Mitigating Autistic Meltdowns

Joshua Kao, Jason Kroslowitz, Noah Lockhart, Andres Perez

Concept of Operations

REVISION – Draft

06 February 2022

Concept of Operations

for

Mitigating Autism Meltdowns

Team 12

Approved by:

__Team 12_____2/08/22__

Project Leader Date

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Prof. Kalafatis Date

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T/A Date

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1. Executive Summary

An autistic meltdown is an involuntary coping mechanism to excessive stimuli, and can be associated with intense and explosive behaviors. These events pose a threat to the safety of these individuals and in some cases others around them. Rather than having a caretaker supervise them 24/7, we propose a device that mitigates meltdowns for these individuals. The 12th Man is a hip wearable device that mitigates meltdowns for individuals with Autism. By monitoring the user's biometrics, the 12th Man uses artificial intelligence to process these signals and predict if a meltdown is imminent. If a meltdown is imminent, an alert is sent to the subject's parent(s) or guardian through an app with the location of the individual and the probability that a meltdown is going to happen. On the device itself a recording from a loved one is played with grounding exercises to calm down the individual. We are hoping that through this device, the lifestyles of autistic people can be changed.

2. Introduction

The following is an introduction to The 12th Man, a device capable of monitoring, mitigating, and supporting individuals with autism no matter where they are. The 12th Man will provide a sense of comfort for these individuals and their loved ones through its prediction, mitigations, and location tracking of meltdowns.

2.1. Background

Autism spectrum disorder (or ASD for short) is a disorder that affects social, emotional, and communication skills. Although the cause is still unknown, it is believed to develop from a combination of genetic, nongenetic, and environmental influences. Recently, ASD has been more heavily researched, and as a result, more conditions have been connected to the disorder. Although symptoms differ per individual, some common symptoms include anxiety, ADHD, epilepsy, schizophrenia, and others.

It is also common for individuals with ASD to be easily agitated. Due to this, meltdowns are an ailment that affect many autstic people. A meltdown is a result of stressors that cause an overload for the individual. During a meltdown, “involuntary physical and emotional reaction to a situation” can occur. While meltdowns can happen with any individual, people with ASD are more prone to them due to the inability to process the overload of stimulants from the surrounding environment. Some examples of these extraneous stressors could be any variety of loud noises, large crowds, and sometimes just everyday life. Meltdowns can result in devastating effects such as wandering, self harm, harm to others, and in the worst case scenarios death.

Typically when addressing meltdowns, it is best to try to prevent them from even happening. Family and friends are the best suited for this task since these individuals understand when there could be potential stressors to the person expecting a meltdown. They are also the most equipped to develop grounding exercises which can help calm the person down. Grounding exercises are a series of activities, patterns, or words that help calm an autistic person down. The tell tale signs are different for each person who experiences a meltdown, so it is important to tailor an individual grounding plan for each person. Currently the method of preventing a meltdown is having the parent/guardian around to assist with the grounding exercises. The other current option is to leave the individual unsupervised.

While having family and friend supervision is ideal, we all know that it is not feasible 24/7. This is where the 12th Man comes to action to predict, prevent, and calm-down meltdowns through artificial intelligence and biometrics.

2.2. Overview

The 12th Man device will be a wearable device on the hip that will collect biometric and environmental data such as position, body temperature, heart rate, acceleration, and environmental audio. The devices inside the wearable include a gps module, sensors, and a microphone to collect data. The microcontroller will be supplied power by a rechargeable battery. Data received from the sensors will be filtered and sent to a cloud to be stored and classified. It will then be stored in a database, and will be readily available for the mobile application to fetch and display. If the artificial intelligence infers a meltdown is likely, the mobile application will receive a notification of a possible meltdown. Furthermore, an audio recording of a loved one will be outputted through a speaker on the wearable to aid in the mitigation process. Grounding exercise instructions will be included in the audio to calm the user. Finally, the location of the individual will be tracked in the case of the individual wandering which could lead to dangerous outcomes.

2.3. Referenced Documents and Standards

- G., T., Brandon W. | 8 years old, Warren W. | 17 years old, & Andrew S. | 17 years old. (n.d.). *Autism speaks*. Autism Speaks. Retrieved February 8, 2022, from https://www.autismspeaks.org/
- *How many people are diagnosed with autism in the U.S.* Therapeutic Pathways. (2021, February 27). Retrieved February 8, 2022, from https://www.tpathways.org/faqs/how-many-people-have-autism/#:~:text=How%20many%20people%20have%20autism%3F&text=According%20to%20the%20Centers%20for,spectrum%20disorder%20%E2%80%93%20over%2075%2C000%2C000%20people.

3. Operating Concept

3.1. Scope

The 12th Man mitigation system for autistic meltdowns is a wearable device composed of a microcontroller and sensors. The system will monitor the biometrics of the wearer and collect data from the individual's environment. Using artificial intelligence, we will identify the precursors of a meltdown in individuals with autism, and make a prediction about whether a meltdown is likely to occur. If a meltdown is likely to occur, a recording from a loved one will be played through speakers on the wearable. The wearable will also store the data it collects in a remote database. This database will be accessible by a mobile application, which will provide parents/guardians with information regarding the location and meltdown status of their dependent.

3.2. Operational Description and Constraints

The 12th Man is a noninvasive, wearable device that operates without any work from the individual. It is intended to be used by the ASD community and their loved ones. While wearing the device, biometric and environmental data will be collected continuously. The wearer will only interact with The 12th Man if an event occurs. Speakers will begin to play audio of their loved ones walking them through a grounding exercise. While using the app, parents/guardians will be able to receive continuous biometric data, location data, and notifications of an imminent meltdown. In order for The 12th Man to perform properly, all the following criteria must be met.

1. The user is wearing the charged 12th Man device.
2. The user is wearing the heart rate monitor around their chest.
3. Parents/Guardians will have to have The 12th Man app installed on their phone and linked to the device.
4. The device wearer must have cellular or internet connection.
5. Past 5 hours the device will lose power causing the user to be unmonitored.

Additionally The 12th Man is not waterproof or perfect. There is a risk of a damaged sensor sending the wrong biometric data to the app which could potentially cause a fake alert.

3.3. System Description

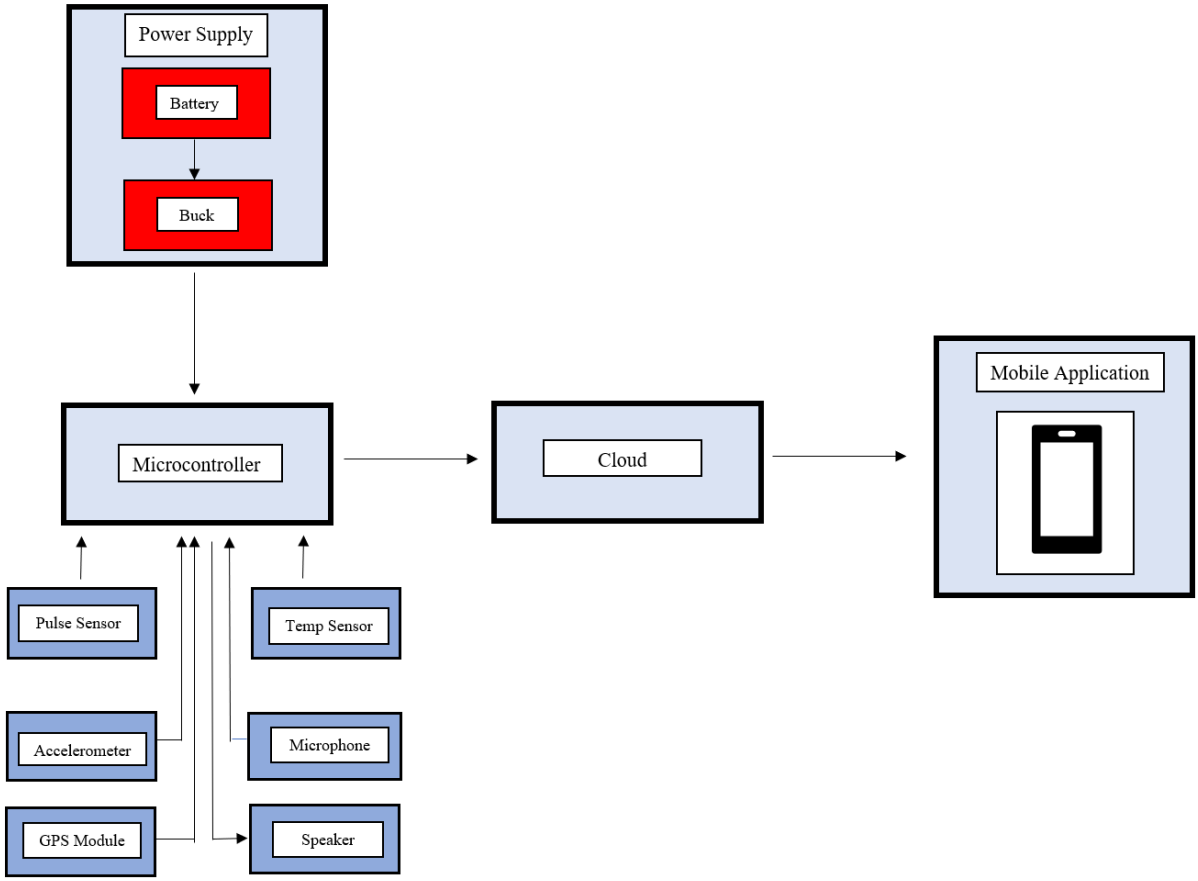

Figure 1: The 12th Man Block Diagram

The 12th Man will be composed of four subsystems. These include artificial intelligence, power supply, mobile application, and interfacing sensors with cleaning data.

Interfacing Sensors: The 12th Man device includes 5 different sensors: GPS, temperature, accelerometer, pulse, and audio. Each sensor will be wired to a Raspberry Pi microcontroller. The sensors will collect and “clean” or filter out the noise from the data through a combination of hardware (filters and op amps) along with some software. The data will then be assembled into packets and sent to the cloud.

Power Supply: The wearable device will have a rechargeable battery in place that will be composed of a battery in a battery holder. The battery will be connected to a battery management system for fuel gauge and a charging port. The batteries will be lithium-ion polymer batteries so they will be able to be recharged. The battery will be recharged by an AC/DC adapter. The rechargeable battery will be connected as an input to a boost converter in order to step up the voltage to meet the required specifications to power the microcontroller as

the output of the boost converter will be connected to a stripped end of a usb-c cable that will have the usb-c end supply power to the microcontroller. This amp-hour specification of the battery will help make battery life last.

Artificial Intelligence: The AI subsystem has several parts. A supervised learning algorithm has been developed by our sponsor to do classification on audio samples. Data preprocessing will entail converting audio samples to mel spectrograms. A CNN will then classify the likelihood of the audio sample originating from one of six types of environments (small conversation, stimuli, large conversation, etc). Another classification model will be constructed, taking as inputs some/all of the biometrics and the output of the acoustic classifier. This model is the final step in the pipeline to predict a meltdown. Should the environment be deemed stressful or over-stimulative, and the vitals indicative of physiological stress, the model will predict a meltdown is likely to occur. Lastly, we may consider building an additional artificial intelligence based on a generative adversarial network with the hopes of generating convincing “fake” data for biometrics. This will be done should we have issues collecting enough biometric data to train the meltdown prediction model.

App and Database: The database will receive and store all the information the hardware sends it. This will include the GPS location and other readings from the sensors. The app will then present all of this information to the guardian. The guardian will be able to see the location of the individual wearing the device as well as all other sensor readings. If a meltdown is predicted to occur, an alert will be pushed to the mobile application, informing the parent/guardian of the situation.

3.4. Modes of Operations

There is only one mode of operation for the system, which is meltdown mitigation. We are intending to provide end-to-end support for individuals with autism as well as their caregivers. The device will operate the same way at all times. An alert will be generated on the mobile application if the device infers that the user is likely to have a meltdown, and an audio recording will be played on the device.

3.5. Users

The 12th Man is marketed to the guardians/care-givers of individuals who are diagnosed with Autism Spectrum Disorder. The 12th Man will be used by the person with Autism with the intent of improving quality of life. The device will be worn on the waist along with a bluetooth chest

band to sense the heartbeat. The app will be easy to use with all the essential information displayed on the home page. The guardian/caregiver and the individual diagnosed with ASD will benefit from the 12th Man since the guardian/caregiver will be more informed of their dependent's status and the user will have more security. User installation will not be complex as instructions will guide the user and guardian/caregiver to utilizing the 12th Man.

3.6. Support

The users will receive a manual with instructions on how to equip the 12th Man wearable on the individual. Provided the sensors are able to collect biometric and environmental data properly, we may include alternative options of wearing the device. The user manual will also include battery life information, cleaning instructions, and warnings. Warnings will be provided to maintain the life span of the 12th Man such as mentioning that the device will not be water-proof and would not be ideal in a water-based environment. Furthermore, we will provide instructions on downloading the mobile application and linking it to the 12th Man device for guardian/caregiver use. The user manual will also have instructions on how to interact with the mobile application to view alerts and the corresponding data retrieved from the device. In the future, it may prove beneficial to have a live call center that a person can receive customer support from.

4. Scenario(s)

4.1. People with Autism

The main usage of the 12th Man is to be worn by people with autism to help them mitigate a meltdown before it occurs. When people with autism are out in public, they can get into situations that can be stressful and overwhelming. When this happens, a meltdown can occur. By monitoring the environment and the biometrics of the wearer, The 12th Man will be able to detect when they are about to have a meltdown. If a meltdown is detected, the device will guide the individual with grounding exercises to calm them down while sending a meltdown alert to the guardian through the mobile application. The guardian will also receive the individual's location for the case of wandering.

4.2. People with Panic Attacks

Another use of the 12th Man could be to detect panic attacks. Since meltdowns can exhibit similar physiological responses as a panic attack does, the device may be used interchangeably. Panic attacks can be caused by an overwhelming amount of stimuli, like crowded areas or loud noises. In addition, panic attacks lead to an increase in heart rate and a shortness of breath. The 12th man can detect when these things are happening and can notify the user of an impending panic attack. The device can also contact a loved one through the app via an alert to let them know that the user is about to or having a panic attack.

4.3. Exercise

The 12th man can also be used by people who are exercising or doing physical activities. By tracking the user's heartbeat and their location, a program can be added to the app to document and show their workout. Additionally, if someone is climbing a mountain, an application can be added to make sure the climber is alright. By tracking the user's heartbeat, the 12th Man can tell the wearer if their heart rate is slowing due to a lack of oxygen.

5. Analysis

5.1. Summary of Proposed Improvements

- The device will have a heartbeat sensor to detect when the individual's heartbeat is speeding up or slowing down. Either scenario could lead to a meltdown.
- The audio inputs, temperature gauge, and accelerometer will give the system more data about the environment the individual is in. For example, determining if the individual is inside or outside, if they are moving, or determining how many people are near them.
- A more advanced GPS in the device will be able to track the user's location more precisely.
- The app will be able to collect all the input data and present it to the guardian of the wearer. The app will show the wearers location and whenever they have a meltdown or if they are about to have a meltdown.
- The AI system in the device will be able to take all the environmental inputs and accurately identify the environment the wearer is in.

5.2. Disadvantages and Limitations

- Sensor data could be unreliable due to bad readings and noise on the signals.
- The device will only be able to last as long as the battery lasts.
- The AI may not be able to detect the environment accurately all the time.
- Input lag from the device to the database to the app and back again may make it difficult to have real time readings.
- Some people may not want to wear the device.
- The wearer could forget to charge the device and the power dies.
- Users may have a hard time understanding how the device works.
- Grounding exercises may not be enough to stop the meltdown.
- Not water resistant

5.3. Alternatives

- An alternate solution could be having someone look after the individual with autism everyday. A trade-off would be having to pay this person every day to watch the individual.
- Trying to inform the public about meltdowns of people with autism. But many people will just ignore the information or could never even hear it. Plus this would cost a lot of money to spread this information.
- The person with autism could also never leave their home and avoid situations that could cause a meltdown entirely. However, this would mean the individual would not live an ideal lifestyle.
- Just let the meltdown happen and deal with the consequences.

5.4. Impact

- This device will help those with autism by preventing and mitigating meltdowns. When the wearer is about to have a meltdown, the device will lead them into grounding exercises to calm the individual.
- Quality of life for people with autism will improve greatly. Now they can go out into public with more security. They know that if they have a meltdown they won't be alone, that the 12th Man will help them. Also they will feel safe knowing that their guardian will be notified and ready to help if it is needed.
- The guardians of the austistic individual would worry less because they will be alerted when the individual has a meltdown and that a mitigation process has been implemented. The guardian will receive the individual's location.

- People around the wearer of the device will also learn what situations can cause a meltdown. When someone sees the device calming someone down, then that person will become more aware of what environments can cause a meltdown.

Mitigating Autistic Meltdowns

Joshua Kao, Jason Kroslowitz, Noah Lockhart, Andres Perez

FUNCTIONAL SYSTEM REQUIREMENTS

REVISION 1

23 February 2022

FUNCTIONAL SYSTEM REQUIREMENTS
FOR

Mitigating Autistic Meltdowns

PREPARED BY:

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Team 12 Date

APPROVED BY:

_____
Josh Kao Date

_____
Prof. S. Kalafatis Date

_____
Eric Robles Date

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1. Introduction

1.1. Purpose and Scope

Meltdowns in the Autistic community have been a debilitating issue affecting the quality of life for individuals with Autism and their loved ones. The intention of the 12th Man is to improve quality of life for individuals with Autism through a safe, discreet, and user-friendly device that autonomously predicts and mitigates meltdowns. The 12th Man is intended for those who have ASD but it can also be used by individuals who suffer from panic attacks. Figure 1 shows a proposed block diagram of the project from CONOPS.

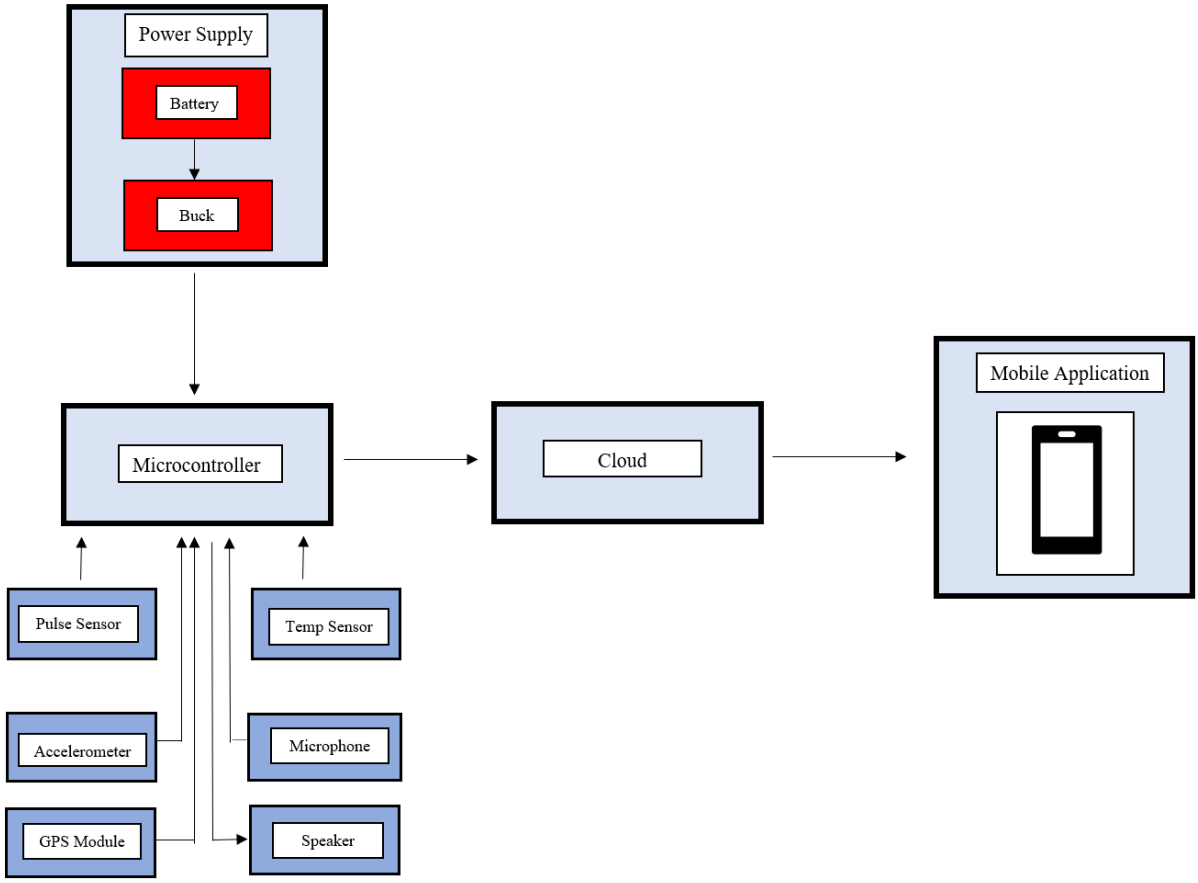

Figure 1: The 12th Man block diagram

The 12th Man is a three stage system composed of a wearable device, artificial intelligence, and mobile application/database. The wearable device shall be composed of a microcontroller, sensors, and a rechargeable battery. Sensors shall monitor the heartbeat, speed, location, and

surrounding noise of the wearer. A Raspberry Pi 4 will then send the data to the artificial intelligence, which shall make a prediction about whether a meltdown is likely to occur. If a meltdown is likely to occur, a recording from a loved one will be played through speakers on the wearable. The wearable will also store the data it collects in a remote database. This database will be accessible by a mobile application, which shall provide parents/guardians with information regarding the location and meltdown status of their dependent.

Figure 2: The 12th Man Wearable Device (Concept Image)

1.2. Responsibility and Change of Authority

The team leader, Joshua Kao, will have the responsibility of ensuring that all the requirements are met. Any proposed changes to the requirements shall be vetted by each team member, and passed on to our sponsor, MarkusAI, for verification and approval. Team members will each have the responsibility of ensuring that their individual subsystems function as outlined in this document. Subsystem responsibility is as follows:

Joshua Kao	Dataset Collection, Microcontroller/Sensors
Jason Kroslowitz	Artificial Intelligence
Andres Perez	Power System
Noah Lockhart	Mobile App and Database

2. Applicable and Reference Documents

2.1. Applicable Documents

Document Name	Revision/Release Date	Publisher
Raspberry Pi Model 4 Datasheet	Release 1 - June 2019	Raspberry Pi Ltd.
TensorFlow Documentation	1.10	Google Brain Team
‘Meltdowns’, surveillance and managing emotions; going out with children with autism	Release 1 - September 2010	US National Library of Medicine and National Institute of Health

2.2. Reference Documents

Document Name	Revision/Release Date	Publisher
50 of most important Raspberry Pi Sensors and Components	July 20, 2020	Raspberry Pi Tutorials
Introduction to Raspberry Pi 4: Tackling the Basic Electronic Kits With the Raspberry Pi 4	May 26, 2020	Device Plus Editorial Team
Meltdown/Tantrum Detection System for Individuals with Autism Spectrum Disorder	December 11, 2020	Applied Artificial Intelligence Journal

2.3. Order of Precedence

In the event of a conflict between the text of this specification and an applicable document cited herein, the text of this specification takes precedence without any exceptions.

All specifications, standards, exhibits, drawings or other documents that are invoked as “applicable” in this specification are incorporated as cited. All documents that are referred to

within an applicable report are considered to be for guidance and information only, except ICDs that have their relevant documents considered to be incorporated as cited.

3. Requirements

The following section will provide definitions of all three stages for the proof of concept we are developing. “The 12th Man” refers to the system in its entirety, including the wearable device where sensor data is collected and packaged, the mobile app and server where data is sent; stored; and viewed, and the artificial intelligence which performs inference on the data collected. The term “The 12th Man Wearable” refers to the physical device including the sensors, rechargeable battery, microcontroller, and enclosure. “The mobile application and database” refers to the subsystem where collected data is stored and made available to the user. The term “Artificial Intelligence” refers to the inference performed onboard the microcontroller to predict if a meltdown is imminent or not based on sensor readings.

3.1. System Definition

The 12th Man is a wearable device that shall monitor an individual with Autism to predict the occurence of meltdowns, and mitigate meltdowns should they occur. The project is composed of four subsystems, which include power systems, microcontroller/sensors, artificial intelligence, and mobile application and database.

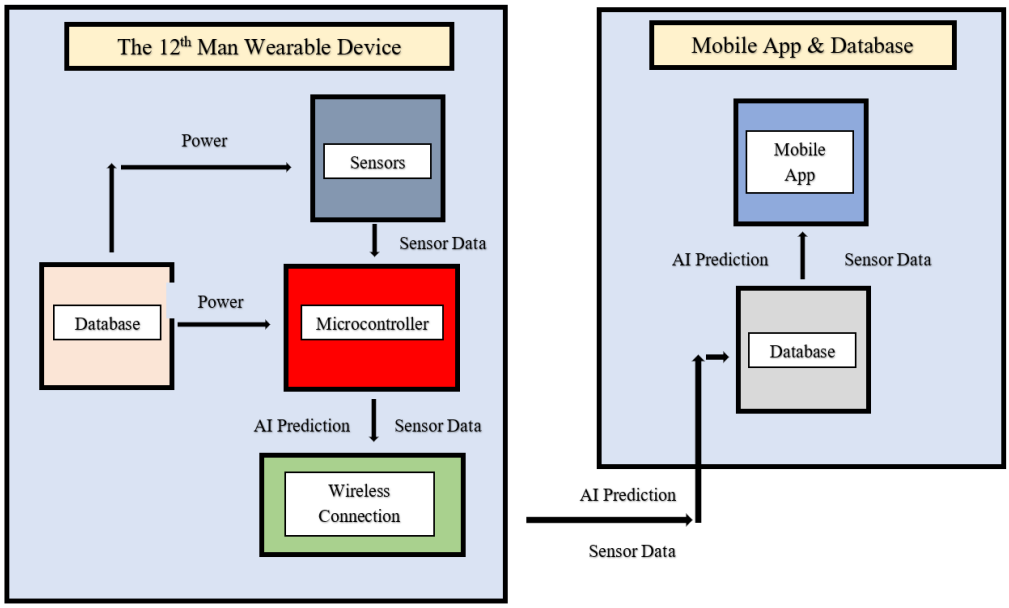

FIgure 3: Functional System Diagram

The power system subsystem shall consist of supplying power to the sensors and microcontroller. The power supply will consist of a lithium-ion battery that will supply power to the GPS module, temperature sensor, and accelerometer. A boost converter shall boost the voltage coming from the battery to supply power to the microcontroller. The system shall have a

battery charger and power-path management integrated circuit to support power management to the battery.

The microcontroller and sensor subsystem shall gather biometric data and package it into usable data. The biometric data gathered by the sensor subsystem will include the subject's location, speed, heart rate, temperature, and surrounding audio data. It should also collect gyroscopic data if needed. Following the collection of data, the microcontroller will organize the data into usable packages. The data will then be sent to the server along with the Artificial Intelligence's prediction.

The artificial intelligence subsystem will be composed of two parts. The environment acoustic classifier shall receive audio data from the microphone sensor, and shall attempt to classify the environment. A separate artificial intelligence will take as input the data from the heartbeat sensor and the accelerometer, in addition to the output of the acoustic classifier. This model shall make a prediction on the likelihood of a meltdown occurring based on the similarity of the features it receives to the "trigger" dataset on which it is trained. (This process is highly dependent on the individual: Meltdowns can express themselves in a plethora of ways, thus it is of the utmost importance to compile a dataset of triggers specific to the individual).

The database and application subsystem contains two parts as well. The first part is the database. The database will store all the input signals that are being read to the 12th Man. The most important set of data the database will hold are the GPS coordinates and the AI meltdown prediction. The app will pull the GPS location and the meltdown prediction and display them. The user can also use the app to check the connectivity of the input functions to the database.

3.2. Characteristics

3.2.1. Functional/Performance Requirements

3.2.1.1 Frequency of Measurements

Each sensor in The 12th Man device shall take a measurement every five minutes. For the microphone sensor, the data collected will be time-series data, i.e. a 10 second audio recording.

Rationale: Meltdowns that are able to be mitigated will not happen instantly, but rather over an extended period of time, during which warning signs specific to the individual are exhibited. The AI will attempt to learn what the "rumble stage" looks like in an individual and help stop it from progressing.

3.2.1.2 Accuracy of Meltdown Predictions

The 12th Man custom artificial intelligence shall meet a threshold objective of 90% correct identification of meltdown probability. When an individual exhibits any one of their several warning signs of meltdown that the AI has been trained to recognize, a meltdown should be predicted to be highly likely.

Rationale: If an individual is going to have a meltdown, it is of the utmost importance that it is predicted with high accuracy so that mitigation can begin immediately. Failing to correctly

identify, mitigate, and provide alerts for a meltdown to parents/guardians could be devastating to the individual's health and safety.

3.2.1.3 System Operation Time Constraint

The 12th Man will have a battery life of five hours. After this amount of time, the device will need to be recharged.

Rationale: The device will be able to function for five hours allowing the guardian of the individual to monitor one in the event that the individual with autism is to be unsupervised.

3.2.1.4 Wireless Communication

The 12th Man and the app must have a strong 4G connection at the minimum, or be connected to wifi at any given time.

Rationale: The device will send the data to the SQL database through the wifi connection. The database will use this data in order to predict if a meltdown will happen. If a meltdown is about to occur then the app will be notified, through the internet connection.

3.2.1.5 System Latency

The data collected by the sensors on the microcontroller and the prediction made by the AI on this data must be made efficiently and transmitted to the database and the mobile application with minimal latency. (10 seconds at the most).

Rationale: When someone is at the beginning stages of a meltdown, then the device must be able to predict this quickly and begin grounding exercises right away (a few seconds could be the difference between the meltdown being mitigated and the meltdown escalating beyond the point of control). Similarly, the parent/guardian will need to be notified as soon as possible if a meltdown is likely to occur.

3.2.2. Physical Characteristics

3.2.2.1 Mass

The mass of The 12th Man wearable shall be less than or equal to 1 kilogram.

Rationale: The device shall not be cumbersome to the individual. Rather, we are attempting to provide a minimal experience that is discreet.

3.2.2.2 Volume Envelope

The volume envelope of The 12 Man wearable shall be less than or equal to 170 mm in length, 112 mm in width, and 50 mm in height. The wearable device will consist of a 3D printed enclosure housing the microcontroller, power system, and sensors.

Rationale: The system must be able to hold all components while still being discreet for the user.

3.2.2.3 Heartbeat Sensor and Device Placement

The heartbeat sensor is unique in that it is not physically connected to the wearable as the other sensors are, but rather, shall be worn around the chest using a strap. The wearable itself shall be placed on the hip and shall feature a strap with a buckle.

Rationale: Heartbeat measurements are most accurate using a sensor that is placed directly across the chest, such as the one that we will be using. Additionally, we determined the most discreet location for the wearable to be the hip.

3.2.3. Electrical Characteristics

3.2.3.1 Inputs

The inputs that The 12th Wearable is able to handle and gather is the power supplied by the components as well as digital data collected from sensors. The sensors will communicate with the microcontroller to receive data .

Rationale: By design, the wearable device is able to be properly powered and readily available to gather data.

3.2.3.2 Power Consumption

The maximum peak power of the system shall not exceed 15W watts. The components will not need to consume a large amount of power to function which shall allow the battery to maintain sustainable battery life. The microcontroller will be the notable component that would draw the most current thus have the highest power consumption.The battery shall then be recharged when there is insufficient energy for the device to consume.

Rationale: The demanding power consumption will not exceed what is required for each component to function properly to ensure the battery shall be sufficient to power the device after a full recharge.

3.2.3.3 Input Voltage Level

The input voltage level of each component shall be in between 3.6V-5V.

Rationale: The battery will be a 3.7V Lithium Ion battery and shall supply power to sensors while the microcontroller shall be supplied with 5V after stepping up voltage coming from the battery with a boost converter.

3.2.3.4 System Data Output

Data collected by the wearable device by the GPS module, temperature sensor, heart beat sensor, accelerometer, and microphone. Data will be stored in a database for the mobile application to fetch. The database will hold GPS coordinates, and the AI predictions of a meltdown.

Rationale: The 12th Man shall include a mobile application for users to view alerts and location of the individual wearing The 12th Man.

3.2.3.5 System Audio Output

The 12th Man wearable shall play an audio recording from a loved one when a meltdown is predicted.

Rationale: This would help mitigate a meltdown however the speaker may draw more current.

3.2.3.6 Wiring

The power supply components and sensors shall be connected on a printed circuit board or PCB.

Rationale: A printed circuit board will help make the wearable device as compact as possible.

3.2.4. Environmental Requirements

3.2.4.1 Wind

The artificial intelligence system that does acoustic classification of the environment in which the individual is located is highly susceptible to wind. Should the individual be in a windy environment, the acoustic classifier will classify the environment as such, regardless of if there is a large conversation also occurring (i.e. failing to classify a large outdoor gathering, which poses danger of overstimulation, due to large amount of wind noise).

3.2.4.2 Rain

The 12th Man is not waterproof. The user must be cautious in wet environments.

Rationale: Exposure to water may cause short circuiting in the wearable device resulting in damaged components.

3.2.5. Failure Propagation

3.2.5.1 Diagnostics

The 12th Man will show the biometrics collected by the wearable on the mobile app. If biometrics are not visible the user can identify if any sensors are no longer receiving data or if there is a connectivity issue.

3.2.5.2 Database Connection

The user will be able to see if the app is not connected to the database properly.

Rationale: Allows users to see if the app is able to pull data.

3.2.5.3 GPS Connection
The user will be notified if the GPS coordinates are not being sent or received correctly.

Rationale: The location of the wearer must be presented in the app at all times.

3.2.5.4 Input Sensor Signals
A test will be added to make sure that each device that is taking an input, the accelerometer, microphone, GPS, heart rate sensor, is sending data to the database.

Rationale: If any of the input signals are no longer sending data, then the device will not be able to detect meltdowns.

4. Support Requirements

4.1.1 User Interface
Users will need to have an Android smartphone to obtain and run the app. The user should also be able to afford and access a data plan or wifi.

4.2.1 Usage of Wearable Device
The user must be wearing the heart rate sensor on their chest for the system to work reliably.

4.3.1 Maintenance
The user should check reading daily to see if the device is working properly before going into an unsupervised area.

Appendix A

AI	Artificial Intelligence
ASD	Autism Spectrum Disorder

CONOPS	Concept of Operation
GPS	Global Positioning System
I/O	Input/Output
mm	Millimeters
PCB	Printed Circuit Board
SQL	Structured Query Language
V	Volts
W	Watts
4G	Mobile Communication Standard

Mitigating Autistic Meltdowns

Joshua Kao, Jason Kroslowitz, Noah Lockhart, Andres Perez

INTERFACE CONTROL DOCUMENT

REVISION 1
23 February 2022

INTERFACE CONTROL DOCUMENT
FOR

Mitigating Autistic Meltdowns

PREPARED BY:

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Team 12 Date

APPROVED BY:

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Josh Kao Date

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Prof. S. Kalafatis Date

_____
Eric Robles Date

Change Record

Rev.	Date	Originator	Approvals	Description
-1	[2/23/2022]	[Team 12]		Draft Release

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1. Overview

The Interface Control Document or ICD for The 12th Man will go into detail regarding how the subsystems in the Concept of Operations and requests from the Functional System Requirements will be fulfilled. The ICD will provide characteristics of the various stages of our project and how they will interact between each other including communications, component location, and electrical characteristics.

2. References and Definitions

2.1. References

MIL-STD-810F
Environmental Engineering Considerations and Laboratories Tests
1 Jan 2000
Change Notice 2
30 Aug 2002

American National Standard for VME64 (ANSI/VITA 1-1994 (R2002))
4 Apr 1995

American National Standard for VME64 Extensions (ANSI/VITA 1.1-1997)
7 Oct 1998

2.2. Definitions

AI	Artificial Intelligence
ASD	Autism Spectrum Disorder
CONOPS	Concept of Operation
GPS	Global Positioning System
IC	Integrated circuit
I/O	Input/Output
mA	Milliampere
mAH	Microamp hours
mm	Millimeters
mW	Milliwatt
Li	Lithium
PCB	Printed Circuit Board
SQL	Structured Query Language
TBD	To Be Determined
V	Volts
W	Watts
4G	Mobile Communication Standard

3. Physical Interface

3.1 Weight

3.1.1 Weight of the Sensors and microcontroller

The sensors and microcontroller have a combined weight of less than half a kilogram This allows for the wearable device to sit comfortably on the user's waist.

Component	**Weight(grams)**
Raspberry Pi 4 (microcontroller)	46 grams
MPU6050(accelerometer)	6.208546
GPS Module GPS NEO-6M	9.8089
Polar H9 Heartrate Monitor	100
USB 2.0 Mini Microphone	22.9631
DS18B20 Temperature Sensor	22.96

3.1.2 Weight of Power System Components

Component	**Weight(grams)**
Li-ion Battery	158.757
Battery Charger and Power-Path Management IC	0.05
Boost Converter	TBD
AC/DC adapter	TBD

3.2 Dimensions

3.2.1 Dimensions of Sensors and Microcontroller

The biometric sensors will fit on a PCB board inside a 3D printed enclosure. The enclosure will be less than or equal to 170 mm in length, 112 mm in width, and 50 mm in height.

Component	Length(mm)	Width(mm)	Height(mm)
Raspberry Pi 4	88	58	19.5
MPU6050	20.066	16.51	9.906
GPS Module GPS NEO-6M	27.686	100.076 mm	22.606
Polar H9 Heartrate Monitor	34.036	65.024	9.906
USB 2.0 Mini Microphone	22.29	18.45	7.12
DS18B20 Temperature Sensor	60.96	15.24 mm	2.54

3.2.2 Weight of Power System Components

Component	Length(mm)	Width(mm)	Height(mm)
Li-ion Battery	109.982	59.944	9.906
Battery Charger and Power-Path Management IC	3.0	3.0	0.9
Boost Converter	TBD	TBD	TBD
AC/DC adapter	TBD	TBD	TBD

3.3. Mounting Locations

3.3.1. Mounting of Sensors

All sensors will be placed on the PCB board such that there is no interference with their data collection. The microphone and temperature sensors will be partially external to allow for accurate noise and temperature collection without interference. The other sensors are not location dependent.

3.3.2. Mounting of Microcontroller

The microcontroller will be inside a 3D printed enclosure below the PCB board. The wiring from the microcontroller to the sensors will also be tucked inside said enclosure and spaced apart to avoid any potential for short circuits.

3.3.3. Mounting of Heartbeat Sensor

The heartbeat sensor should be around the user's chest to ensure the best heartbeat possible.

3.3.4. Mounting of the device

The 12th man device should be attached to the user's pants or belt around their waist without anything covering the microphone. This to ensure the best audio quality of the surrounding noise is collected.

4. Electrical Interface

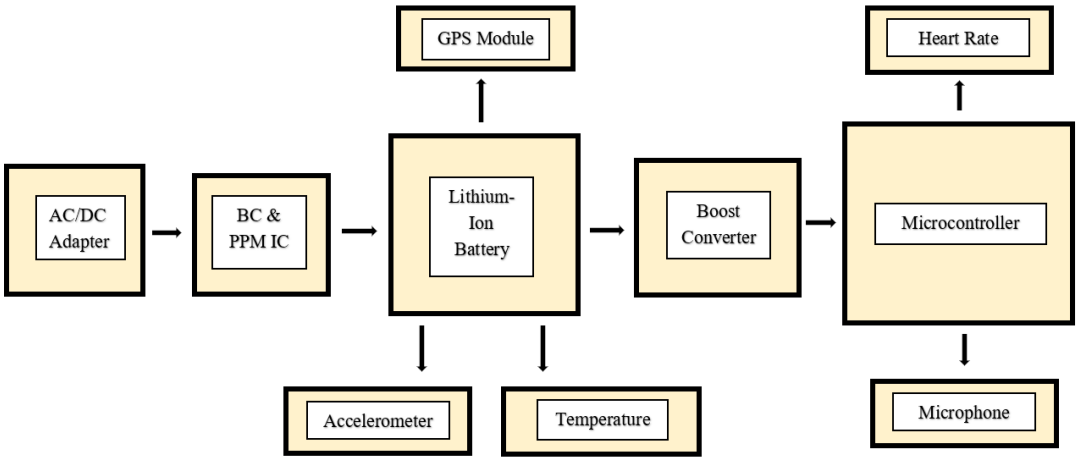


Figure 1. Electrical block diagram

4.1. Primary Input Power

The Lithium Ion battery shall be charged and recharged by an AC/DC adapter in which a battery charger and power path management integrated circuit shall be connected to the 3.7V 10,500 mAh battery. The battery shall supply power to the GPS module, temperature sensor, and accelerometer. The battery shall provide input voltage to a boost converter to boost the voltage output to 5V and supply power to the Raspberry Pi. The microphone shall be powered by the microcontroller via usb. The heart rate sensor is an internally powered sensor.

4.2. Voltage and Current Levels

4.2.1. Voltage, Current, and Power Consumption

Component	Voltage(V)	Current(mA)	Power(mW)
Raspberry Pi 4b	5	3000	15000
GPS Module	3.6-5V	Capture 45mA/5.0V	TBD
Temperature Sensor	3-5.25	TBD	TBD

Accelerometer	3.3V	TBD	TBD
Microphone + Speaker	TBD	TBD	TBD

The current drawn by the GPS module, temperature sensor, accelerometer is assumed to not draw significant current. The Raspberry Pi 4b will draw a significant amount of current. The battery shall have a capacity of 10500mAh to ensure sustainable battery life for the device.

4.3. Signal Interfaces

4.3.1. Input Sensors

The GPS module, ambient temperature sensor, heart rate sensor, accelerometer, and microphone shall communicate with the Raspberry Pi so that data can be collected.

4.3.2. Output Signals

For the purpose of mitigation, The 12th Man device should have an output speaker that can be used to play audio recordings. Said audio recordings are grounding exercises recorded by loved ones. The Raspberry Pi should be able to communicate with the speaker so that it can be utilized as an output device.

4.4. User Control Interface

4.4.1. Database Signals

The mobile application will provide the user with a control interface. This interface will provide the user the ability to tether their mobile application to the 12th Man device their dependent will be wearing. The parent/guardian shall then be able to view the data collected by the device and an indication of the meltdown status of their dependent.

The user will be able to check the status of each input signal. The user will see if all the database is receiving data from the GPS, accelerometer, ambient temperature sensor, heart rate sensor, and microphone.

4.4.2. Physical Device

The individual with Autism who is wearing the device is not provided a control interface whatsoever, and is simply responsible for wearing the device.

5. Communications / Device Interface Protocol

5.1. Wireless Communications (WiFi)

Wifi connection will be achieved using the Raspberry Pi 4 microcontroller. The Raspberry Pi 4 microcontroller utilizes a Wifi package that allows for wireless connectivity. The wifi connection will allow the device to take inputs from the GPS, accelerometer, heart rate sensor, temperature gauge, and microphone and send that information to the database. The database will use this data to identify if a meltdown will occur. If a meltdown is about to happen, a signal will be sent to the device to start the grounding exercises. The database will also send information from the database to the app using a HTTP connection, while the app is connected to the internet.

5.2. Microcontroller Input and Output

The raspberry pi includes an assortment of digital and analog inputs. Analog Input pins take in voltage at 5v and also take in signals from an accelerometer and GPS. The digital input pins receive microphone data via bluetooth and USB ports. All the following pins meet the requirements for the sensors used above.

5.3. Sensor Communication

The sensors will primarily communicate through pins with the Raspberry Pi using an I2C connection. The heartbeat sensor will use the bluetooth module attached to the Raspberry Pi and the microphone will use the USB module included with the Raspberry Pi.

5.4. Device Peripheral Interface

The database will be connected to the mobile app through a HTTP connection. This is a reliable way to send data from a SQL database to an application.

Mitigating Autistic Meltdowns

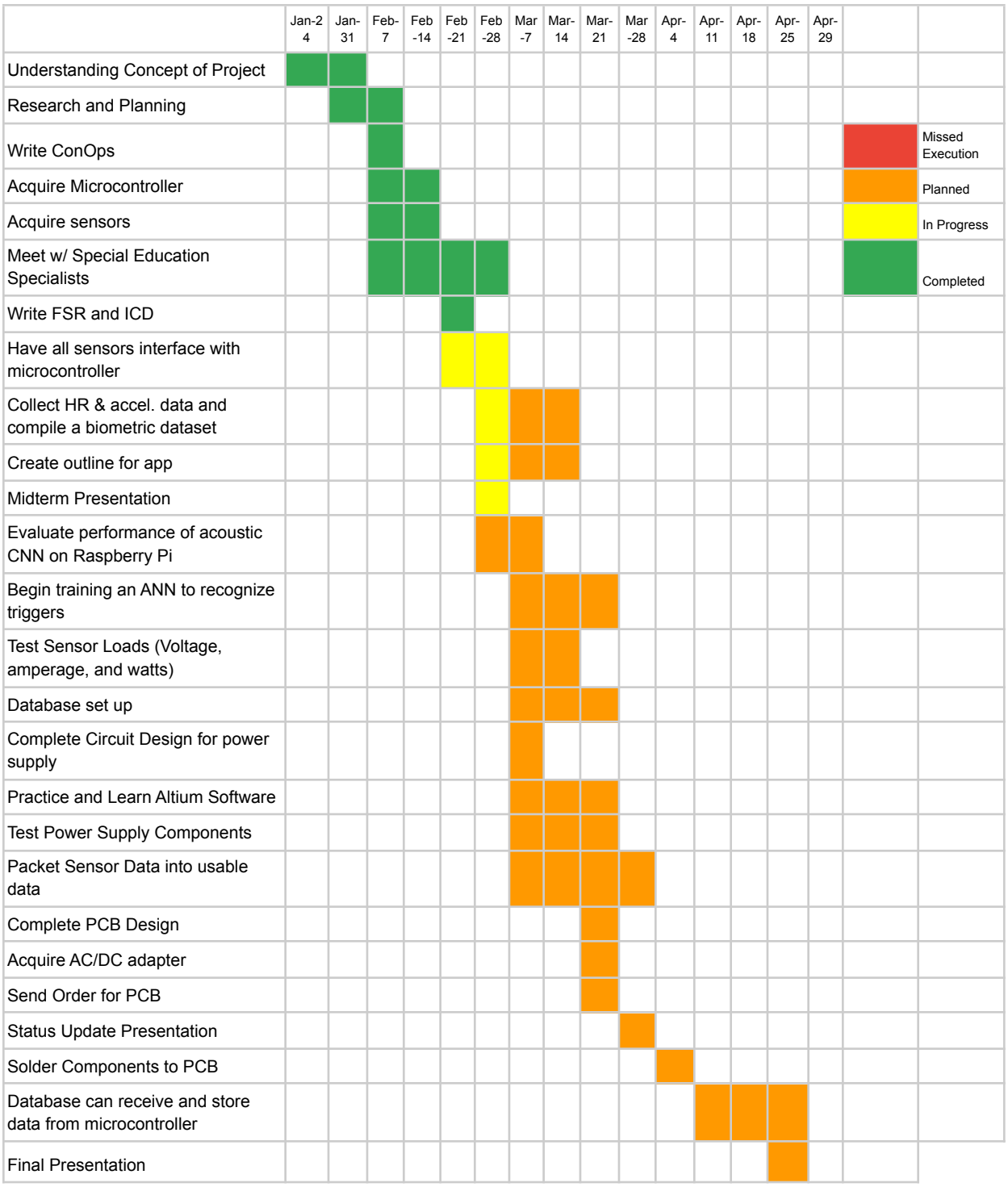
Joshua Kao, Jason Kroslowitz, Noah Lockhart, Andres Perez

Execution and Validation Plan

REVISION – Draft 1

23 February 2022

1. Execution Plan



2. Validation Plan

Task	Status	Responsibility
Interface Sensors with Microcontroller	In Progress	Joshua
Collect HR & accel, data and compile (biometric) trigger dataset (ML)	In Progress	Joshua & Jason
Interview and research data from Special Education Specialists	In Progress	Joshua & Jason
An Outline of mobile application	In Progress	Noah
Verify sensor sizes according to wearable constraints	In Progress	Joshua & Andres
Evaluate acoustic CNN performance on correctly classifying environments	In Progress	Jason
Format/package data into packets (for transmission to database)	Not Completed	Joshua
Send data to database	Not Completed	Joshua & Noah
Preprocess and clean ML dataset; remove outliers and zero values	Not Completed	Jason & Joshua
Setting up Database	Not Completed	Noah
Augment trigger dataset to include acoustic triggers	Not Completed	Jason
Connecting App to Database	Not Completed	Noah
Begin training ANN to recognize meltdown triggers (combination of biometric inputs and acoustic CNN output).	Not Completed	Jason
Displaying App on Phone	Not Completed	Noah
Provide Proper Input Voltage and Current Levels(Sensors)	Not Completed	Andres and Joshua
Provide Proper Input Voltage and Current Level(Microcontroller)	Not Completed	Andres & Joshua

Fine tune prediction models	Not Completed	Jason
Create Functional Rechargeable Battery	Not Completed	Andres
Provide Sustainable Battery Life(5hours)	Not Completed	Andres