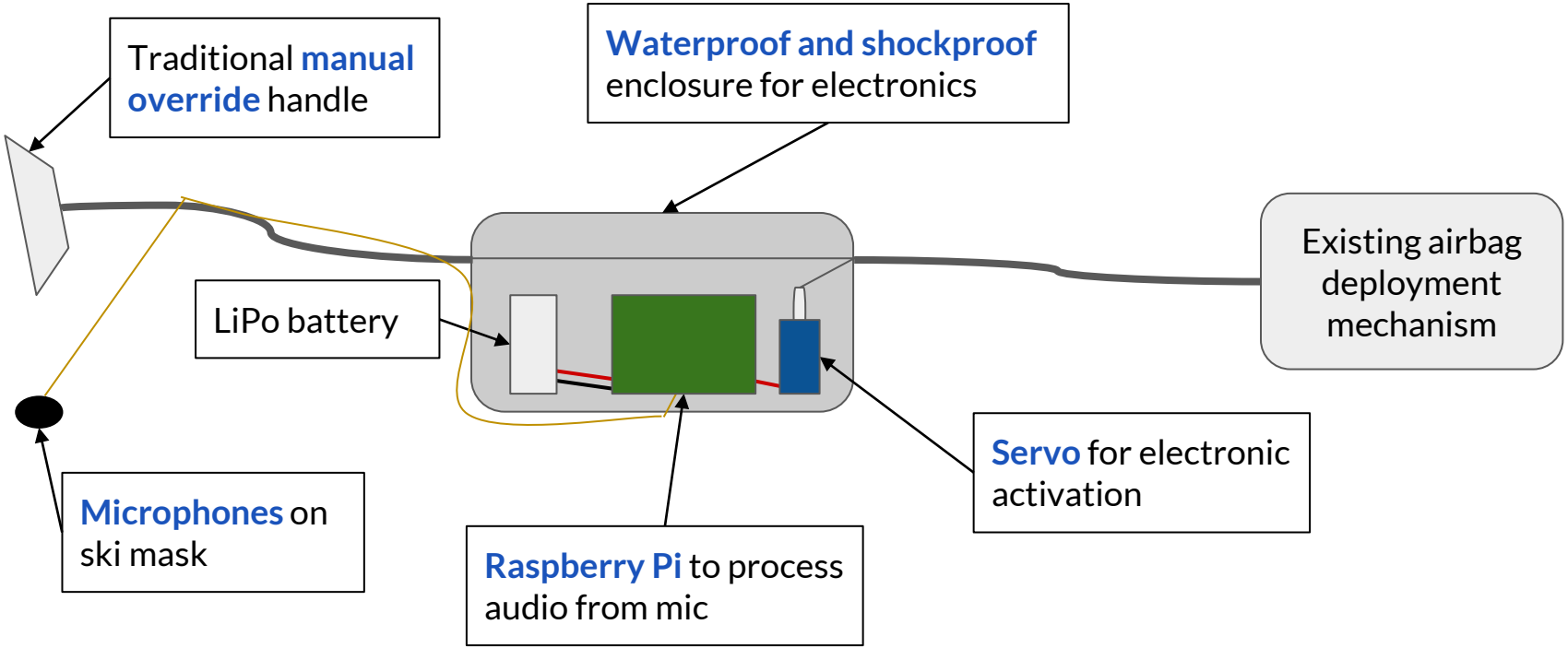
Initial Proxy Servo Test:
2.5 kg-cm

Current Implementation:
27 kg-cm

Manual Override

Triz Principle #11 for **speed vs. reliability**: “Beforehand cushioning”

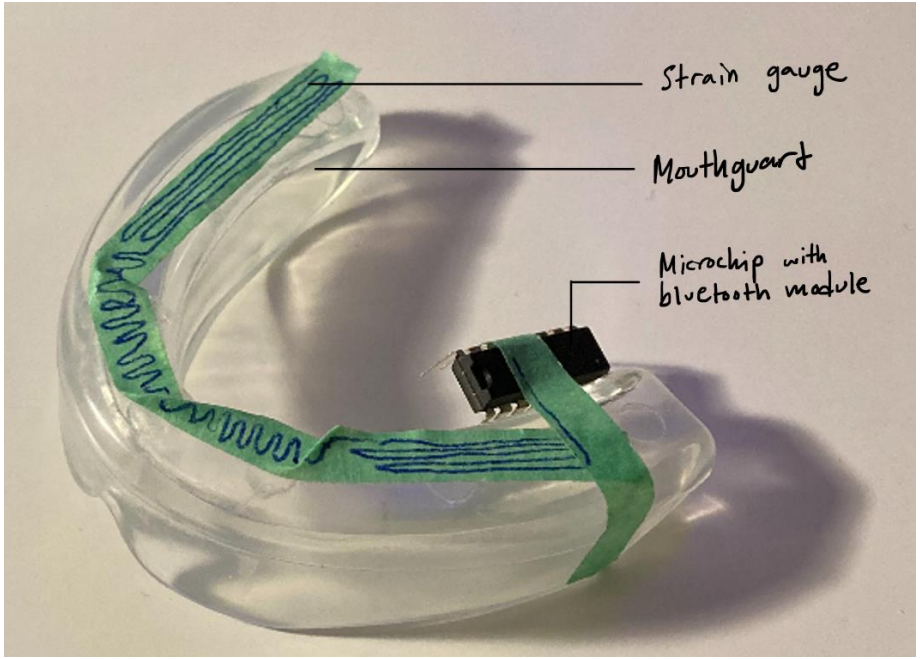
Wiring


Traditional manual override handle
Waterproof and shockproof enclosure for electronics
Existing airbag deployment mechanism
LiPo battery
Microphones on ski mask
Raspberry Pi to process audio from mic
Servo for electronic activation

03. TESTING AND EVALUATION

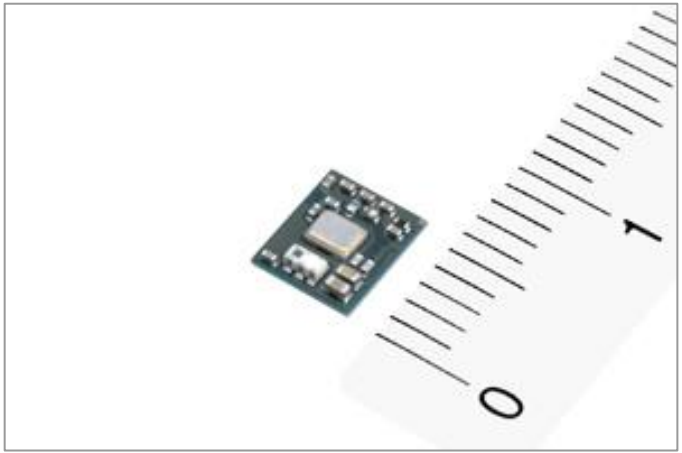
Candidate 2: Computer Vision Autoactivation

Candidate 3: Mouthguard Sensor



Deploys airbag wirelessly after clenching teeth for 1.5 seconds.

Pressure sensor has a 1% uncertainty.



Metrics

Detection Accuracy [%]

Movement Restriction Level

Deployment Time [s]

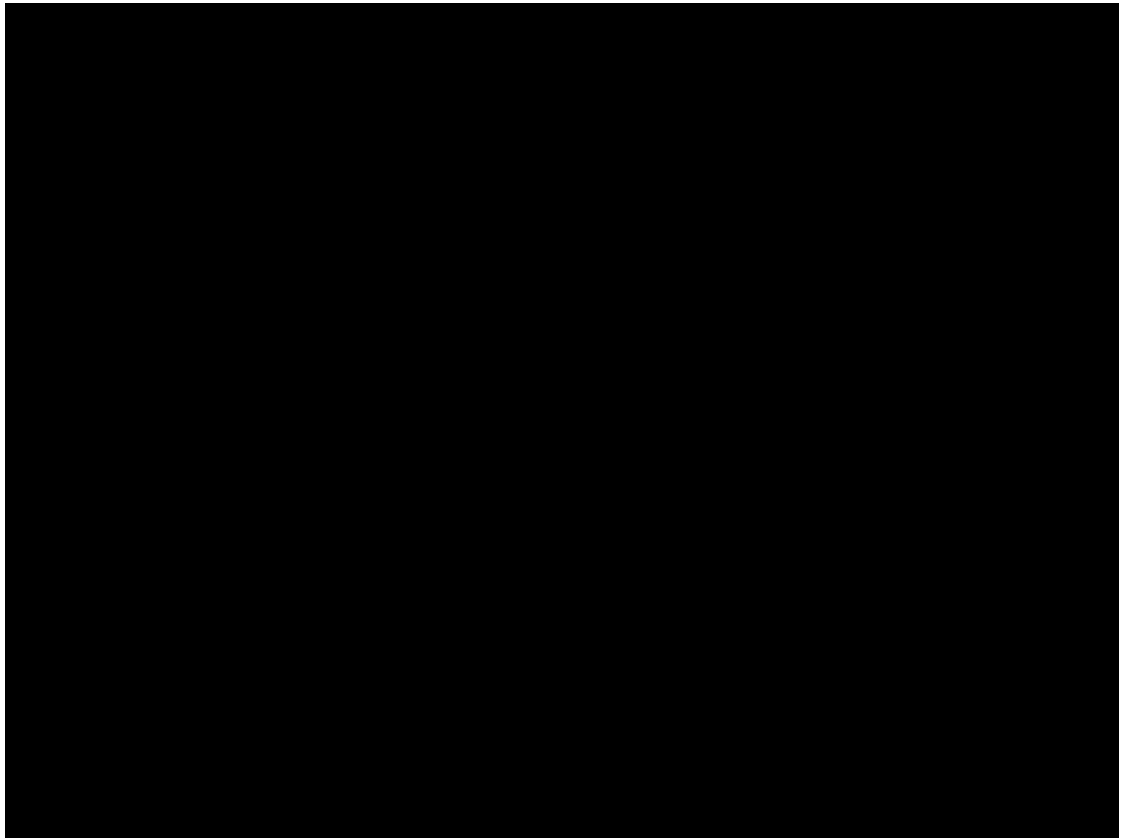
Power Consumption [W]

Number of Activation Steps [#]

Number of Points of Failure [#]

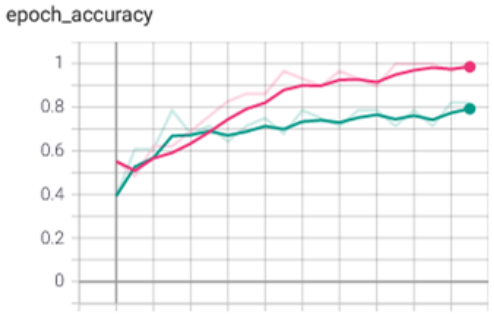
Setup Time [s]

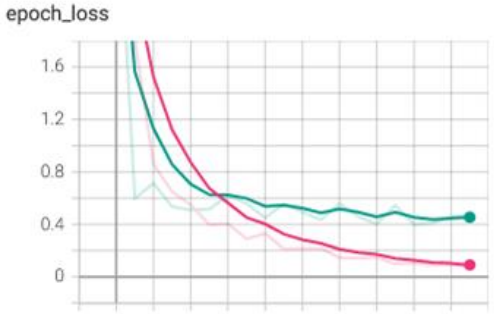
Design Cost [CAD]



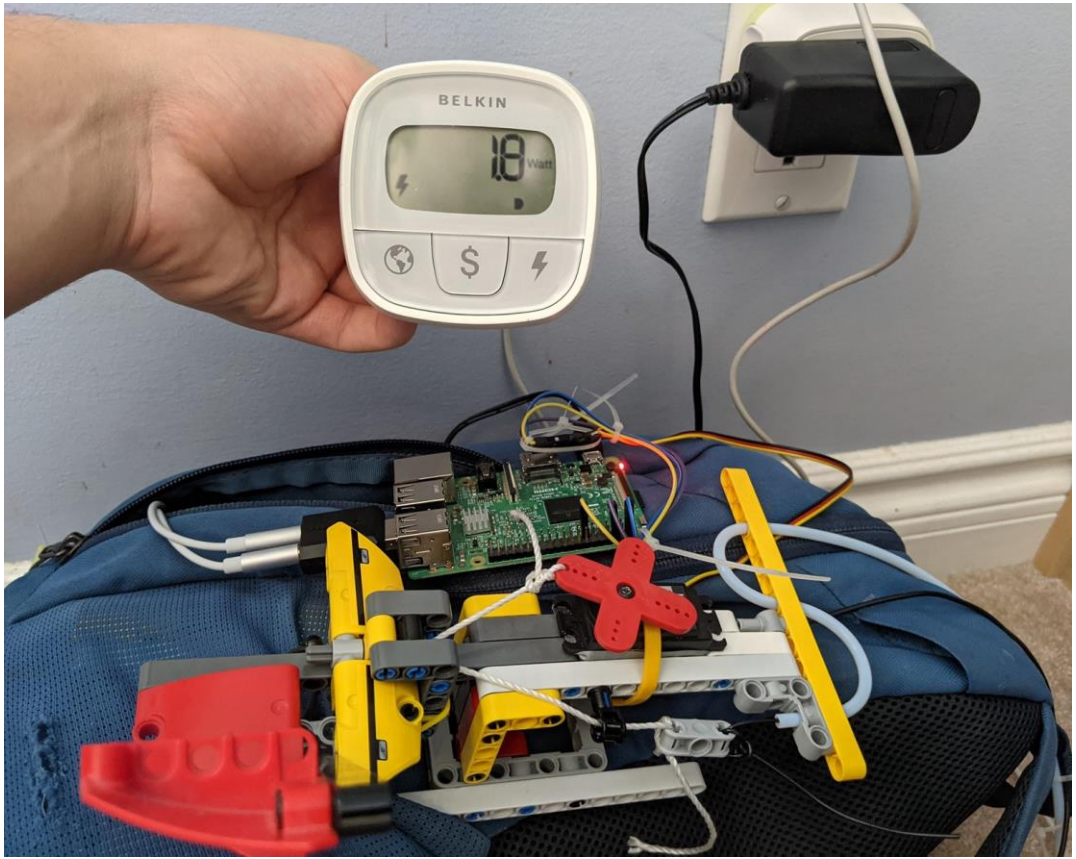
Voice detection accuracy test with blowdryer to simulate slope conditions.


```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              
=================================================================
rescaling_1 (Rescaling)      (None, 60, 75, 1)         
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 60, 75, 16)        
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 30, 37, 16)        
_________________________________________________________________
dropout_1 (Dropout)          (None, 30, 37, 16)        
_________________________________________________________________
flatten_1 (Flatten)          (None, 17760)             
_________________________________________________________________
dense_2 (Dense)              (None, 128)               
_________________________________________________________________
dense_3 (Dense)              (None, 2)                 
=================================================================
Total params: 2,273,826
Trainable params: 2,273,826
Non-trainable params: 0
```





Computer vision prototype has an **accuracy of 75-85%**.



Testing **power consumption**.

Comparison Matrix

Metrics	*Camera*	*VoiceEvo*	*Mouthguard*
Body movement restriction level [rubric]	1	1	2
Detection accuracy [%]	75-85	95	99
Time to deployment upon input [s]	5	2	1.5
User activation steps [number]	0	1	1
Power consumption (± 0.1 W)	5	1.8	1.5
Number of single points of failure (SPOF) and dependencies [number]	3	3	4
Maintenance/setup time before use) [± 2 s]	15	30	30
Design Cost Estimate [CAD]	~180	~80	~130

Metrics ordered in *decreasing* priority.

Assumptions, Limitations

We assumed **no user input error.**

This is a **valid assumption** backed by research (Arnal).

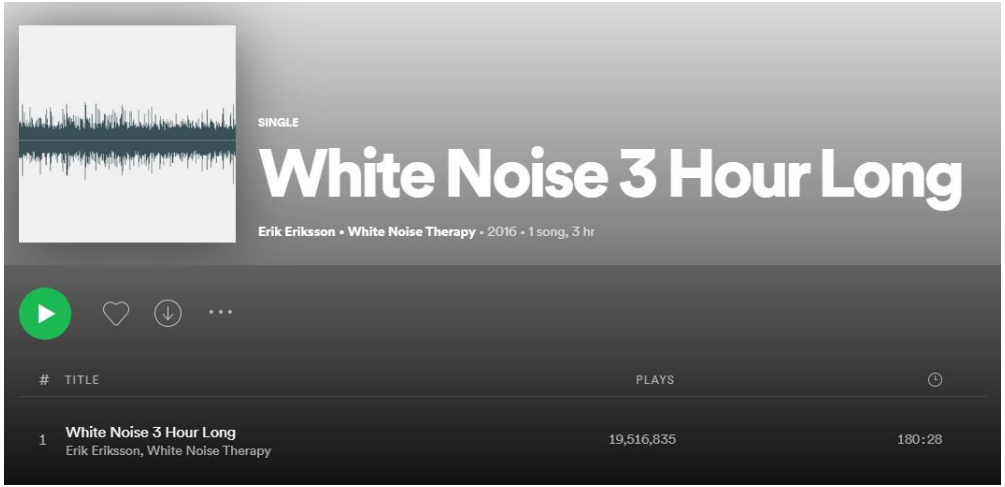
Limited testing of **failure rate** without high fidelity prototypes.

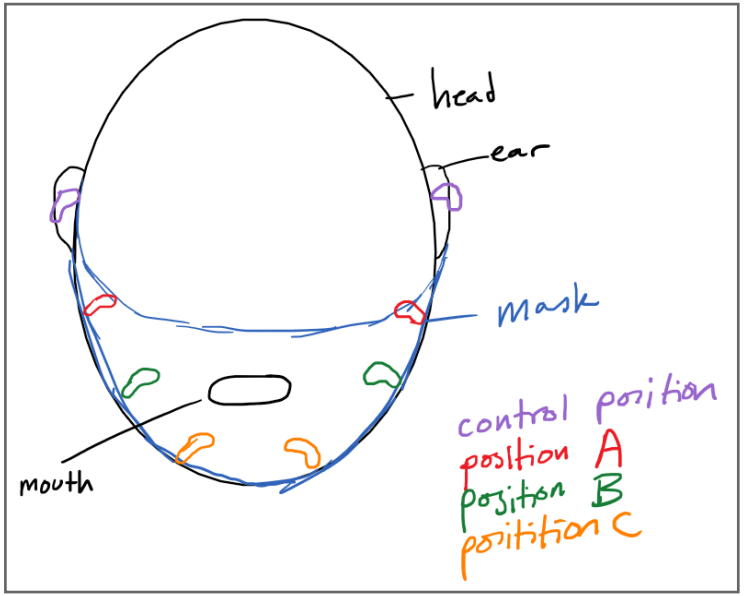
We **proxied** with **single points of failure** (Menčík, 2016).

04. VoiceEvo REFINEMENTS

Microphone Position Testing

SCAMPER: **Dual microphone** digital signal processing for sound separation.



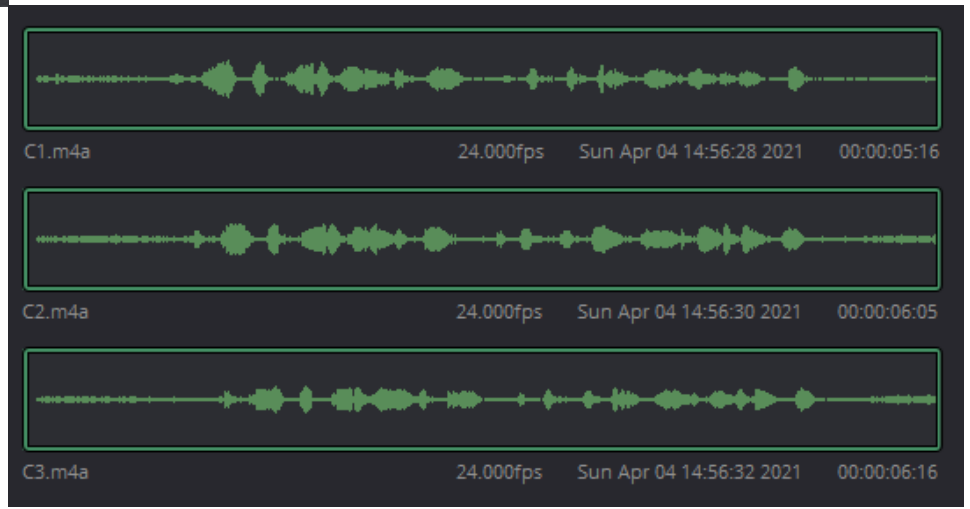


David C. Byrne & Efrem R. Reeves (2008) Analysis of Nonstandard Noise Dosimeter Microphone Positions, Journal of Occupational and Environmental Hygiene, 5:3, 197-209,
Harvard Sentences. (2021). Columbia.edu. https://www.cs.columbia.edu/~hgs/audio/harvard.html

Chosen Microphone Position

Placing the microphones under the mouth is the most reliable.

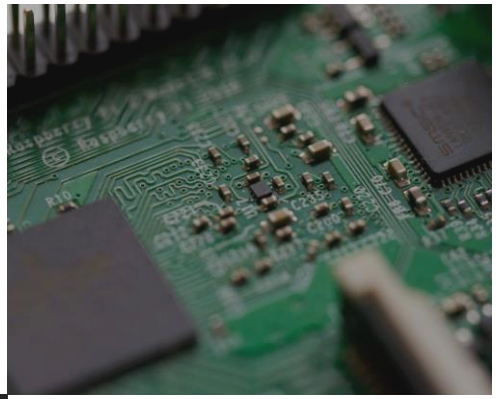
No audio clipping.
Low noise levels.
Moderate wave height.



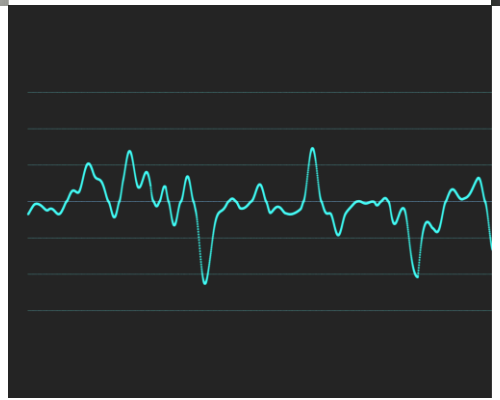
Sharon Gannot et al. A consolidated perspective on multi-microphone speech enhancement and source separation. IEEE/ACM 2017,25 (4), pp.692-730.

Wind

Alango software for **software**-based wind noise cancellation.



Microphone **foam windscreen** absorbs and diffuses wind to reduce wind noises.



Further investigate **dual channel audio processing.**

N. Yousefian and P. Loizou, “A dual-microphone speech enhancement algorithm based on the coherence function,” IEEE Transactions on Audio, Speech, and Language Processing, 2011.

Phonetic and Detection Considerations

cluster	word	transcription
/sm/	*small*	/smɔl/
/sn/	*snap*	/snæp/
/st/	*stay*	/steɪ/
/sw/	*sweet*	/swit/
/sk/	*sky*	/skaɪ/
/sl/	*slow*	/sləʊ/
/sp/	*spin*	/spɪn/
/sf/	*sphere*	/sfɪə/
/θw/	*thwart*	/θwɔt/
/dw/	*dwell*	/dwɛl/
/tw/	*twig*	/twɪg/
/θr/	*three*	/θri/
/dr/	*draw*	/drɔ/

What makes a good hotword?

Avoid:

- Consonant clusters (Al-Rubaat, 2019)
- Verbs and repetition (Goldwater et al., 2009)
- Short words (Shinozaki & Furui, 2001)

"Avalanche" is a good hotword.

Low false positive rate

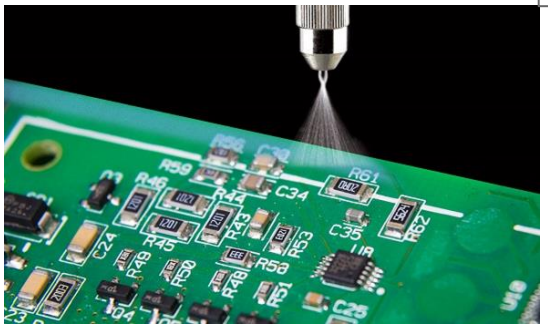
"Lanche", "Ava", "Cattleranch", "Olivebranch" do not activate.

05. Next Steps

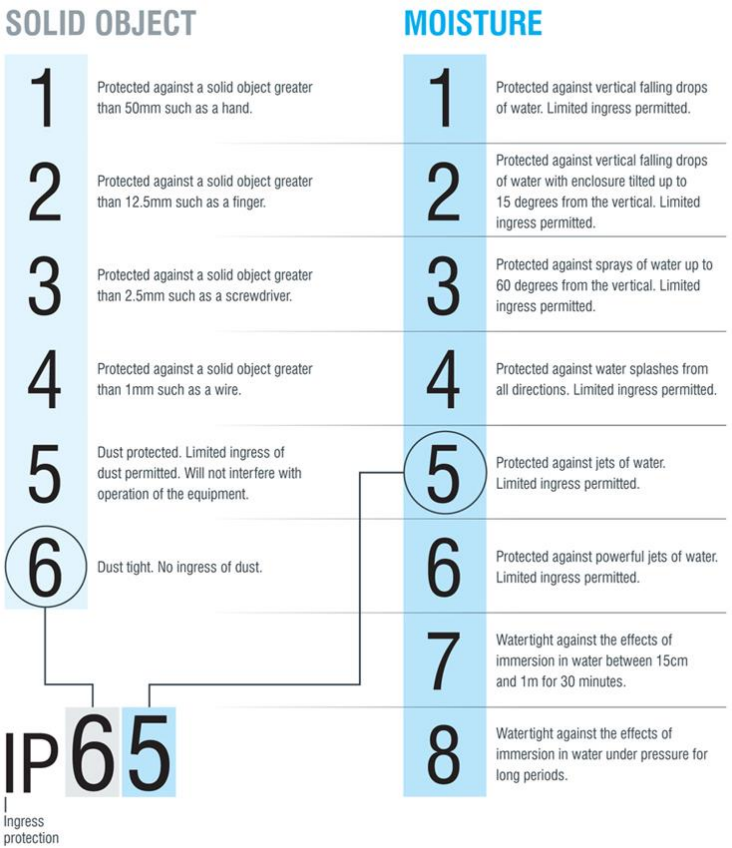
Waterproofing Electronics

Conformal coating on all PCBs

Waterproof cable pass throughs

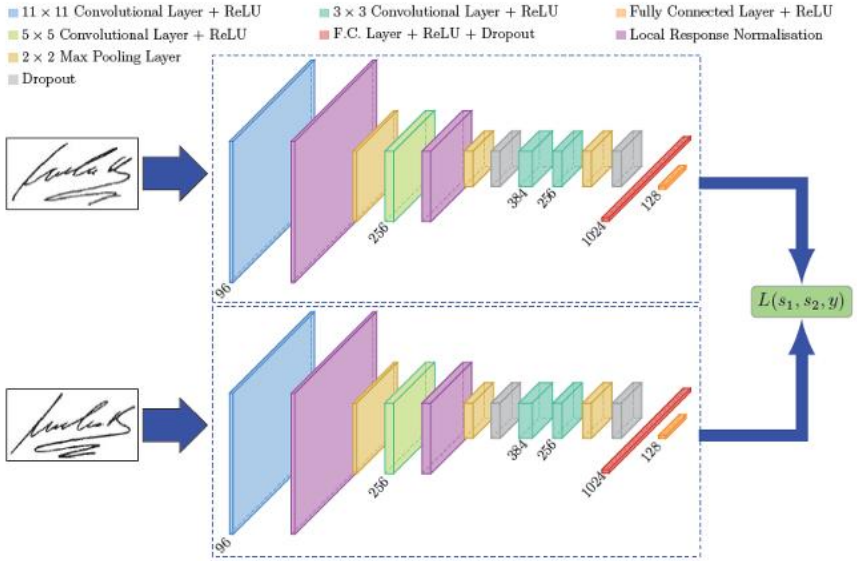


Waterproof enclosure



ISO 20653:2013 - testing Ingress Protection (IP)

Personalization: Customizing a Voice Profile



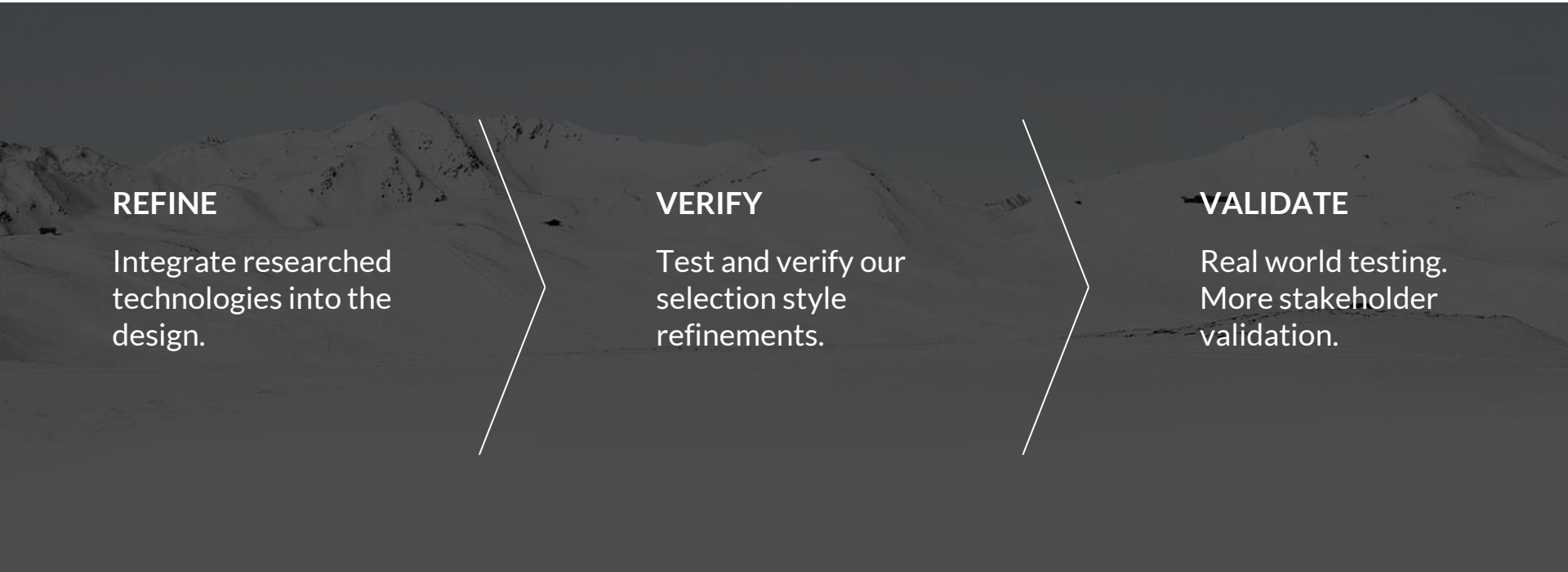
https://github.com/Speaker-Identification/You-Only-Speak-Once

One shot learning based voice authentication system using a **Siamese network.**

Improves **speed** and addresses **privacy concerns.**

https://arxiv.org/abs/1707.02131

LOOKING AHEAD



REFINE

Integrate researched technologies into the design.

VERIFY

Test and verify our selection style refinements.

VALIDATE

Real world testing. More stakeholder validation.


QUESTIONS?

APPENDIX

Reframing Research

Language

Shouting

Microphone Position Testing

Set Up Time Testing

Requirements Research

Comparison Matrix

Converging Folder for Early Prototypes

Motion Inhibition Rubric

Impedance Level 1	**2**	**3**	**4**
User does not report any difference as compared to wearing an ordinary ski backpack without an airbag.	Device is visible and may be aesthetically displeasing-however , it does not impact the user's arm or leg, which are critical to maintaining balance.	The device extends to, or in some way is attached to the user's arms or legs when equipped. It does not impede movement, but is noticeable while the user is skiing.	Device in some way inhibits movement of body parts essential for balance, including arms, legs or bending at the waist, either by restricting movement or causing physical discomfort when the user attempts to move with the device equipped.

Minimize, or remove, the involvement of body parts essential for balance (arms, legs, trunk).

Wind Noise and Alango

When wind strikes the surface of a microphone, it causes an effect known as "wind noise". Similar noise is produced when the microphone surface is rubbed while recording.



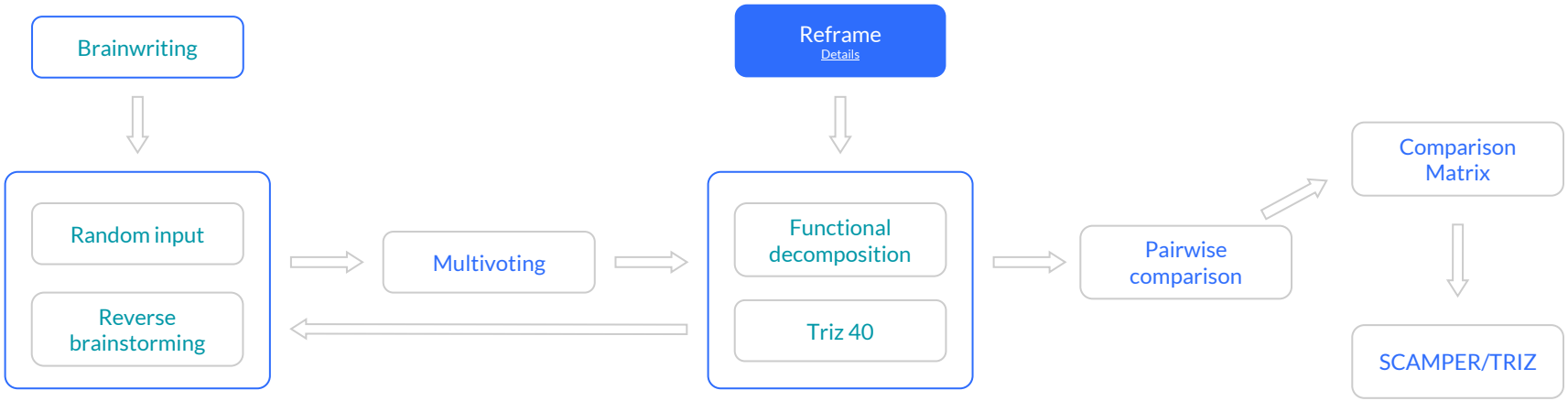
A passive way to reduce wind noise is the usage of windscreens made of open cell foam, fur, or other materials. Windscreens are effective solutions but have disadvantages such as size and durability. Windscreens are usually not used in communication devices.

Alango provides a "software only" **Adaptive Wind Noise Reduction (AWNR)** solution. Wind noise is automatically detected and then significantly attenuated while clear speech in quiet conditions is fully preserved. Wind noise character may differ for different devices and use conditions. AWNR fully exploits the advantages of Alango sub-band processing. Problematic frequency regions containing wind noise are automatically detected and wind noise is suppressed only in contaminated frequency bands. The clean signal remains unaffected.

http://alango.com/technologies-awnr.php#:~:text=Adaptive%20Wind%20Noise%20Reduction,-Technologies%20%2F%20Voice%20Enhancement&text=When%20wind%20strikes%20the%20surface,%2C%20fur%2C%20or%20other%20materials

70+ Hour Battery life under 1.8W, at 5 V (3.6 A)

OUR PROCESS


Brainwriting
Random input
Reverse brainstorming
Multivoting
Reframe
Details
Functional decomposition
Triz 40
Pairwise comparison
Comparison Matrix
SCAMPER/TRIZ