CptS 484: Software Requirements

WRS Evolution

Requirements Elicitation

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James Abitria
Osaze Ogieriakhi
Isaiah Doan
Michael Hull
Nicholas Lopez
Evan Glasscock

Contents

Revision History

Date	Version	Changes	Editor
10/4/2025	1.0	Initial Draft	Michael Hull, Osaze Ogieriakhi
10/5/2025	1.1	modifications	Michael Hull, Osaze Ogieriakhi
10/12/2025	1.2	Added analysis of issues with preliminary definitions, functional/non-functional requirements, prototype interface mock-ups, user manual	James Abitria, Michael Hull
12/7/2025	1.3	Added KAOS models for Goals and Responsibilities	Michael Hull
12/7/2025	1.4	Final edits to WRS document	James Abitria, Michael Hull

[1] Introduction

1.1. Purpose

The objective of our project is to develop a mobile app that assists in navigation of indoor spaces for individuals who are blind or visually impaired. The mobile app we are creating, which has been named Theia, will provide audible instructions along with vibrations on the phone to guide users through floors, stairs, and other obstacles that the phone can detect dynamically during navigation.

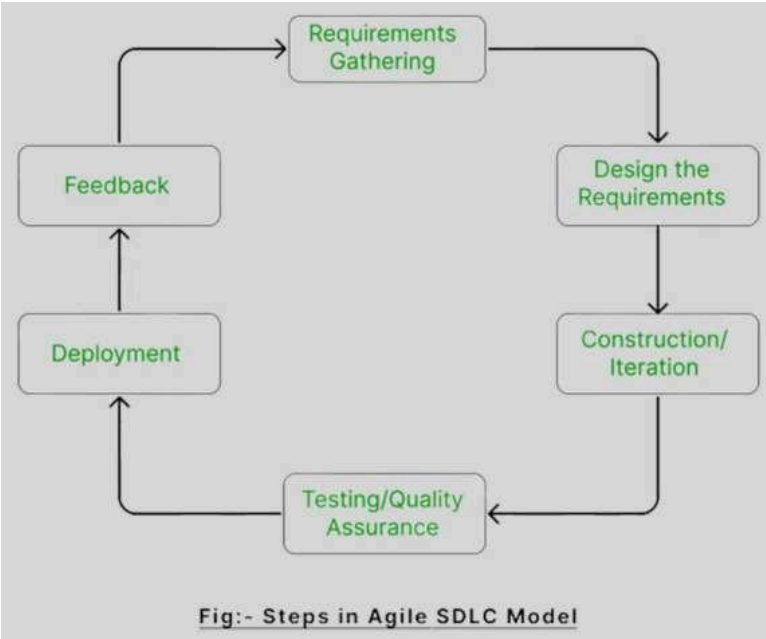


Figure 1: The Agile development process. This system is a repeating framework that is used during the development. Since it's a repeating framework it can be used as many times as needed for each section during the development.

During the development of Theia the developers met and decided what was the best language and system to create Theia on. Decisions like how a GPS will be tracked and how the phone would navigate the environment were the main points focused on. Along with that a discussion based on posters in the environment to help Augmented Reality was discussed, as damage or removal of the posters could lead to the program breaking. For a demonstration of Theia the developers met and decided to use winforms to create a facsimile version. This was used to demonstrate the user interface and how a user would navigate the application.

1.2. Scope

The scope of Theia revolves around navigation through a physical space. This leads to information about the environment being captured by a camera and then translated or interpreted by the application to provide instructions to the visually impaired user. These instructions should be audible and said through the speaker of the phone. The data interpreted from the camera then can be used to find pathways and

objects allowing Theia to keep the visually impaired user safe. The pathway then must be referenced to a map provided by a non visually impaired user of the building showing the application where they are allowed to navigate. This would be done by having the user walk through the building with the camera up to allow Theia to create an initial map. This map that Theia creates can then be used to guide the visually impaired user through a set pathway, avoiding objects and walls, by listening to audible instructions and warning vibrations from the phone.

1.3. Objectives and Success Criteria

During this projects development our Success Criteria must meet the following:

- Store map data of individual buildings
- Speak voice commands to guide in navigation
- Vibrate the phone when too close to a wall or object
- Have the upper section of the phone, when tapped, calibrate the location of the individual
- Have the lower section of the phone, when tapped, call for help from a number provided.
- Dynamically find objects in the environment
- Automatically make phone calls
- Not be overly reliant on environmental variables
- Be simple to use and navigate the app for anyone assisting the impaired individual

1.4. Definitions, Acronyms, and Abbreviations

Term, Acronym, or Abbreviation	**Definition**
Dynamically locate object	Find objects in the environment and import them into AR in real time
AI	Artificial Intelligence - this covers a large class of computer machine learning models which can classify inputs or generate outputs based on those inputs
AR	Augmented Reality – a system where the devices surroundings as visible through the camera are placed into a virtual 3D coordinate space for positioning and object detection
Theia	The name of the project that this document analyzes. This is a mobile app designed to aid blind/visually impaired individuals navigate indoors in various buildings, with features similar to Google Maps to get them to rooms, verbal commands that are easy to follow, and emergency services.
Requirement	A criterion that the software must meet in order to fit the needs of stakeholders.

Functional Requirement	A requirement focused on how the system should be structured, an English description of a feature.
Non-Functional Requirement	A requirement focused on performance metrics of the system, aspects of a system that describe the quality to which a system should do its job, not a feature.
Domain	The world in which the system is being implemented, involving the general circumstances that influence how the system should be built.
Stakeholder	Any individual or group with a vested interest in the success of the system. Stakeholders can be involved with the system at any level, either directly as consumers, or indirectly as sponsors providing money for the project.

1.5. Overview

This document performs in-depth analyses of the requirements necessary to build Theia. The document records the evolution from the preliminary ideas for the project, performs analysis on any issues or ambiguity that arise from the initial definitions, and shows how the requirements evolve into specific, descriptive specifications.

Section 2 contains the initial definitions of what the domain of the app is that will be analyzed, as well as the initial definitions of the functional and non-functional requirements. Section 3 breaks down the problems with the initial definitions, proposes several options to resolve each issue, and provides rationale for the selected solution. Section 3 also provides traceability for which requirements resolve each issue. Section 4 contains the revised and improved definitions for the domain, refocused functional/non-functional objectives and requirements, and concludes with the specifications by which the software can be developed from.

The document then continues in Section 5, discussing the prototyped design of Theia through diagrams and descriptions. Because the primary focus is on the evolution of the requirements, the prototype is not currently functional. It is solely the diagrams as described previously. This constraint also applies to the named prototype features mentioned in the Functional and Non-Functional Requirements in Section 4. The document then concludes with a preliminary user manual, describing how to operate Theia in Section 6.

[2] Preliminary Definition

2.1. Preliminary Domain

PD_ID	Preliminary Domain Description
PD_1	Blind individuals can receive instructions in other ways.
PD_2	Caretakers may need to access the app as well.
PD_3	The kinds of environments a user is in can vary.
PD_4	Patient data is protected under HIPAA, and cannot be shared.

2.2.Preliminary Functional Requirements

P FR_ ID	Preliminary FR Description
P FR_1	Speak instructions through a speaker
P FR_2	Create instructions based on visual images
P FR_3	Compare visual images to map data and place correctly
P FR_4	Use camera to get visual data
P FR_5	Convert visual data to AR
P FR_6	Protect user's data from being easily accessed

2.3.Preliminary Non-Functional Requirements

PNFR_ ID	Preliminary NFR Description
P N-FR_1	Audio can be easily understood regardless of language
P N-FR_2	Information regarding map data and users remains confidential to Theia only
P N-FR_3	Text to voice reliable regardless of input
P N-FR_4	All objects detected from camera properly labeled and told through speaker
P N-FR_5	AI text reader not using foul or unneeded language

P N-FR_6	Posters in environment for AR

[3] Issues with the Preliminary Definition Given

3.1. Domain Issues

Domain Issue ID	Domain Issue Description	
DI1	**PD_ID**	PD1. Blind individuals can receive instructions in other ways.
	Ambiguous: How should users of the app receive instructions?	
	Option 1	Utilize haptics, where different vibration frequencies represent different actions, like Morse code.
	Option 2	Use a combination of haptics and vocal instructions, to notify the user of an instruction, and explain the instruction to the user.
	Option 3	Rely on vocal instructions to guide the user.
	Choice	Option 2
	Rationale	Both methods are viable to communicate to blind individuals, but a combination of both will maximize the clarity of an instruction for the user.
Satisfied by	NFR1	

Domain Issue ID	Domain Issue Description	
DI2	**PD_ID**	PD2. Caretakers may need to access the app as well.
	What operations should caretakers be able to perform on the app?	
	Option 1	Caretakers should be able to add themselves as an emergency contact, but nothing else.
	Option 2	Caretakers should be able to set up the app based on the needs of their patient, including volume, vibration intensity, and emergency contacts.
	Choice	Option 2
	Rationale	For caretakers, it will be easier for them to set up the app based on the preferences of their patient simply because they can see and navigate through the phone

		screen. Therefore, the caretaker and patient can then communicate, and the patient can still make the decisions while the more able individual operates the app.
Satisfied by	FR5	

Domain Issue ID	**Domain Issue Description**	
DI3	**PD_ID**	PD3. The kinds of environments a user is in can vary.
	Ambiguous: What kinds of variations should the system account for, and how should they be accounted for?	
	Option 1	The environment should be detected dynamically, including where the walls of the building are, and the obstacles.
	Option 2	The system should have some baseline information regarding the kind of building the user is inside of. However, obstacles can be detected dynamically.
	Choice	Option 2
	Rationale	Relying solely on the detection systems is expensive, and the system is prone to making more mistakes as more variables need to be accounted for. However, it cannot be assumed that the environment is static between any given day, so some detection software is needed.
Satisfied by	FR2	

Domain Issue ID	**Domain Issue Description**	
DI4	**PD_ID**	PD4. Patient data is protected under HIPAA, and cannot be shared.
	Too general. In what scenarios does HIPAA protect user data, and in what cases is it okay to share data?	

	Option 1	Constantly store patient data in spite of HIPAA, simply have a disclaimer that patients must consent to in order to utilize the app and avoid legal trouble.
	Option 2	The system will comply with HIPAA by only sharing data with individuals or groups that have a need to access that information.
	Choice	Option 2
	Rationale	HIPAA's regulations state that patient data is private, unless there is a medical reason to access the data. The key user groups for this project are the blind individuals themselves, caretakers, and emergency operators. Caretakers need the medical information to care for the individuals, and emergency operators need the information to send help and inform the first responders of the situation.
Satisfied by	NFR2	

3.2. Functional Requirements Issues

FR Issue ID	**Description**	
FRI1	**P FR_ID**	P FR_1. Speak instructions through a speaker.
	How should the instructions that the user must take during navigation be formatted?	
	Option 1	Instructions consist of many short, concise instructions, each roughly 3-5 seconds long.

	Option 2	Instructions are descriptive and longer, possibly over 10 seconds.
	Choice	Choice 1

	Rationale	The longer an instruction gets, the more room for interpretation is possible, especially as the user will lack visual cues to build off instruction information. It is best to maximize understanding by making instruction presets short, allowing the user to follow the instructions as literally as possible.
Satisfied by	FR1	

FR Issue ID	**Description**	
FRI2	**P FR_ID**	P FR_2. Create instructions based on visual images
	Ambiguous: What visuals should factor into the program's instruction creation?	
	Option 1	Create an AI model that takes large sums of information from an image, and then determines which objects are important for instruction generation.
	Option 2	Create an AI model that is good at recognizing key components of an image (i.e. walls, floor, rooms, objects) and base its instructions off of the detected objects.
	Choice	Option 2
	Rationale	The navigation system should be fast and efficient, and an AI model that processes vast sums of information would be inefficient. As mentioned in option 2, there are only a few major objects in an environment that are relevant for navigation, so the program should focus on those objects.
Satisfied by	FR2	

FR Issue ID	Description	
FRI3	**P FR_ID**	P FR_3. Compare visual images to map data and place correctly
	Ambiguous: How would the program know where the user currently is on the map?	
	Option 1	The current location of the user is gathered using the phone's internal data, which is then used to locate the user's position on the stored map.
	Option 2	Based on the visuals of the camera, the program will search the map and find a matching configuration of the surroundings.
	Choice	Option 1
	Rationale	It is expensive to search through an entire map, and it could entail issues of accidentally choosing the wrong area of the map, if there are several locations in a building that look similar. The current location is already easily accessible by the app, and it would make locating the user trivial.
Satisfied by	FR3	

FR Issue ID	Description	
FRI4	**P FR_ID**	P FR_4. Use camera to get visual data
	Ambiguous: Which camera(s) should be used to gather data for the program?	
	Option 1	Use both the front and back facing cameras, to gather full information about the surroundings.
	Option 2	Use only the back facing camera, to gather information on what is ahead of the user.
	Option 3	Switch usage of the front, back, or both camera views as necessary.
	Choice	Option 3

	Rationale	Because the person is visually impaired, the app should not have to assume the orientation the phone is in. The program should be able to tell how the user is holding the phone and use whichever camera is opposite the user's body to scan ahead. If truly necessary, it could also use both perspectives to gather all data around the user.
Satisfied by	FR4	

FR Issue ID	**Description**	
FRI5	**P FR_ID**	P FR_5. Convert visual data to AR
	Is it necessary for AR elements to constantly be onscreen?	
	Option 1	Leave AR elements constantly active onscreen, even if the user cannot see them.
	Option 2	Keep AR elements off by default, and have it as a setting that can be changed by a caretaker.
	Choice	Option 1
	Rationale	For people around the user, it can be useful to see what the app is picking up, especially if there is something that the app misses, but people are able to see, and can assist the user to avoid any objects that were missed by the application.
Satisfied by	FR5	

3.3. Non-Functional Requirements(NFR) Issues

NFR Issues ID	**Description**	
NFRI1	**P N-FR_ID**	P N-FR_1. Audio can be easily understood regardless of language
	What if the user does not speak any of the currently preset languages?	

	Option 1	Have an AI tool that can translate program instructions into the user's language.
	Option 2	Have a system that caretakers can put in requests for expanded language support.
	Choice	Option 2
	Rationale	While AI is rapidly improving at its ability to communicate fluently with humans, translation must be verified to be correct, beyond just textbook definition, literal translations. It should be the task of the developers to properly implement language support by working with native speakers.
Satisfied by	NFR1	

NFR Issues ID	**Description**	
NFRI2	**P N-FR_ID**	P N-FR_2. Information regarding map data and users remains confidential to Theia only
	What if an emergency occurs and first responders need to locate the user?	
	Option 1	Rely solely on haptics, audio, and visual hardware on the device to aid emergency service employees in finding the user.
	Option 2	Share information about the user's location and personal data to emergency services in the event of an emergency.
	Choice	Option 2

	Rationale	In emergency situations, it makes sense to give as much information as possible to aid first responders, paramedics, firefighters, and police officers as much as possible to locate the user. Thus, privacy should be compromised for the good of the user.

Satisfied by	NFR2

NFR Issues ID	**Description**	
NFRI3	**P N-FR_ID**	P N-FR_3. Text to voice reliable regardless of input
	Ambiguous: What counts as a reliable text-to-voice system?	
	Option 1	The system should give an audible notice if the input appears to be invalid, and communicate to the user that they should remain in place until the system is ready.
	Option 2	The system should give some default directions based on its last input to place the user off to the side, close to a wall, until it receives valid input again.
	Choice	Option 2
	Rationale	While it could be good to leave the user in place, depending on where they are, they may be in the way of other people or objects in the hallway, that the app can no longer track in that moment while it's not receiving proper input. It would be best to ensure the user is at least safe and off to the side while the system recalibrates.
Satisfied by	NFR3	

NFR Issues ID	Description	
NFRI4	**P N-FR_ID**	P N-FR_4. All objects detected from camera properly labeled and told through speaker
	What if there are many objects in the environment?	
	Option 1	All objects are detected and labelled, but they are not described to the user unless relevant (i.e. the user is about to run into one)
	Option 2	Objects that are within a specific distance of the camera are announced to the user.
	Choice	Option 1
	Rationale	It is good that the system tracks all objects that the camera perceives, however, including announcements of all objects around, plus feeding instructions to the user would be overwhelming. The best solution is to store information about objects in case they cross the user's path in the future, but not announce them.
Satisfied by	NFR4	

NFR Issues ID	Description	
NFRI5	**P N-FR_ID**	P N-FR_5. AI text reader not using foul or unneeded language
	Is the AI going to be forming the instruction descriptions itself?	
	Option 1	Use a text-to-speech reader that reads preset instructions passed to it by the navigation systems.
	Option 2	The text-to-speech reader creates instructions based on the outputs of the navigation systems, rather than using a preset.

	Choice	Option 1
	Rationale	Preset instructions give developers the most control over what is said to the user, preventing foul or unneeded language. The system would also be simpler to implement, as the AI could possibly hallucinate, and give an incorrect instruction on the given outputs.
Satisfied by	NFR5	

NFR Issues ID	**Description**	
NFRI6	**P N-FR_ID**	P N-FR_6. Posters in environment for AR
	Ambiguous: What are the posters and where would posters be present in the building?	
	Option 1	The posters are stickers that are placed on the walls and doors of a building, and each sticker contains a QR code, with the logo of the Theia app on the sticker.
	Option 2	The posters are stickers that are designed with a symbol that the Theia app can recognize, specially designed so that the application can discern specifically that there is a wall/door in that area, based on what symbol is on the poster.
	Choice	Option 2
	Rationale	The Theia app should have its own custom markers for the AR technology, so that it can navigate the user as best as possible. Having specially designed posters can then be hard-coded into the design, of how the app should orient its navigation based on where it detects the posters.
Satisfied by	NFR6	

[4] WRS

4.1.W

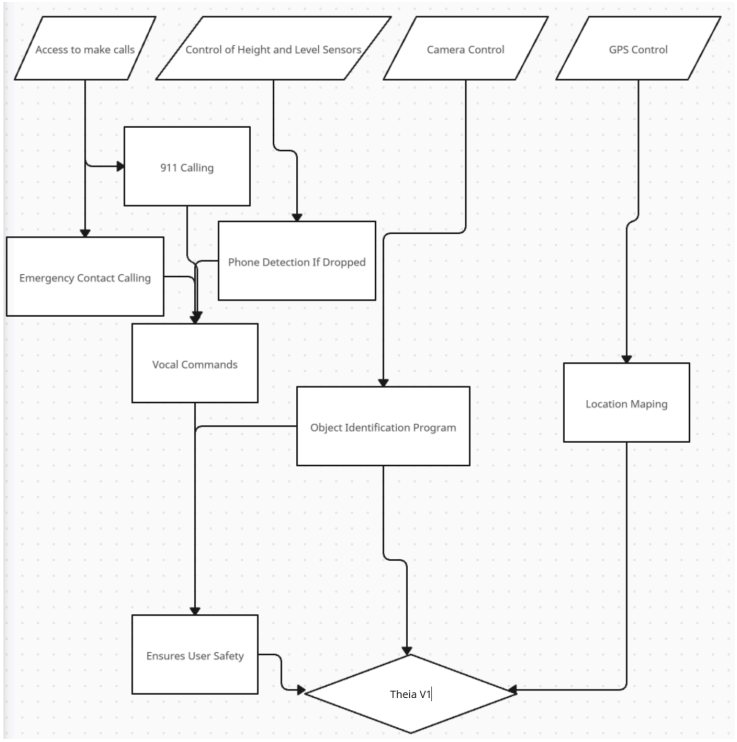
4.1.1. Problem

Problem ID	Problem Description	Corresponding Goals
P1	Blind and visually impaired individuals cannot independently navigate unfamiliar indoor environments safely and efficiently.	G1
P2	Environmental changes (construction, removed AR markers, rearranged furniture) cause outdated maps and inaccurate routes.	G3, G4
P3	Users have difficulty interpreting visual feedback or complicated interfaces.	G2, G5
P4	In emergency or lost situations, users may be unable to reach help quickly.	G6

4.1.2. Goals

Goal ID	Goal Description	Backward Traceability	Forward Traceability
G1	Safely guide users through indoor spaces using precise navigation cues.	P1	IFRO1, INFRO6
G2	Provide clear audio and vibration feedback suitable for users with visual impairments.	P1, P3	IFRO1, IFRO5, INFRO1, INFRO5
G3	Keep building maps and object data current despite environmental changes.	P2	IFRO2, IFRO3, IFRO4

G4	Dynamically adjust routing when obstacles or detours occur.	P2	IFRO2, IFRO4, INFRO3, INFRO6
G5	Ensure intuitive, low-effort interaction for users, caregivers, and emergency services.	P3	IFRO1, IFRO5, INFRO3, INFRO4
G6	Make it very quick and simple for a user to call emergency services.	P4	IFRO3, IFRO4, INFRO2



Above is a KAOS goal model that shows the 4 main aspects of the phone that we need to have access to. For the first aspect, Access to make calls, it branches into the visually impaired user being able to call 911 or call a preset emergency contact. The second aspect, control of height and level sensor which are built into most modern phones. This allows us to detect if a phone is dropped or still indicating the user may be in trouble. We can then pair this with information from the user's microphone allowing them to make phone calls or access aspects of Theia to ensure the user's safety. For the third aspect, Theia needs control of the camera. This is for Theia to look through the camera and use a program to automatically mark objects and provide a pathway for a user. Finally the last aspect would be access to the GPS functionality of the phone which would be required to help the initial mapping of a building and navigation later on.

4.1.3. Improved Understanding of Domain, Stakeholders, Functional, and Non-Functional Objectives

4.1.3.1. Improved Domain

Improved Domain ID	Improved Domain Description
ID1	Blind and visually impaired individuals require non-visual feedback such as speech and vibration to interpret navigation cues.
ID2	Caretakers will be able to assist users with the app and have the ability to configure the app with GUI elements.
ID3	Indoor environments differ by building type and accessibility features; system must adapt to variations.

4.1.3.2. Stakeholders

- Team Members:
  James Abitria, Osaze Ogieriakhi, Isaiah Doan, Michael Hull, Nicholas Lopez, Evan Glasscock
- Project Mentor:
  Bolong Zeng
- Users of Theia:
  Blind/visually impaired individuals: primary users that will need the assistance of the app's

navigational capabilities, relying on vocal instructions and haptics.

Caretakers: secondary users that will help set up the app based on the preferences of the blind/visually impaired individual that will be using the app. Caretakers will navigate the GUI to set emergency contacts, instruction volume, and possibly common destinations.

Emergency services: secondary users that will receive information regarding the blind/visually impaired individual's location and personal data as needed, in the event of an emergency.

4.1.3.3. Improved Functional Objectives

Improved FR Objective ID	Objective Description	Alleviates Problems	Achieves Goals
IFRO1	The audible instructions given to the user will be short and easy to understand.	P1,P3	G1, G2, G5
IFRO2	The instructions will be generated quickly, based on the most relevant information detected.	P1,P2	G3, G4
IFRO3	It should be easy to determine where the user is in the building.	P1,P4	G3, G6
IFRO4	The app should be able to gather information about all of the user's surroundings.	P1,P2	G3, G4, G6
IFRO5	The app should be easy to navigate for both users and caretakers.	P3	G2, G5

4.1.3.4. Improved Non-Functional Objectives

Improved NFR Objective ID	Objective Description	Alleviates Problem	Achieves Goal
INFRO1	The app should be functional for users even if they speak a different language.	P1	G2
INFRO2	Data should be secured, but accessible for caretakers/emergency services.	P4	G6
INFRO3	The user should be kept out of harm's way.	P1,P2	G4, G5

INFRO4	Users should not be overwhelmed by the amount of information given.	P3	G5
INFRO5	The app should give consistent wording for its instructions.	P3	G2
INFRO6	There should be additional markers that assist the app with its functionality.	P1	G1, G4

4.2. RS

4.2.1. Functional Requirements

FR ID	**Description**
FR1	Each instruction must be 3-5 seconds long, with a simple action that the user must take.
Satisfies Functional Requirement Issue	FRI1
Satisfies Objectives	IFRO1
Satisfied by prototype feature	Information parsing module

FR ID	**Description**
FR2	Relays important information first regarding obstacles or problems that the camera detects in the environment.
Satisfies Functional Requirement Issue	FRI2
Satisfies Objectives	IFRO2
Satisfied by prototype feature	AR-based path mapping module

FR ID	Description
FR3	Information is taken from the camera that measures distance to walls, looks for AR posters, and applies it to an internal map provided by the user.
Satisfies Functional Requirement Issue	FRI3
Satisfies Objectives	IFRO3
Satisfied by prototype feature	Information parsing module

FR ID	Description
FR4	The camera scans the environment looking for walls and objects along with anything that moves to provide proper and in-time instructions for the users.
Satisfies Functional Requirement Issue	FRI4
Satisfies Objectives	IFRO4
Satisfied by prototype feature	AR-based path mapping module

FR ID	Description
FR5	The GUI should be minimalistic and straightforward for caretakers to easily set up settings for blind/visually impaired individuals, and the users should be able to navigate independently with the app.
Satisfies Functional Requirement Issue	FRI5
Satisfies Objectives	IFRO5
Satisfied by prototype feature	GUI module

4.2.2. Non-Functional Requirements

NFR ID	Nonfunctional Requirement
NFR1	Speech output must be clear and natural at various volumes/languages, and accentuated by haptic vibrations.
Operationalized Functional Requirements	FR2
Satisfies Nonfunctional Requirement Issue	NFRI1
Satisfies Non-functional Objective	INFRO1
Constrains	P1
Satisfied by prototype feature	Information parsing module

NFR ID	Nonfunctional Requirement
NFR2	The privacy of user location and data is secured, but if emergency services are triggered, that data is sent to caregivers/emergency service employees.
Operationalized Functional Requirements	FR1, FR3, FR4
Satisfies Nonfunctional Requirement Issue	NFRI2
Satisfies Non-functional Objective	INFRO2
Constrains	P4
Satisfied by prototype feature	User information storage module

NFR ID	Nonfunctional Requirement
NFR3	If input is invalid, the user should be instructed to step to the side, and stand near a wall in the environment to wait for further instruction.
Operationalized Functional Requirements	FR4

Satisfies Nonfunctional Requirement Issue	NFRI3
Satisfies Non-functional Objective	INFRO3
Constrains	P1, P2
Satisfied by prototype feature	Information parsing module

NFR ID	**Nonfunctional Requirement**
NFR4	Users are only notified about objects that are close enough to collide with them.
Operationalized Functional Requirements	FR2
Satisfies Nonfunctional Requirement Issue	NFRI4
Satisfies Non-functional Objective	INFRO4
Constrains	P3
Satisfied by prototype feature	AR-based path mapping module

NFR ID	**Nonfunctional Requirement**
NFR5	The instructions given by the app should use the same wording for the same action it is guiding the user to take.
Operationalized Functional Requirements	FR2
Satisfies Nonfunctional Requirement Issue	NFRI5
Satisfies Non-functional Objective	INFRO5
Constrains	P3
Satisfied by prototype feature	Information parsing module

NFR ID	Nonfunctional Requirement

NFR6	Stickers containing specially designed symbols to denote doors and walls should be placed through buildings that support Theia.
Operationalized Functional Requirements	FR3
Satisfies Nonfunctional Requirement Issue	NFRI6
Satisfies Non-functional Objective	INFRO6
Constrains	P4
Satisfied by prototype feature	AR-based path mapping module

4.2.3. Specifications

Functional Specification ID	Functional Requirement
FS1	Upon receiving a destination, Theia will determine how to reach the destination from where the user currently is, generate instructions, and relay each instruction as a brief command, step-by-step to the user. Each instruction will be accompanied by a vibration to signal the start of a new instruction.
Satisfies Functional Requirement	FR1, FR2, FR3
Satisfies Objectives	IFRO1, IFRO2, IFRO4, INFRO5
Satisfied by prototype feature	Information parsing module

Functional Specification ID	Functional Requirement
FS2	When an obstacle is in the user's path, and the user is about to collide with it, the AR technology will show this object on the screen, highlighted red. The phone will vibrate, with a voice command telling the user to stop moving, and instead will navigate the user around the object.

Satisfies Functional Requirement	FR2, FR4
Satisfies Objectives	IFRO2, IFRO4

Satisfied by prototype feature	AR-based path mapping module

Functional Specification ID	**Functional Requirement**
FS3	While the camera is active, Theia will search for stickers on walls/doors with a symbol to gather information about the user's surroundings, marking obstacles and updating its internal map.
Satisfies Functional Requirement	FR3
Satisfies Objectives	IFRO3, IFRO4, INFRO6
Satisfied by prototype feature	AR-based path mapping module

Functional Specification ID	**Functional Requirement**
FS4	Caretakers should be able to tap the Settings button on the home screen to enter preferences that change the instruction volume, language spoken, the common destinations for the user, and their contact information for emergencies.
Satisfies Functional Requirement	FR5
Satisfies Objectives	IFRO5, INFRO1, INFRO2
Satisfied by prototype feature	GUI module

Functional Specification ID	**Functional Requirement**

FS5	If the user feels uncomfortable or lost, they can double tap the screen. Theia will then notify the user verbally that emergency contacts are being notified. It will continue giving verbal assurance until a contact is reached.
Satisfies Functional Requirement	FR5
Satisfies Objectives	INFRO2, INFRO3, INFRO5

Satisfied by prototype feature	GUI module

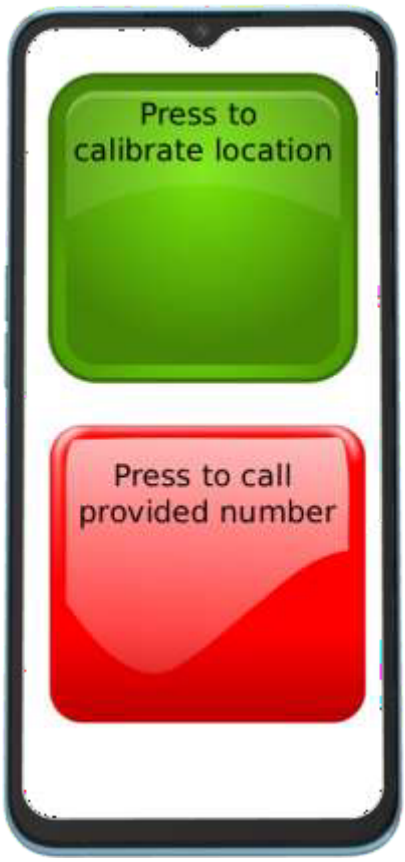
Functional Specification ID	**Functional Requirement**
FS6	During navigation, Theia will give verbal notifications to the user if there is an object that is 5 feet or closer to them, and is actively moving closer.
Satisfies Functional Requirement	FR2
Satisfies Objectives	INFRO3, INFRO4
Satisfied by prototype feature	AR-based path mapping module

[5] Preliminary Prototype & Prototype Interface Mock-ups

The basic homepage GUI will have a layout like the depiction above. With 4 options, the caretaker can choose from the first allows them to create a new map by holding the camera up and providing the initial map data for the program. The second option allows them to alter the map data setting zones that the visually impaired user should avoid. Along with that a preferred path through the building can be set and customized by the user.

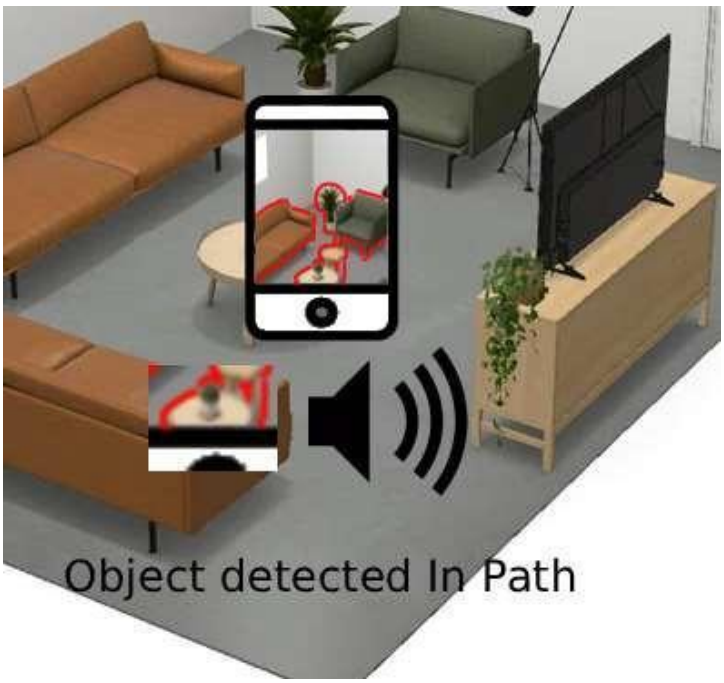
When running the application, the caretaker will choose a map and an endpoint on the map. This will provide instructions to the visually impaired user walking them to the end goal and then when prompted will provide reverse instructions back to the starting point.

The Settings button is also for the caretakers to perform initial setup of the application. When they press the Settings button, they will be navigated to an alternative screen that allows them to enter the blind/impaired individuals information, including their name, age, and physical appearance. The Settings page is also where the preferences for volume, spoken language, and emergency contacts can be found and entered.



For the visually impaired user, only two buttons are provided covering a large portion of the screen for easy access to press. The bottom button covers the lower portion of the phone and when double tapped, calls a number provided in the settings automatically to call for help. In situations where they don't answer, 911 should be called. The top button should recalibrate and provide instructions again when pressed in case the visually impaired user finds themself lost or didn't hear the instructions.

In this depiction, the phone will use the camera to find and outline objects building appropriate dimensions based on information it already has. It will measure distances from the wall to the phone to help properly set all dimensions of the environment. Finally, the phone looks for specific AR posters on the wall that can help this process further.



When an object is detected, the phone will use a text to speech module to warn the visually impaired user that something may be in their way and to move around it with caution.

[6] User Manual

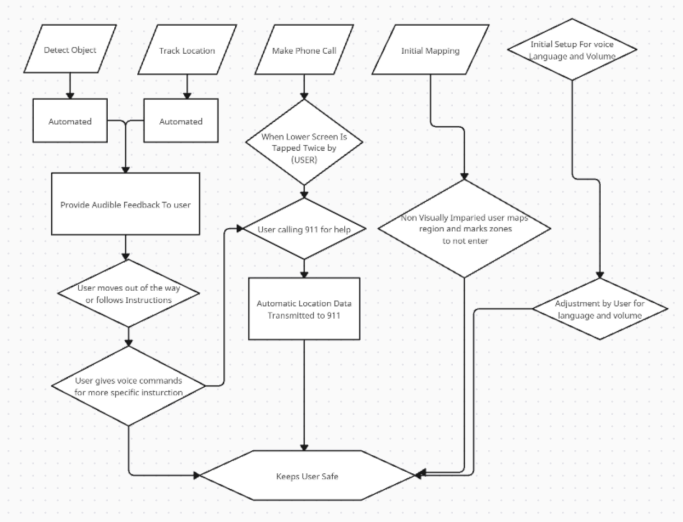
When using Theia, caretakers will have the ability to create a new map, alter an existing map, select a map to be used, and settings of the app. When creating a map, the caretaker will walk around in the environment for the application to build the initial data taking note of objects and distances and recording the data into AR. When altering map data the caretaker can set “no-go” zones along with a preferred path through the environment. They can also use the settings for multiple features, including if they should be called automatically if tracking is lost and if police can be called by holding down a button for 10 seconds. The caretaker can also create presets that match the blind/visually impaired individual’s preferences. These preferences include the following:

- The language that verbal commands are spoken.
- The volume of verbal commands.
- The intensity of phone vibrations.
- Emergency contact information.
- Common destinations in buildings.

Once presets have been created by the caretaker, the visually impaired user can receive the phone and will begin navigating through the environment with audible instructions from the phone. These instructions can be warnings, directions, or other notifications that will be a concise guide to what to do. For the best results, the user should hold the phone at roughly chest-shoulder level to give Theia the best capability of viewing the environment. Theia will automatically determine the user’s position in the room, and will give verbal indications of incoming obstacles, guiding the user around them accordingly. Once the end goal is reached, by pressing the top half of the phone again, the app will guide the user back to the starting point.

The user has the ability to contact their emergency contacts at any point of navigation, as well as 911 if their contacts are unavailable, by double-tapping the bottom half of the screen, where the large red button is located. If the user accidentally contacts emergency services however, they can simply double tap the bottom half of the screen again to cancel the request. The user should stand still while emergency services are being contacted. Theia will assure the user that help is being contacted, and the app serves as a communication line between the user and emergency contacts. In emergency operations, the location and information about the user, including name, age, and appearance will be shared with emergency contacts, to expedite the process of locating them and ensuring they are safe.

[7] System Requirements



Above is the responsibility KAOS which shows the division of responsibilities for the user to handle and what Theia handles automatically. While Theia is running it should automatically detect objects in the way of the visually impaired user and track their location. When an object or person is detected by Theia it should automatically output audible instructions that the user can use to navigate through their pathway around the object. It falls under the user's responsibility to trust and follow the instructions to keep the final goal of keeping the user safe. When Theia is making phone calls it will either wait for the user to tap the lower screen twice and then call their emergency contact first. If the phone detects it's been dropped or the user calls out for help, the phone will instead dial 911 and automatically transmit the location data to the police to make sure help arrives as soon as possible. It is up to a non-visually impaired user to set up the initial mappings of an area, setting the language, and volume. These can be changed at any time for convenience and when installing Theia the user will be prompted to fill these out before continuing.

[8] References

K. Wiegers and J. Beatty, *Software Requirements*, 3rd edition, Microsoft Press, 2013.

P. Loucopolous and V. Karakostas, *System Requirements Engineering*, London, England: McGraw Hill Publishing, 1995.