

# **Vision and Scope Document for the Visual Guidance System THEIA**

**Final Technical Report**

**Fredy Corona, Levi Chapman, Jose Hurtado, Panashe Dione**

**Revision History**

<b>Date</b>	<b>Version</b>	<b>Description</b>	<b>Author</b>
11/11/25	1.0	Initial creation of the Vison Document	Jose H.
12/6/25	1.1	Formatting & Section Work.	Fredy C.
12/7/25	1.2	Final Section Work.	Fredy C.

1. Introduction.....	5
1.1 Purpose.....	5
1.2 Scope.....	5
1.3 Definitions, Acronyms, and Abbreviations .....	6
1.4 References.....	7
1.5 Overview.....	7
2. Positioning .....	9
2.1 Business Opportunity.....	9
2.2 Problem Statement.....	9
2.3 Product Position Statement.....	9
3. Stakeholder and User Descriptions .....	10
3.1 Market Demographics.....	10
3.2 Stakeholder Summary .....	10
3.3 User Summary .....	10
3.4 User Environment .....	11
3.5 Stakeholder Profiles .....	11
3.5.1 Accessibility Staff.....	11
3.5.2 Development Team.....	12
3.6 User Profiles.....	12
3.6.1 Primary User .....	12
3.6.2 Caregiver/Family Assistant .....	12
3.7 Key Stakeholder or User Needs .....	13
3.8 Alternatives and Competition .....	14
3.8.1 Microsoft Soundscape.....	14
□ Description: Outdoor navigation app using 3D audio cues. ....	14
□ Strengths: Rich audio spatialization; strong accessibility brand.....	14
□ Weaknesses: Discontinued (2023); limited indoor capability .....	14
3.8.2 Aira: Be My Eyes.....	14
□ Description: Live human assistance via video call. ....	14
□ Strengths: Human guidance ensures accuracy. ....	14
□ Weaknesses: Requires constant network and loss of privacy. ....	14
3.8.3 Blind Square.....	14
□ Description: GPS based navigation for outdoor use. ....	14
□ Strengths: Operates offline and integrates with existing accessibility API's. ....	14

□ Weaknesses: Ineffective indoors due to its GPS limitations. ....	14
4. Product Overview .....	15
4.1 Product Perspective.....	15
4.2 Summary of Capabilities.....	15
4.3 Assumptions and Dependencies .....	16
4.4 Cost and Pricing.....	14
4.5 Licensing and Installation .....	14
5. Product Features.....	18
5.1 <aFeature> .....	15
5.2 <anotherFeature> .....	15
6. Constraints .....	19
6.1 User Dependency .....	19
7. Quality Ranges.....	20
8. Precedence and Priority .....	22
9. Other Product Requirements.....	24
9.1 Applicable Standards .....	24
9.2 System Requirements.....	24
9.3 Performance Requirements .....	24
9.4 Environmental Requirements.....	26
10. Documentation Requirements.....	27
10.1 User Manual.....	27
10.2 Online Help.....	27
10.3 Installation Guides, Configuration, and Read Me File .....	27
10.4 Labeling and Packaging .....	27
A Feature Attributes.....	28
A.1Status .....	23
A.2Benefit .....	23
A.3Effort .....	23
A.4Risk.....	24
A.5Stability .....	24
A.6Target Release .....	24
A.7Assigned To.....	24
A.8Reason .....	24

## 1. Introduction

### 1.1 Purpose

The purpose of this Vision document is to define, analyze, and communicate the high-level needs, goals, and desired capabilities of the **Theia Indoor Navigation System**. Theia is an assistive mobile application designed to help blind and visually impaired users navigate safely and independently within indoor environments such as schools, offices, and public facilities.

This document establishes a shared understanding among stakeholders, developers, designers, accessibility specialists, and end-users regarding *what* the system must achieve and *why* these capabilities are essential. It serves as a foundational reference for later project artifacts, including the Use-Case Specification, Supplementary Specification, and Software Requirements Specification (SRS).

### 1.2 Scope

This Vision document applies to the **Theia project**, a smartphone-based navigation solution that leverages built-in sensors, accessibility APIs, and voice-driven interaction to guide users through indoor spaces. The document covers the product's conceptual boundaries, major features, user expectations, and constraints.

Theia's scope includes:

- **Primary function:** Assist blind and visually impaired users in navigating from one indoor location to another via voice instructions and haptic feedback.
- **Core components:** Indoor positioning (using BLE beacons, Wi-Fi, or inertial sensors), obstacle detection through camera input, and emergency alert functionality.
- **Phase I (MVP) focus:** Single-floor navigation, basic obstacle detection, voice-based interaction, and an emergency assistance feature.

Future iterations will extend Theia to support multi-floor navigation, adaptive learning of user habits, and more sophisticated obstacle recognition through AI-driven computer vision.

This document influences all activities within the project lifecycle—from requirements elicitation through design, implementation, and testing—and guides stakeholder validation of product goals.

### 1.3 Definitions, Acronyms, and Abbreviations

Term / Acronym	Definition
Theia	Smartphone-based indoor navigation system for blind and visually impaired users. Named after the Greek goddess of vision.
MVP	Minimum Viable Product — the initial prototype demonstrating essential functionality.
BLE	Bluetooth Low Energy — wireless technology used for short-range localization and proximity sensing.
IMU	Inertial Measurement Unit — sensor cluster (accelerometer, gyroscope, compass) used for motion tracking.
TTS	Text-to-Speech — technology used to convert system messages into spoken output.
AS-IS / TO-BE	Analysis terms describing the current state versus the envisioned future state of the system.
FR / NFR	Functional Requirements / Non-Functional Requirements.
WCAG 2.2	Web Content Accessibility Guidelines 2.2 — accessibility standard ensuring digital content usability for people with disabilities.
API	Application Programming Interface — defines interactions between software components (e.g., speech or sensor libraries).
Accessibility API	OS-level interfaces such as Apple VoiceOver or Android TalkBack that provide screen-reader and voice control support.

## 1.4 References

- Abidi, M. H., Siddiquee, A. N., Alkhalefah, H., & Srivastava, V. (2024). *A comprehensive review of navigation systems for visually impaired individuals*. **Heliyon**, **10**(11), e31825. <https://doi.org/10.1016/j.heliyon.2024.e31825>
- World Wide Web Consortium (W3C). (2025). *Guidance on Applying WCAG 2.2 to Mobile Applications (WCAG2Mobile)* [W3C Draft Note]. World Wide Web Consortium. Retrieved from <https://www.w3.org/TR/wcag2mobile-22/>
- White, J., & O'Connor, J. (2022). *Natural Language Interface Accessibility User Requirements* (W3C Working Group Note). World Wide Web Consortium. Retrieved from <https://www.w3.org/TR/naur/>
- Parker, A. T., Swobodzinski, M., Wright, J. D., Hansen, K., Morton, B., & Schaller, E. (2021). *Wayfinding tools for people with visual impairments in real-world settings: A literature review of recent studies*. **Frontiers in Education**, **6**, Article 723816. <https://doi.org/10.3389/educ.2021.723816>
- Liu, J., Yang, Z., Zlatanova, S., Li, S., & Yu, B. (2025). *Indoor localization methods for smartphones with multi-source sensors fusion: Tasks, challenges, strategies, and perspectives*. **Sensors**, **25**(6), 1806. <https://doi.org/10.3390/s25061806>
- U.S. Access Board. (2017). *Information and Communication Technology (ICT) Final Standards and Guidelines* (Section 508 Refresh). Retrieved from <https://www.access-board.gov/ict/>
- World Health Organization & United Nations Children's Fund. (2022). *Global Report on Assistive Technology*. Geneva: WHO. Retrieved from <https://www.who.int/publications/i/item/9789240049451>

## 1.5 Overview

The remainder of this Vision document elaborates on the Theia system's motivation, users, and expected features, organized as follows:

- **Section 2 - Positioning:** Describes the problem statement, system justification, and value proposition of Theia within the domain of assistive indoor navigation.

- **Section 3 - Stakeholder and User Descriptions:** Defines all key stakeholders and user personas, including primary users (blind individuals) and secondary users (caretakers, accessibility staff).
- **Section 4 - Product Overview:** Summarizes the system context, product perspective, and interaction with external components such as sensors and cloud services.
- **Section 5 - Product Features:** Lists high-level product capabilities, including voice-guided routing, obstacle detection, and emergency support.
- **Section 6 - Constraints:** Identifies environmental, technical, and regulatory constraints such as hardware variability and accessibility compliance.
- **Section 7 - Quality Ranges:** Defines measurable quality expectations (e.g., performance, reliability, usability).
- **Section 8 - Precedence and Priority:** Explains the relative priority and implementation sequence of features.
- **Section 9 - Other Product Requirements:** Captures ancillary requirements such as privacy, maintainability, and ethical considerations.
- **Section 10 - Documentation Requirements:** Specifies deliverables, formats, and documentation standards.
- **Appendix A - Feature Attributes:** Provides detailed metadata about each product feature, such as benefit, risk, and success metrics.



## 2. Positioning

### 2.1 Business Opportunity

One of the main opportunities being met by this project is the specific user category it targets. Many would consider a very specific user category for their application to be a nonbeneficial attribute, however Theia benefits from this specific user category. The main reason for it being that the user experience is built around visually impaired accessibility features. Things like voice navigation over visual and large buttons blend and contrast other apps that are not very friendly to the visually impaired. It takes the usefulness and ideas of common navigation applications and tailors them to fit the needs of the visually impaired, however it also does not limit the use of the application to only visually impaired individuals. This means that although the main audience and users of the application are for visually impaired people, others who do have any impaired eyesight can still view the application and find it useful.

### 2.2 Problem Statement

The problem of	navigating indoors
affects	visually impaired individuals
the impact of which is	them crashing, falling or even potentially fatally injuring themselves without proper navigation services
a successful solution would be	preventing injuries and improving accessibility of facilities for visually impaired individuals

### 2.3 Product Position Statement

For	visually impaired people
Who	need better tailored navigation services
The Theia Application	is a focused and fitted solution
That	will keep users safe while increasing accessibility
Unlike	other navigation apps that are not well suited for individuals with no eyesight and focus more on outdoor navigation rather than indoor
Our product	focuses on a specific group of society to help them achieve a better quality of life

### 3. Stakeholder and User Descriptions

To design an indoor navigation system that meets the real needs of blind and visually impaired users, it is essential to identify the individuals, organizations, and roles that influence or are influenced by Theia. This section outlines the stakeholders and users, their responsibilities, environments, and motivations for adopting the system.

#### 3.1 Market Demographics

Theia targets the **assistive-technology market**, focusing on accessibility and inclusive design for individuals with blindness or severe visual impairments.

Key demographic segments include:

- **Educational institutions** (universities, community colleges) with accessibility offices supporting blind students.
- **Government and public service facilities** obligated under ADA and Section 508 to provide accessible environments.
- **Common households** with visually impaired family members.

#### 3.2 Stakeholder Summary

Name	Description	Responsibilities
<b>Accessibility Department Staff</b>	Campus or organizational staff ensuring ADA compliance and supporting disabled students.	Provide accessibility standards, feedback, and integration with campus infrastructure.
<b>Software Development Team</b>	Students and engineers designing, implementing, and maintaining Theia.	Deliver accessible, reliable, and secure application; ensure compliance with user needs.
<b>Project Supervisors / Faculty Advisors</b>	Academic mentors overseeing the project's technical and ethical standards.	Review design, guide methodology, and validate deliverables.
<b>Emergency Services / Campus Security</b>	Responders assisting users in distress via Theia's emergency alerts.	Ensure quick response when alerts are triggered; integrate communication protocols.
<b>Funding and Administrative Sponsors</b>	University departments or grants financing the research.	Allocate resources, track milestones, and evaluate project impact.
<b>Caretakers / Family Members</b>	Secondary supporters of blind users.	Configure emergency contacts; assist with setup and feedback.

#### 3.3 User Summary

Name	Description	Responsibilities	Stakeholder (Yes/No)
------	-------------	------------------	----------------------

<b>Primary User – Blind or Visually Impaired Person</b>	Individuals requiring non-visual indoor navigation assistance.	Operate Theia through voice commands; provide feedback on usability and safety.	<b>Yes</b>
<b>Accessibility Consultant / Orientation Trainer</b>	Professionals training users on mobility tools.	Assist in onboarding users; validate navigation accuracy and safety.	<b>Yes</b>
<b>Caretaker / Family Assistant</b>	Secondary user who can remotely assist or monitor emergencies.	Input emergency contact data; receive alerts; help with calibration.	<b>Yes</b>

### 3.4 User Environment

- **People involved:** Primarily one user at a time; optional remote caretaker during setup or emergency.
- **Task duration:** Typical navigation sessions last 2–10 minutes; repeated daily for classes or work tasks.
- **Environment:** Indoor spaces such as classrooms, hallways, offices, and labs with variable layouts.
- **Constraints:** Unreliable GPS signals, variable lighting and acoustics, moving obstacles, and intermittent Wi-Fi.
- **Platforms:** Android and iOS smartphones equipped with standard sensors (camera, IMU, microphone).
- **Integration:** Works with native accessibility APIs; M132ay extend to wearables (smartwatch vibration).
- **Mobility context:** Fully mobile; requires hands-free or pocket use to support cane or guide-dog mobility.

### 3.5 Stakeholder Profiles

#### 3.5.1 Accessibility Staff

<b>Representative</b>	Accessibility Coordinator
<b>Description</b>	Personnel ensuring institutions accessibility rules.
<b>Type</b>	Administrator/Support
<b>Responsibilities</b>	Validate usability; approve integration with campus facilities.
<b>Success Criteria</b>	Full ADA and Section 508 compliance; reduced support incidents.
<b>Involvement</b>	Requirements Reviewer; periodic usability tester.
<b>Deliverables</b>	Feedback reports; facility access data.
<b>Comments / Issues</b>	Limited resources.

### 3.5.2 Development Team

<b>Representative</b>	Project Manager.
<b>Description</b>	Team designing and implementing Theia.
<b>Type</b>	Technical / Engineering Team
<b>Responsibilities</b>	Develop core features; ensure sensor integration; maintain codebase.
<b>Success Criteria</b>	Functional prototype meeting safety and usability standards.
<b>Involvement</b>	Requirements definition, development, testing.
<b>Deliverables</b>	Source code, documentation, prototype.

## 3.6 User Profiles

### 3.6.1 Primary User

<b>Representative</b>	Accessibility Department User Tester
<b>Description</b>	Individual who uses Theia for independent indoor navigation.
<b>Type</b>	End User / Novice to Moderate Technology Experience
<b>Responsibilities</b>	Initiate navigation via voice; follow audio or haptic directions; report issues.
<b>Success Criteria</b>	Safe, timely arrival without external assistance.
<b>Involvement</b>	System Tester / User Evaluator.
<b>Deliverables.</b>	Usability feedback forms; test logs.
<b>Comments / Issues</b>	Environmental noise and limited tech confidence can affect adoption.

### 3.6.2 Caregiver/Family Assistant

<b>Representative</b>	Registered Emergency Contact
<b>Description</b>	Secondary supporter assisting the user in setup and emergency response.
<b>Type</b>	Casual User / Non-Technical
<b>Responsibilities</b>	Respond to alerts; help configure preferences and safety contacts.
<b>Success Criteria</b>	Reliable notifications and easy setup experience.
<b>Involvement</b>	Beta tester / Requirements Reviewer.

<b>Deliverables</b>	User feedback and configuration templates.
<b>Comments / Issues:</b>	Dependence on stable network for emergency features.

### 3.7 Key Stakeholder or User Needs

<b>Need</b>	<b>Priority</b>	<b>Concerns</b>	<b>Current Solution</b>	<b>Proposed Solution</b>
<b>Accurate Indoor Navigation</b>	<b>High</b>	<b>GPS unreliable indoors.</b>	<b>Human assistance or manual exploration.</b>	<b>BLE / IMU-based pathfinding with voice guidance.</b>
<b>Obstacle Detection</b>	<b>High</b>	<b>Risk of collisions with objects or people.</b>	<b>White cane / guide dog.</b>	<b>Smartphone camera + LiDAR alert system.</b>
<b>Emergency Assistance</b>	<b>High</b>	<b>No automatic distress notification.</b>	<b>Phone call (if reachable).</b>	<b>Voice-triggered SOS alert to contact list.</b>
<b>User Autonomy and Confidence</b>	<b>Medium</b>	<b>Reliance on others reduces independence.</b>	<b>Orientation training / staff help.</b>	<b>Fully voice-driven self-navigation workflow.</b>
<b>Accessibility Integration</b>	<b>Medium</b>	<b>Inconsistent screen reader compatibility.</b>	<b>Manual use of built-in APIs.</b>	<b>Direct integration with VoiceOver / TalkBack.</b>
<b>Ease of Setup and Customization</b>	<b>Medium</b>	<b>Complex configuration for low-vision users.</b>	<b>Caretaker assistance only.</b>	<b>Guided voice setup wizard + saved profiles.</b>
<b>Need</b>	<b>Priority</b>	<b>Concerns</b>	<b>Current Solution</b>	<b>Proposed Solutions</b>

### 3.8 Alternatives and Competition

#### 3.8.1 Microsoft Soundscape

- **Description:** Outdoor navigation app using 3D audio cues.
- **Strengths:** Rich audio spatialization; strong accessibility brand.
- **Weaknesses:** Discontinued (2023); limited indoor capability

#### 3.8.2 Aira: Be My Eyes

- **Description:** Live human assistance via video call.
- **Strengths:** Human guidance ensures accuracy.
- **Weaknesses:** Requires constant network and loss of privacy.

#### 3.8.3 Blind Square

- **Description:** GPS based navigation for outdoor use.
- **Strengths:** Operates offline and integrates with existing accessibility API's.
- **Weaknesses:** Ineffective indoors due to its GPS limitations.

### Competitive Advantages of Theia

- Dedicated to indoor environments.
- Operates offline and integrates with existing accessibility API's
- Provides real time instructions without human intervention.

## 4. Product Overview

### *Product Perspective*

THEIA is a self-contained system designed to provide a mobility-assistive service to visually impaired and blind individuals, supporting their daily mobility tasks. THEIA operates independently on a user's smartphone; THEIA uses the smartphone's sensors for navigation and safety features.

However, THEIA can also be viewed as a component that can be connected to a larger safety and navigational ecosystem that includes a user's mobile device, geolocation services such as GPS, an emergency alert system to help the individual in emergencies, and can be utilized with other visually impaired services such as a Guide Dog, Caregiver, and walking cane for additional supportive assistance.

The primary purpose of THEIA is to support a visually impaired/blind individual in enhancing their independent mobility, situational awareness in new and familiar environments, and personal safety by relying on real-time sensor feedback.

### **4.1 Summary of Capabilities**

THEIA offers a range of capabilities that help visually impaired/blind individuals perform a variety of mobility tasks. THEIA has an integrated suite of mobility, safety, and navigation tools that are designed to support visually impaired/blind individuals travelling independently. Some of THEIA's core benefits and features are:

#### **1. Fall Detection & Emergency Alerting**

THEIA has an algorithm that detects when a user has fallen using the user's device's gyroscope and accelerometer sensors. When the algorithm detects that the user has fallen, a notification will appear asking whether the user is okay. If the user is not okay or doesn't respond to the notification, the fall detection algorithm will send an alert to the user's emergency contact. If the user does not have an emergency contact, or the emergency contact doesn't respond, an emergency alert will be sent to EMS to assist the user.

#### **2. Indoor Positioning**

THEIA uses the user's device's sensors, such as Bluetooth and Wi-Fi adapters and inertial sensors, in combination with the environment's sensors, such as Bluetooth Beacons and Wi-Fi access points, to provide the user with a precise location within their selected environment.

#### **3. Real-Time Obstacle and Pathway Detection**

Using the user's device's camera for input, THEIA can identify and detect objects and hazards along the user's path, providing immediate auditory feedback to the user to help the user navigate around the obstacles safely.

#### **4. Optimized Navigation**

THEIA's navigation system uses Dijkstra's algorithm to find the fastest route to the user-selected destination. Such functionality depends on the user's floor map being

converted into a traversable graph, so that the algorithm can calculate the quickest route to the destination.

## **4.2 Assumptions and Dependencies**

THEIA's development and operation rely on several assumptions and external factors; if any of these conditions change, the Vision Document and/or the System Requirements may need to be revised to accommodate the changes. Listed below are some of the Assumptions and Dependencies for THEIA.

### **1. Device Hardware Availability**

- It is assumed that THEIA will operate within a smartphone device, and thus a functional gyroscope, accelerometer, Bluetooth, Wi-Fi, and GPS module, and a rear-facing camera for data input.
- THEIA depends on the availability of the listed sensors for a variety of core features, such as fall detection, navigation, and object recognition and detection.
- If hardware configurations vary (e.g., different types of smartphones may include different internal components) or sensors are limited or unavailable; certain features may not operate as intended or may be modified.

### **2. Operating System Compatibility**

- THEIA assumes that the device supports modern iOS/Android operating systems (OS) that provide access to background processing, camera APIs, Core Motion/Android Sensor APIs, and accessibility frameworks.
- If changes occur to the OS, the OS permissions, or access to background processes or sensors, it could affect the system's functionality and THEIA's operability.

### **3. Network Connectivity**

- THEIA assumes that the navigation and route optimization features will rely on internet access for map data access (from cloud database) and user information.
- Changes to THEIA's architectural system may be needed if a user's internet connectivity is unavailable. Such changes could be helpful for Offline support.

### **4. Mapping Service Availability**

- THEIA depends on a user's device for navigation, and on a third-party mapping provider (such as a building with properly configured BLE devices and/or Wi-Fi access points) for routing and location-based services.
- Any updates or changes to the mapping service APIs may require additional changes to THEIA's navigational system.

### **5. Emergency Communication Availability**

- THEIA's fall detection algorithm and emergency alert system assumes that the user's devices can send SMS messages, make phone calls, or contact emergency service numbers and/or APIs.
- Areas with limited cell service coverage, Wi-Fi accessibility, and/or disabled emergency service permissions (e.g., on a user's device) will affect THEIA's emergency alert system functionality.



## **6. Device Audio Output Accessibility**

- THEIA's system assumes that TTS, audio routing, and accessibility features such as haptic feedback are enabled and supported on a user's device.
- A user's audio hardware (i.e., headphones, hearing aids, built-in speakers) must be functional and remain functional for safe operation of the THEIA system.

## **7. ML Model Performance**

- THEIA's system assumes that the object detection module's capability depends on a pretrained Machine Learning (ML) model for accurate obstacle detection.
- THEIA's system assumes that the user's device has sufficient processing power to run the pretrained ML model with minimal time delays.
- The results of the ML model and object detection module will depend on the extent to which external factors (such as lighting conditions, camera quality, and environmental factors) affect the images captured for processing.
- A user's device's internal components can also compromise the effectiveness of the object detection module.

## **8. User Environment and Safety Concerns**

- It is assumed that the users of THEIA will operate the application in an indoor environment.
- Unusual or unexpected environmental conditions (e.g., poor lighting for camera-based detection, poor cell service / Wi-Fi accessibility coverage) may limit THEIA's ability to provide a safe, reliable service.

## **9. Legal & Regulatory Requirements**

- It is assumed that THEIA's Emergency Alert system and data handling of user information must comply with privacy laws (such as GDPR, or CCPA if in California) and local regulations.
- Changes in legal requirements, dependent upon the region of service, may necessitate revisions to THEIA's data collection and emergency alert system.

## **10. User Training & Familiarity**

- THEIA assumes that users of this service will receive basic training on using the application, interacting with audio commands, and using gesture controls.
- The usability and/or safety of THEIA may be affected if users do not complete the onboarding process.

## **5. Product Features**

### **5.1 Map generation(current)**

Provides the ability to generate graph-based representations based on information about the indoor environments.

### **5.2 Map Loading and Editing Interface**

The system includes a user interface that allows users to load existing map graphs

### **5.3 Pathfinding and Distance Calculation (current)**

The system can compute distances between user-selected start and end points within an indoor map graph.

### **5.4 Fall Detection and Safety Monitoring (current)**

The system includes fall-detection capabilities that identify when a user may have experienced a fall and trigger an alarm for it

### **5.5 Turn-by-Turn Navigation (Future)**

The system will provide spoken, step-by-step navigation instructions that guide users through indoor spaces.

### **5.6 Obstacle Detection and Alerts (Future)**

Future versions will incorporate real-time detection of obstacles and hazards using device sensors or computer-vision techniques.

### **5.7 Audio Guidance and Feedback (Future)**

The system will offer audio feedback, including distance updates, landmark notifications, and environmental cues.

### **5.8 Environmental Awareness Mode (Future)**

The system will describe nearby rooms, hallways, doors, and other structural features to enhance spatial awareness.

## 6. Constraints

### 6.1 User Dependency

One of the main issues that we face is the reliance on a caretaker or nonimpaired user to set up a lot of the applications features, for example the following,

- Log in/Sign up
- User Information (name, age, address, emergency number)
- Creating the floorplan and add static obstacles

### 6.2 Layout constraints

The floorplan layout is well structured however, a few things constrain our design like the following,

- If there are non-rectangular shaped floors the floorplan might look awkward, our floorplan starts in the shape of the rectangle so oddly shaped floors would likely cause the layout to look confusing
- Only static objects are allowed to be mapped as obstacles, this means floors where obstacles are constantly moving will not be ideal for users.
- When mapping distances from room to room/obstacles, the caretaker or user is responsible for mapping those distances accurately

## 7. Quality Ranges

The quality ranges in this section define the measurable targets and acceptable limits that Theia must achieve to ensure safety, reliability, and accessibility for blind and visually impaired users. These characteristics extend beyond basic functionality and directly affect user confidence and adoption

Quality Attribute	Measurement	Target Range	Description
<b>Performance – Voice Latency</b>	Response time between user voice input and system reply	<b>Ideal <math>\leq 1.5</math> s,</b> Acceptable $\leq 2.5$ s	Ensures near-real-time interaction during navigation.
<b>Performance – Path Computation Time</b>	Time to compute route using Dijkstra algorithm	<b>Ideal <math>\leq 1.0</math> s,</b> Acceptable $\leq 3$ s	Depends on number of nodes $< 200$ per floor.
<b>Performance – Sensor Sampling Rate</b>	Frequency of sensor data updates	$\geq 10$ Hz for motion; $\geq 5$ Hz for obstacle sensing	Guarantees smooth guidance and timely obstacle detection.
<b>Robustness – Error Recovery Rate</b>	Successful recovery from temporary sensor or network failure	$\geq 90$ % of transient errors auto-recovered	Critical for maintaining navigation continuity indoors.
<b>Fault Tolerance – Fail-Safe Alerts</b>	Percentage of hardware or software failures that trigger safe fallback	<b>100 %</b> (all faults must default to safety state)	System must issue verbal or vibration alert on any malfunction.
<b>Reliability – Uptime &amp; Crash Rate</b>	Hours of continuous use without crash	$\geq 8$ h uptime, $< 1$ crash per 100 sessions	Ensures consistent operation during daily navigation.
<b>Reliability – Accuracy of Distance Estimation</b>	Error between estimated and actual traveled distance	$\leq 10$ % error tolerance	Keeps step-count and turn estimation within safe limits.
<b>Usability – Task Completion Rate</b>	Percentage of users reaching destination unaided	$\geq 95$ % under controlled tests	Reflects system's core purpose—independent navigation.
<b>Usability – Learning Time</b>	Time for first-time user to complete setup and first navigation	$\leq 10$ min setup, $\leq 5$ min first route learned	Indicates ease of adoption for non-technical users.
<b>Usability – Cognitive Load Score</b>	NASA TLX or equivalent usability survey	$\leq 30 / 100$	Lower scores = less mental effort required.
<b>Accessibility – Voice Recognition Accuracy</b>	Correct interpretation of speech commands	$\geq 95$ % accuracy under $< 60$ dB noise	Core accessibility metric for blind users.
<b>Accessibility – Screen Reader Compatibility</b>	Compliance with WCAG 2.2 & Section 508	<b>100 %</b> of UI elements accessible	Validated using API's

Security – Data Protection	Encryption level for stored / transmitted data	<b>AES-256 at rest, TLS 1.3 in transit</b>	Prevents interception of location or voice data.
Privacy – User Consent Control	Presence of clear opt-in/opt-out options	<b>Mandatory opt-in required</b>	Ensures informed consent before data collection.
Maintainability – Code Complexity Index (CCI)	Measured via static analysis (e.g., radon or pylint)	<b>CCI <math>\leq 10</math> / module, Cyclomatic Complexity <math>\leq 8</math></b>	Keeps modules simple and maintainable by small dev teams.
Maintainability – Defect Resolution Time	Mean time to resolve bug (MTTR)	<b><math>\leq 2</math> working days for critical, <math>\leq 7</math> days for minor</b>	Ensures quick patching of accessibility or safety issues.
Extensibility – Integration Effort	Time to add new sensor or feature module	<b><math>\leq 5</math> person-days for prototype integration</b>	Demonstrates modular, scalable architecture.
Portability – Platform Support	Android & iOS version coverage	<b><math>\geq 95</math> % of devices released in last 3 years</b>	Guarantees wide accessibility.
Energy Efficiency	Battery consumption per hour of active navigation	<b><math>\leq 5</math> % battery per hour</b>	Enables extended daily use without recharge.
Localization Accuracy	Mean position error indoors using BLE/Wi-Fi fusion	<b><math>\leq 1.5</math> m average error, max <math>\leq 3</math> m</b>	Critical to precise turn and obstacle notifications.
Scalability	Maximum nodes per floor supported	<b><math>\geq 200</math> nodes per floor, route query <math>\leq 3</math> s</b>	Allows large buildings to be mapped efficiently.
Safety – Obstacle Alert Latency	Delay between detection and user notification	<b><math>\leq 0.8</math> s</b>	Ensures timely avoidance of hazards.
Safety – Emergency Call Reliability	Successful delivery rate of SOS alerts	<b><math>\geq 99</math> % with Wi-Fi or cell signal</b>	Mandatory for user protection.

## 8. Precedence and Priority

To ensure that Theia delivers maximum value to users, all system features have been prioritized according to their importance, **user** impact, and implementation feasibility.

Priorities are ranked as follows:

- Priority 1: Core safety and accessibility functions required for MVP and compliance.
- Priority 2: Major functional enhancements that improve independence and usability.
- Priority 3: Features that enrich user experience or system intelligence but are not essential for basic operation.
- Priority 4: Long term or research-driven improvements intended for expansion.

Feature	Description	Priority Level	Rationale
Turn-by-Turn Audio Guidance	Real-time route instructions via spoken prompts.	1	Core navigation function; dependent on successful path computation.
Obstacle Detection & Alerts	Detect and warn users of nearby obstacles using sensors.	1	Directly tied to user safety and trust.
Emergency Assistance	Voice-triggered call or message to caretaker or campus security.	1	Required for user protection.
Indoor Position Estimation	Compute position and route without GPS.	2	Core to navigation accuracy; relies on building data availability.
Personalized Feedback Configuration	Adjust speech rate, volume, and vibration intensity.	2	Enhances comfort for diverse user abilities.
Accessibility API Integration	Native compatibility with VoiceOver (iOS) and TalkBack (Android).	2	Ensures full accessibility compliance.
Environmental Noise Compensation	Dynamically adapt audio output to background noise.	3	Improves usability but not mandatory for MVP.
Adaptive Route Mapping & Learning	Learn frequent routes and suggest preferred paths.	3	Adds convenience and autonomy; depends on stable core routing.
Context-Aware Feedback Modulation	Adjust frequency and verbosity of prompts dynamically.	3	Improves cognitive comfort during prolonged use.
Multi-Floor Navigation Support	Extend routing to include stairs and elevators.	4	Future enhancement; depends on reliable 2-D navigation.

<b>Advanced Computer-Vision Obstacle Classification</b>	Distinguish between obstacle types.	<b>4</b>	Research-intensive; suitable for Phase II+ extensions.
---	-------------------------------------	----------	--

## 9. Other Product Requirements

### 9.1 Applicable Standards

Category	Standard	Description
Accessibility & Usability	<b>ADA (Title III)</b>	Ensures equal access for users with disabilities in public facilities.
	Section 508 of the Rehabilitation Act	Mandates electronic & information-technology accessibility for federal and educational institutions.
	WCAG 2.2 (Level AA)	Governs accessible design for mobile interfaces and voice interaction.
Software Engineering & Quality	ISO/IEC 25010 (SQuaRE)	Defines quality characteristics – reliability, usability, portability – used in Theia’s evaluation.
	IEEE 830 & 1016	Provides structure and best practices for requirements and design documentation.
Data Security & Privacy	GDPR / CCPA Compliance	Regulates user-data privacy and consent, particularly for voice and location data.
	AES-256 / TLS 1.3 Encryption	Required encryption standards for data storage and transmission.
Communication Protocols	Bluetooth Low Energy (BLE 5.0+)	Ensures interoperability and efficiency for indoor localization.
	Wi-Fi 802.11ac+	Supports network-based positioning and data exchange when available.
Platform Compliance	Android Accessibility API / iOS VoiceOver Framework	Native platform standards for accessibility support and input handling.

### 9.2 System Requirements

Component	Requirement	Description
Supported OS	Android 11 or later; iOS 15 or later	Provides required accessibility APIs and sensor frameworks.
Processor / Hardware	64-bit ARM CPU @ $\geq 1.5$ GHz	Ensures smooth voice processing and sensor computation.
Memory (RAM)	2 GB minimum	Supports real-time speech and sensor fusion.
Sensors Required	Microphone, Accelerometer, Gyroscope and Camera.	Needed for voice input, orientation, and obstacle detection.
Network Connectivity	Wi-Fi or Cellular	Used for map updates, cloud sync, and emergency calls.
Storage Space	$\geq 250$ MB free space	Application binaries + local map cache + logs.
Companion Software	TTS Engine, Accessibility Services Enabled	Required for audio feedback and speech synthesis.
<b>Permissions Required</b>	Microphone, Camera, Location, Bluetooth, Network Access	Necessary for navigation, detection, and emergency functionality.



### 9.3 Performance Requirements

Parameter	Target Metric	Conditions
Voice Recognition Latency	$\leq 1.5$ seconds	Under normal CPU load.
Obstacle Detection Latency	$\leq 0.8$ seconds	Between sensor input and user alert.
Path Computation Time	$\leq 3$ seconds for $\leq 200$ nodes	Dijkstra-based graph routing.
Audio Output Reliability	$\geq 99$ % successful prompt delivery	Includes TTS and haptic feedback.
Localization Accuracy	$\leq 1.5$ m average error indoors	BLE and IMU sensor fusion.
Battery Consumption	$\leq 5$ % per hour of active use	Based on average smartphone capacity.
Emergency Call Success Rate	$\geq 99$ % with network availability	Verified under Wi-Fi and LTE.
System Uptime / Crash Rate	$\geq 8$ h continuous operation; $< 1$ crash per 100 sessions	Ensures daily reliability.

## 9.4 Environmental Requirements

Category	Requirement	Description
Operating Environment	Indoor spaces such as classrooms, hallways, offices, laboratories	Controlled temperature and lighting; acoustically variable areas.
Lighting Conditions	50 – 800 lux (typical indoor range)	Sufficient for camera-based obstacle detection.
Acoustic Environment	Background noise $\leq 70$ dB	Beyond this threshold, audio guidance relies on vibration.
Device Shock Resistance	Must operate after minor drops ( $< 1$ m)	Reflects typical mobile use durability.
Temperature Range	0 °C to 40 °C	Smartphone operating norms.
Humidity Range	10 % – 90 % non-condensing	Ensures sensor stability.
Resource Availability	Offline maps cached per building $\leq 50$ MB	Required for non-network use.
Maintenance / Update Cycle	Every 6 months (minimum)	Incorporates bug fixes and new accessibility features.
Error Handling and Recovery	Automatic graceful degradation (fallback to voice alerts if visual sensor fails)	Guarantees continuity and safety.

## **10. Documentation Requirements**

### **10.1 User Manual**

The user Manual will provide users with clear instructions on how to use the Theia application. Its purpose is to guide users through the main features of this system, including selecting a destination, receiving navigation instructions, and managing user settings.

The manual will be concise and easy to follow, focusing on task-based instructions rather than technical details. It will include step-by-step guides, screenshots and simple explanations Suitable for non-technical users. An index and glossary of terms will be included to help users quickly understand and find important terminology or information. A user manual will follow a tutorial-style approach, allowing users to learn about the system by example.

### **10.2 Online Help**

Theia will include an in-app online help system to assist users while using the application. The system will help provide short explanations, tips, and guidance related to specific screens or actions. The online help will be designed to be easy to navigate and accessible using clear language and structured organization. Because online help combines technical information and documentation, its development will be planned early to ensure it remains consistent with the app's interface and functionality.

### **10.3 Installation Guides, Configuration, and Read Me File**

An installation guide will be provided to explain how to install and configure the Theia app on supported devices. This guide will include system requirements, installation steps, and basic configuration instructions.

A Read Me file will also be included as part of the distribution. The Read Me file will highlight important information such as new features in the current release, known bugs, compatibility considerations, and possible workarounds. This document will serve as a quick reference for users and admins.

### **10.4 Labeling and Packaging**

Theia will maintain a consistent look and feel across all the components, including installation screens, the graphical user interface, and the help system. Labeling within that application will include project branding and standardized icons as well as appropriate copyright notices. Consistent visual elements such as font, colors, and logos will be used to ensure clarity and professionalism throughout the application.

## **A. Feature Attributes**

### **A.6.1 Map Generation (Feature 5.1)**

**Status:** Incorporated

**Benefit:** Critical

**Effort:** Medium

**Risk:** Medium

**Stability:** High

**Target Release:** 1.0 (Initial Release)

**Assigned To:** Levi and Fredy

**Reason:** Enables the creation of graph-based indoor maps that form the structural foundation for navigation and routing tasks.

### **A.6.2 Map Loading and Editing Interface (Feature 5.2)**

**Status:** Incorporated

**Benefit:** Important

**Effort:** Medium

**Risk:** Low

**Stability:** Medium

**Target Release:** 1.0

**Assigned To:** Panashe

**Reason:** Provides the ability to load, visualize, and modify map graphs to match real building layouts.

### **A.6.3 Pathfinding and Distance Calculation (Feature 5.3)**

**Status:** Incorporated

**Benefit:** Critical

**Effort:** Medium

**Risk:** Low

**Stability:** High

**Target Release:** 1.0

**Assigned To:** Levi and Fredy

**Reason:** Supports route evaluation and is required to compute shortest paths within a

graph.

#### **A.6.4 Fall Detection and Safety Monitoring (Feature 5.4)**

**Status:** Incorporated

**Benefit:** Important

**Effort:** Medium

**Risk:** Medium

**Stability:** Medium

**Target Release:** 1.0

**Assigned To:** Moises

**Reason:** Enhances user safety by detecting falls and enabling responsive alerting

behavior.

#### **A.6.5 Turn-by-Turn Navigation (Feature 5.5 — Future)**

**Status:** Proposed

**Benefit:** Critical

**Effort:** High

**Risk:** High

**Stability:** Medium

**Target Release:** 2.0

**Assigned To:** Navigation & Guidance Team

**Reason:** Provides real-time accessible navigation for visually impaired users.

#### **A.6.6 Obstacle Detection and Alerts (Feature 5.6 — Future)**

**Status:** Proposed

**Benefit:** Important

**Effort:** High

**Risk:** High

**Stability:** Medium

**Target Release:** 2.0

**Assigned To:** Panashe

**Reason:** Improves safety by identifying hazards and notifying the user during navigation.

#### **A.6.7 Audio Guidance and Feedback (Feature 5.7 — Future)**

**Status:** Proposed

**Benefit:** Important

**Effort:** Medium

**Risk:** Low

**Stability:** High

**Target Release:** 1.1 or 2.0

**Assigned To:** Moises

**Reason:** Enables audio-based interaction suitable for visually impaired users.

**A.6.8 Environmental Awareness Mode (Feature 5.8 — Future)**

**Status:** Proposed

**Benefit:** Useful

**Effort:** Medium–High

**Risk:** Medium

**Stability:** Low–Medium

**Target Release:** 2.0+

**Assigned To:** Contextual Intelligence Team

**Reason:** Provides contextual descriptions (e.g., rooms, hallways, doors) to enhance spatial understanding.