

# Problem Statement and Goals

## Audio360

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Table 1: Revision History

Date	Developer(s)	Change
2025-09-22	Nirmal, Sathurshan, Omar, Kalp, Jay	Initial Write-up
2025-09-29	Jay	Update goals and stretch goals

# 1 Problem Statement

## 1.1 Problem

Individuals who are deaf or hard of hearing tend to have difficulties with staying situationally aware, generally leading to increased risk of injury. Many safety cues such as “the sounds of a tea kettle, the warning beep as a fork lift backs up, and the engine of an oncoming car may be missed”. [1] General sound cues such as someone calling their name, or a phone ringing, may also be missed, often leading to miscommunication and elevated frustration. With 1 in 10 Canadians being impacted by hearing loss [2], there are over 4 million individuals in Canada dealing with these struggles every day.

## 1.2 Inputs and Outputs

The high level input of the system is the audio from the surrounding environments, with the output being a visual indication of the direction of audio sources and their respective classifications.

## 1.3 Stakeholders

The primary stakeholders are individuals who are deaf or hard of hearing.

## 1.4 Environment

The software environment is a real-time operating system (RTOS, i.e. FreeRTOS) running C/C++ code. The hardware environment is a 4 dimensional microphone array, with each microphone connected to a STM32F767 microcontroller for processing, as well as a pair of smart glasses (Rokid Smart Glasses) for the visual display.

# 2 Goals

- Capture real-time audio from a 4-microphone array with synchronized sampling to enable accurate spatial analysis of sound sources.
- Estimate direction of arrival (DoA) with less than or equal to  $45^\circ$  error for single sound sources, providing reliable localization for practical use cases.

# 3 Stretch Goals

- Classify sounds using audio fingerprinting with at least 90% accuracy, allowing the system to recognize and differentiate between common sounds.
- Display audio classification and transcription on smart glasses with a latency of  $\leq 1\text{s}$ , supporting real-time, user-friendly interaction.

## **4 Extras**

1. Price + Hardware Selection Report
2. Usability Report

## Appendix — Reflection

1. What went well while writing this deliverable?

**Omar Alam:** I think all members of our team were proactive and genuinely interested in the project presented which made it easier to delegate and expect high quality work.

**Jay Sharma:** We aligned quickly on the problem and split responsibilities in a way that played to each person's strengths. Our LaTeX/Git workflow came together smoothly, which helped us iterate fast on the documents.

**Kalp Shah:** I think we all had a good understanding of the project after discussing it in detail during the write up for the development plan. Due to this, everyone was able to quickly contribute to the problem statement and goals without much difficulty.

**Sathurshan Arulmohan:** I focused on writing the Extras section of this deliverable. Since these items were pre-approved by the course instructor during the project approval stage, the writing process was straightforward and required minimal revisions.

**Nirmal Chaudhari:** I think our team worked well when dividing up the tickets, and assigning reviewers for each PR. Moreover, we had frequent sync ups to discuss and reach out to our stakeholders, and determine the scope of our overall project.

2. What pain points did you experience during this deliverable, and how did you resolve them?

**Omar Alam:** Since the project idea incorporates glasses with displays that are visible to the user, we had to do a significant amount of research to figure out if it was feasible in the time that we have. We resolved this by developing a contingency plan that would allow us to still allow us to develop the core algorithms without the display glasses.

**Jay Sharma:** Our main pain point was deciding on the hardware that we would use for the project. We had to spend a significant amount of time researching the different options and their feasibility.

**Kalp Shah:** I think we did end up spending a lot of time exploring the scope and feasibility of the project while writing the development plan which caused us to spend less time writing the problem statement and goals. We ended up writing it all on the day before the deadline which was not a problem (as mentioned above - we already knew what to write), but cause a bit of stress.

**Sathurshan Arulmohan:** My main contribution to this deliverable was reviewing pull requests. The challenge was understanding the expected quality and depth since it is the team's first submission. To address this, we used Pull Requests to exchange feedback and propose improvements. This process helped the team establish documentation standards and align on expectations.

**Nirmal Chaudhari:** Based on discussions with our supervisor, MVM, we were told it won't be easy to find a cheap solution that has 4 ADCs. To remain consistent with our project goals and requirements, having one ADC for each microphone was crucial for real time audio recognition. Our supervisor was very helpful in helping us overcome this challenge as he suggested a couple options from which Omar investigated further. We later met as a team and decided that we will only know if its compatible or not after actually buying hardware.

3. How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?

**Omar Alam:** My team and I spent a significant amount of time researching the feasibility of the project. Since the team does not have much experience with signal processing, we decided to consult with Dr. Mohrenschmidt to get his opinion on the project. He provided us with valuable feedback on how to constraint our project goals to ensure that we can complete the project in the time we have.

**Jay Sharma:** We started by mapping the problem space, did feasibility analyses, and set criteria around impact, difficulty, and time. We also checked in with Prof. Mohrenschmidt to advise the direction of our project and keep the scope focused for the capstone timeline.

**Kalp Shah:** A lot of what we did for defining the scope of the goals was done through research and consulting with Dr. Mohrenschmidt and Dr. Smith. Dr. Mohrenschmidt helped us better understand the expected time and resource costs of the project since he has experience with similar work and confirmed with us that our scope is neither too simple nor too ambitious for a Capstone project.

**Sathurshan Arulmohan:** During the project proposal stage, the scope of the project was large. We had many features in mind, and we were not aware of the software and hardware complexities of achieving our vision. To refine this, each member shared their desired learning outcomes and technical interests. Through this discussion, we narrowed the scope of features and goals that balanced feasibility with sufficient challenge.

**Nirmal Chaudhari:** Our team decided to go with the iterative approach for this project. During our first meeting with MVM, we discussed the feasibility of this project and our supervisor mentioned we should research each part individually first. This ensures that we can validate our project goals early on, and adjust as needed.

## References

- [1] E. Masterson, “Measuring the impact of hearing loss on quality of life,” *NIOSH Science Blog*, 2016.
- [2] Healthing.ca, “Hearing loss in canada: Stats, impact and resources,” *Healthing.ca*, 2025.