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Computer Prototype

Introduction

This report presents the design evolution, prototype implementation, and usability evaluation plan for *Glove Guide*, a haptic navigation system developed to enhance safety and convenience for cyclists and pedestrians. The project aims to replace traditional visual and auditory navigation cues with intuitive haptic feedback delivered through wearable components such as gloves or bracelets, allowing users to remain attentive to their surroundings while navigating.

Building on insights from earlier low-fidelity testing, this deliverable details the refined prototype, the procedures for usability testing, and the methods for data recording and reporting. It also includes a comprehensive user manual to ensure that evaluators can operate the system independently. Together, these materials provide a clear framework for assessing the system's usability and guiding further refinements toward a fully functional, user-validated prototype.

User Manual / Installation Guide

Navigation App User Manual – Glove Guide

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1. Getting Started

About Glove Guide

Glove Guide is a haptic-based navigation system designed to enhance safety and focus for cyclists and pedestrians. It connects Bluetooth-enabled gloves with a smartphone app to deliver hands-free, eyes-free navigation through vibration patterns.

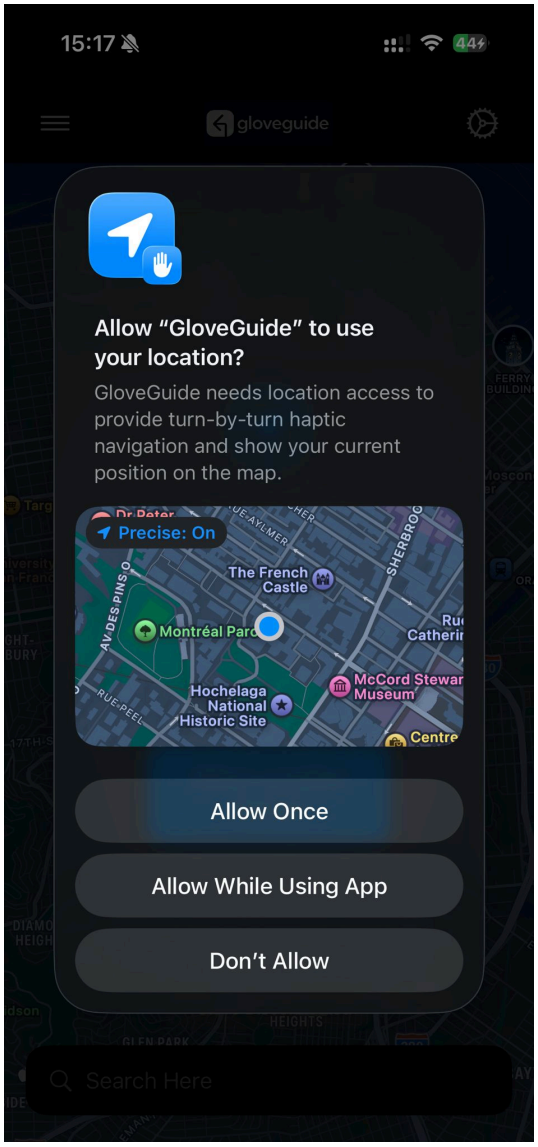
App Installation

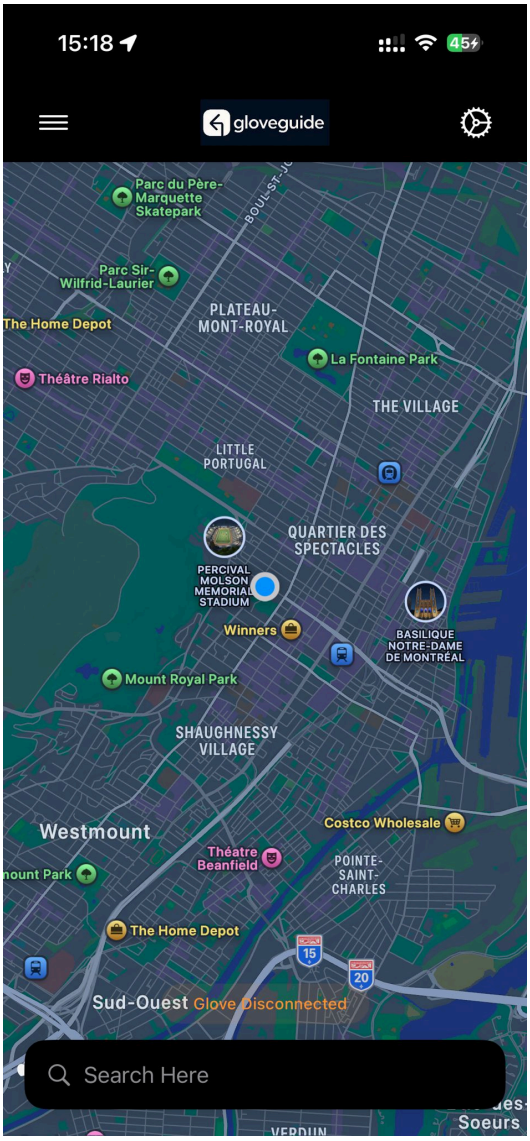
You can install the Glove Guide app in one of two ways:

- **Direct installation**: Transfer the application from a desktop or laptop to your phone.
- **TestFlight**: Download and install through Apple's TestFlight testing platform.

First Launch

1. Open the Glove Guide app.
2. Allow location permissions when prompted.
3. The app will display a map centered on your current location.
4. Note the "**Gloves Disconnected**" status at the bottom — you'll connect your gloves in the next section ("Setting Up Your Gloves").





2. Setting Up Your Gloves

Bluetooth Connection

1. Tap the **Settings** icon (⚙️) in the top-right corner.
2. Under “**Bluetooth Connection**”, check the **Device Status**.
    - If it says **Connected**, your gloves are ready.
    - If it says **Disconnected**, tap **Connect** and ensure your gloves are in pairing mode.

3. When connected, the main screen will show **“Gloves Connected.”**

Important: Make sure your gloves are charged and within Bluetooth range.

3. Main Navigation Interface

Map Overview

The main map displays your location and nearby points of interest.

- **Your Location:** Blue dot
- **Landmarks:**
    - Parks – Green
    - Transit Stations – Blue
    - Restaurants – Orange
    - Shopping Areas – Yellow
    - Entertainment/Art – Pink
    - Hospitals/Medical – Red
    - Hotels – Purple

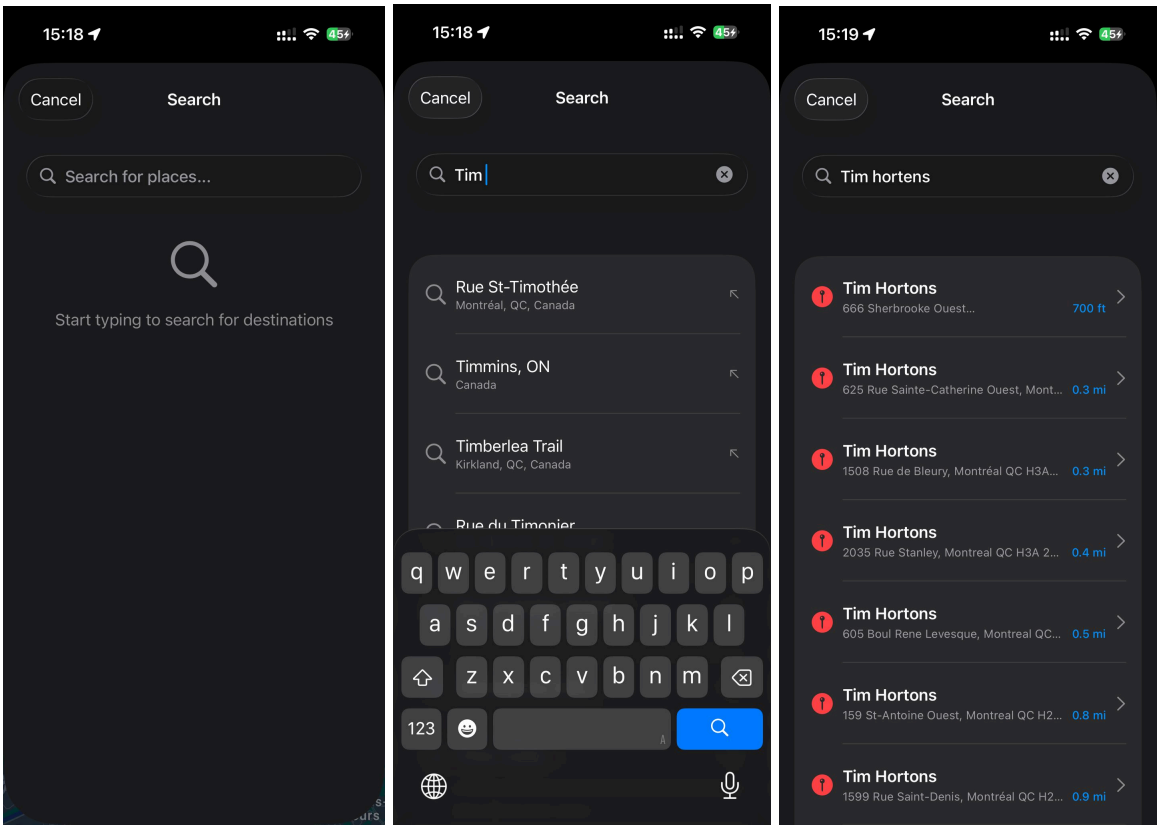
Interface Elements

- **App Logo:** “gloveguide” (top center)
- **Menu Button (≡):** Top left
- **Settings (⚙️):** Top right
- **Search Bar:** Bottom (“Search Here”)
- **Connection Status:** “Gloves Connected/Disconnected” indicator

4. Searching for Destinations

Steps

1. Tap the **Search Bar** at the bottom.
2. Type your desired destination (e.g., *"McGill"*).
3. Choose from **Recent Searches** or **Nearby Locations**.
4. Select the destination, the map will center on it.



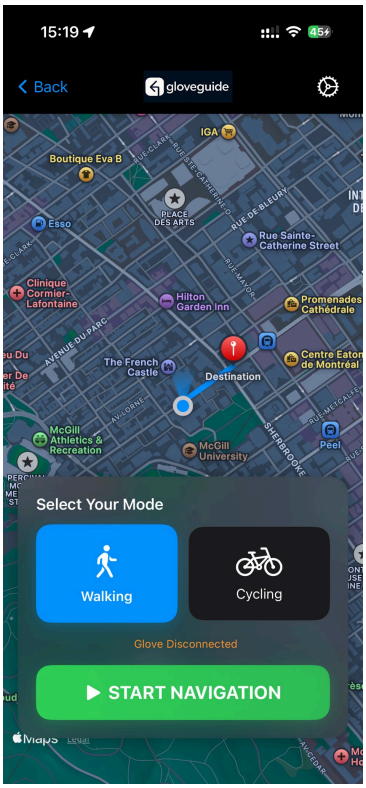
5. Selecting Transportation Methods

Available Modes

- **Cycling Mode** – Bicycle icon (Black button): Shows bike-friendly paths.
- **Walking Mode** – Walking figure icon (Blue button): Shows pedestrian routes.

Mode Selection Process

After choosing a destination, select your preferred mode.
The app will calculate and display an optimized route.



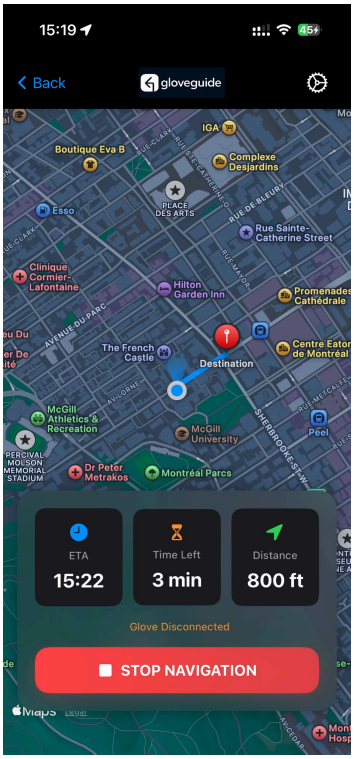
6. Navigating with the App

Starting Navigation

1. Tap **Start Navigation**.
    - **Blue route line** – Your path
    - **Blue dot** – Current location
    - **Red pin** – Destination
    - **Navigation Card** – ETA, Time Left, and Distance
    - **Stop Navigation** button (red)

During the Journey

- The map updates your position in real time.
- Gloves vibrate to indicate turns and alerts.
- Distance and ETA adjust automatically.



7. Understanding Haptic Feedback

How It Works

- **Left glove** vibrates for left turns; **Right glove** vibrates for right turns.
- Vibrations occur before intersections, based on your lead-time setting.
- Intensity may **increase progressively** as you approach a turn.
- **Both gloves** may vibrate to signal arrival or rerouting.

This design allows for intuitive, glance-free navigation while maintaining focus on the road or path.

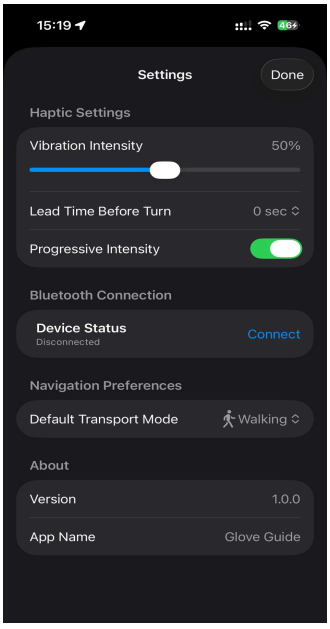
8. Configuring Settings

Accessing Settings

Tap the ⚙️ icon in the top-right corner to open settings.

Haptic Settings

- **Vibration Intensity:** Adjustable slider (0–100%). Default: 50%.
- **Lead Time Before Turn:** Set between 0–20 seconds. **Progressive Intensity:** Toggle ON/OFF. When enabled, vibrations strengthen as you approach a turn.



Bluetooth Connection

- **Device Status:** Displays current connection.
- **Connect Button:** Re-pairs gloves if disconnected.

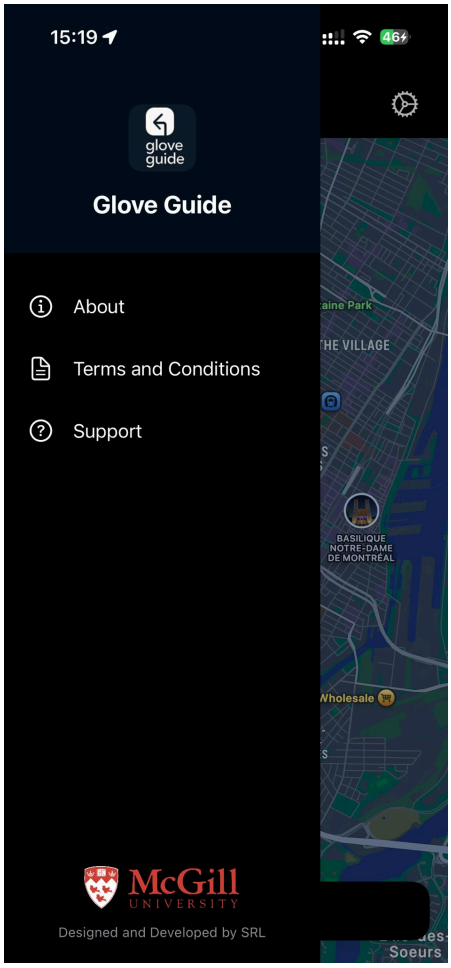
Navigation Preferences

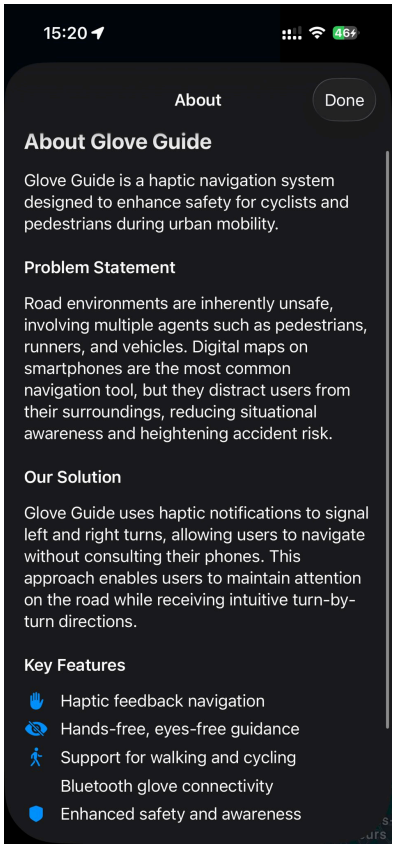
- **Default Mode:** Choose *Walking* or *Cycling*. Can be changed per trip.

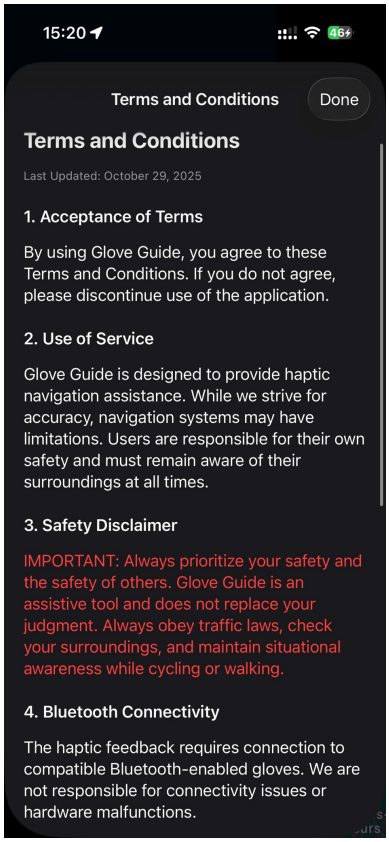
About Section

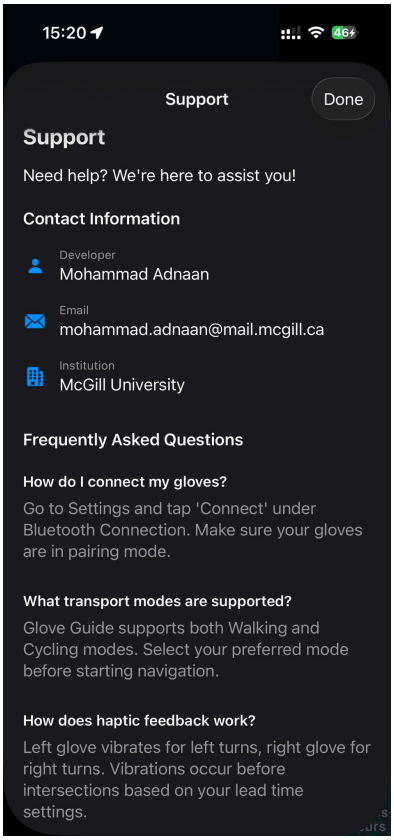
Displays app version and general information.
Example:

- Version: 1.0.0 & App Name: Glove Guide




15:20
About
Done
About Glove Guide
Glove Guide is a haptic navigation system designed to enhance safety for cyclists and pedestrians during urban mobility.
Problem Statement
Road environments are inherently unsafe, involving multiple agents such as pedestrians, runners, and vehicles. Digital maps on smartphones are the most common navigation tool, but they distract users from their surroundings, reducing situational awareness and heightening accident risk.
Our Solution
Glove Guide uses haptic notifications to signal left and right turns, allowing users to navigate without consulting their phones. This approach enables users to maintain attention on the road while receiving intuitive turn-by-turn directions.
Key Features
Haptic feedback navigation
Hands-free, eyes-free guidance
Support for walking and cycling
Bluetooth glove connectivity
Enhanced safety and awareness


15:20
Terms and Conditions
Done
Terms and Conditions
Last Updated: October 29, 2025
1. Acceptance of Terms
By using Glove Guide, you agree to these Terms and Conditions. If you do not agree, please discontinue use of the application.
2. Use of Service
Glove Guide is designed to provide haptic navigation assistance. While we strive for accuracy, navigation systems may have limitations. Users are responsible for their own safety and must remain aware of their surroundings at all times.
3. Safety Disclaimer
IMPORTANT: Always prioritize your safety and the safety of others. Glove Guide is an assistive tool and does not replace your judgment. Always obey traffic laws, check your surroundings, and maintain situational awareness while cycling or walking.
4. Bluetooth Connectivity
The haptic feedback requires connection to compatible Bluetooth-enabled gloves. We are not responsible for connectivity issues or hardware malfunctions.


15:20
Support
Done
Support
Need help? We're here to assist you!
Contact Information
Developer
Mohammad Adnaan
Email
mohammad.adnaan@mail.mcgill.ca
Institution
McGill University
Frequently Asked Questions
How do I connect my gloves?
Go to Settings and tap 'Connect' under Bluetooth Connection. Make sure your gloves are in pairing mode.
What transport modes are supported?
Glove Guide supports both Walking and Cycling modes. Select your preferred mode before starting navigation.
How does haptic feedback work?
Left glove vibrates for left turns, right glove for right turns. Vibrations occur before intersections based on your lead time settings.

9. Ending Your Journey

Arrival at Destination

When you arrive:

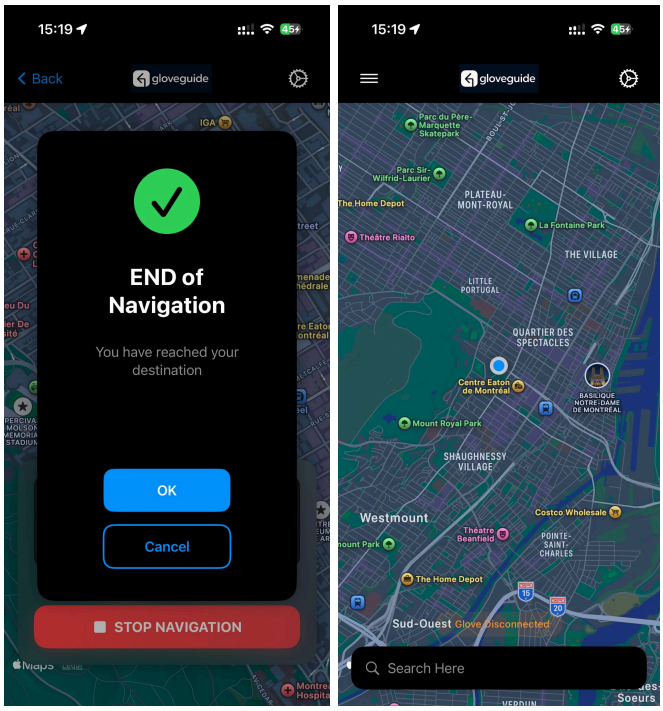
- A popup appears: **“END of Navigation”**
- Message: *“You have reached your destination.”*
- Tap **OK** (blue) to finish, or **Cancel** to continue.

Stopping Manually

1. Tap **STOP NAVIGATION** (red).
2. Confirm to return to the main map.

After Navigation

- The map returns to exploration mode.
- Gloves remain paired for future use.



10. Menu Layout

Access the main menu via the **Menu Button (≡)** in the top left.

Menu Sections

- **About:** Problem Statement, Solution, Key Features
- **Terms and Conditions:** Acceptance, Use of Service, Safety Disclaimer
- **Bluetooth Connectivity:** Information and troubleshooting
- **Support:** Developer contact and FAQs

Design Evolution

Following the low-fidelity prototype testing and peer feedback, several revisions were identified to enhance both the usability and technical feasibility of the Glove Guide system. These design evolutions were driven by direct user observations, peer comments, and new insights gained during preliminary implementation planning.

1. Transition from Planned Google Maps API to Apple Maps API/Kit
While the team initially planned to implement navigation functionality using the Google Maps API, subsequent study with members of the target user group—including participants from the low-fidelity usability test—showed that most users primarily relied on Apple Maps for daily navigation. In addition, the development team possesses stronger experience with the iOS platform. As a result, the team decided to adopt **Apple Maps API/Kit** for future development to better align with user familiarity and streamline implementation.
Justification: Improved intuitiveness for users and higher development feasibility due to platform expertise.

2. Improved Bracelet Feedback through Adjustable Straps
Test participants reported inconsistent haptic sensations from the bracelet, often caused by variable tightness around the wrist. To address this issue, the new prototype includes **adjustable straps**, enabling users to control the fit according to personal comfort. This modification ensures more consistent haptic transmission and enhances the reliability of feedback during use.
Justification: Increased reliability, effectiveness, and overall user satisfaction.

3. Lightweight Fingerless Glove Design
During the initial tests, users found that the glove design restricted their hand movements and felt cumbersome. To improve comfort and usability, the new iteration adopts a **lightweight, fingerless glove**, allowing free finger movement while retaining necessary sensing and feedback functionality.
Justification: Improved user comfort and satisfaction during use.

4. Customizable Haptic Feedback Settings
Usability testing revealed notable individual differences in how participants perceived and preferred haptic feedback. For example, **Participant 1** reported that the vibration intensity was generally comfortable and clear, whereas **Participant 2** found the vibrations too subtle when moving the arm. Confidence ratings in interpreting directional cues ranged between **3.5 and 5.0**, indicating variability across users.
To accommodate these differences, the new prototype includes a **customization interface** allowing users to:

- Adjust vibration intensity to their preference.
- Choose how many seconds before a turn the vibration should begin.

This feature personalizes the interaction, improving clarity and overall user confidence.
Justification: Enhanced reliability, effectiveness, and user satisfaction through personalization and adaptability.

Prototype Implementation

The computer-based prototype of the Glove Guide builds upon the structure of the earlier low-fidelity version and continues to consist of three main components: **electrical**, **physical**, and **software application** elements. Together, these components enable users to experience the full "look and feel" of the intended system with minimal reliance on Wizard of Oz techniques.

Electrical Components
The electrical system remains unchanged from the previous iteration, as it already fulfilled the intended functionality. It includes two switches, each connected to a distinct vibration motor positioned on the left and right sides of the wearable parts. When a switch is activated, the corresponding motor provides haptic feedback to the user, and the vibration stops when the switch is turned off. This setup ensures precise and immediate tactile cues corresponding to directional signals.

Physical Components

The physical design has been updated to reflect user feedback obtained during the low-fidelity testing phase. The full-hand gloves have been replaced by lightweight**, fingerless gloves**, and the fixed-tight bracelets have been replaced with an **adjustable strap design**. These adjustments improve comfort and usability by allowing users to move freely and customize the fit according to personal preference. The vibration components remain securely attached to the physical parts in the same relative positions as before—specifically, the left vibration motor is mounted on the left wearable, and the right motor on the right wearable—ensuring clear directional correspondence between haptic feedback and navigational cues.

Software Application
The most significant progress has been achieved in the software component. The user interfaces developed during the paper prototype stage have been implemented as an **iOS application**. The app provides users with all key interactions that were identified as central during the low-fidelity testing phase, including:

- Destination search and selection
- Transport mode selection
- Haptic feedback customization (intensity and timing)

The application can be easily installed on standard iOS devices without requiring special technical skills, ensuring accessibility and portability for future usability testing. This implementation now allows users to interact directly with the system's main functions, providing a realistic impression of its final look and feel.

Alignment with Project Objectives

The Glove Guide project aims to enhance navigational safety by replacing visual and auditory navigation outputs with **haptic feedback**, allowing users to remain attentive to their surroundings while receiving navigation instructions. The current prototype successfully demonstrates this functionality by delivering directional guidance through tactile cues, meeting the project's central objective of hands-free, eyes-free navigation.

User Population

In the initial project proposal, five user segments were defined; however, subsequent review revealed that these segments did not adequately reflect the activity contexts relevant to our system's intended use. Based on this reassessment, we redefined the user population into three primary segments: **Bikers**, **Pedestrians**, and **Individuals with Disabilities**. These groups represent the main target audiences who could benefit from hands-free, haptic-based navigation assistance.

For the present usability testing phase, the required participants are defined as follows:

- **18 years of age or older**
- **Experienced cyclist or motorcyclist**
- **Comfortable navigating while cycling or walking**

This participant profile corresponds directly to the **Biker** and **Pedestrian** segments, which are the main focus of the current test sessions. While the **Individuals with Disabilities** segment is not explicitly targeted for recruitment at this stage, participation from this group remains **welcome and encouraged** should volunteers be available. We recognize that some additional interface and hardware adaptations would be necessary to fully accommodate specific accessibility needs, and these enhancements are planned for future iterations once the core interactions have been validated.

Usability Goals

The usability evaluation for the Glove Guide computer prototype focuses primarily on the **software application**, with an emphasis on how effectively it supports distraction-free navigation and intuitive interaction. The following usability goals were selected because they directly support the project's main objective: enabling users to receive navigation guidance through haptic cues while maintaining attention on their surroundings.

Usability Goal	Description	Measurement
Efficiency	Evaluate how quickly users can respond to navigation cues generated by the application.	Average **reaction time** (in seconds) between the onset of a haptic or audio signal and the user's corresponding action.
Calm Technology	Assess how effectively the system minimizes visual distraction during navigation.	**Number of times** users check their phone while navigating.
Effectiveness	Determine the accuracy with which users interpret navigation cues.	Number of **missed or misunderstood haptic signals** per task or session.
Learnability	Measure how easily users can learn to operate the application's main functions.	**Time required** to complete key application tasks (e.g., selecting a destination, adjusting haptic settings) during the initial session.

While the physical components remain present during testing, this evaluation focuses on the **user interaction with the mobile application**. The collected data will provide quantitative insights into how efficiently and effectively users can interact with the system and how well the application supports calm, attentive navigation.

Usability Test Procedure

The usability test will be conducted by a team of **two to three examiners**.

Equipment:
In addition to the prototype described previously, the examiners will require a **timer or stopwatch**, **pen and paper** for note-taking, and an **iOS smartphone** for running the application (to be provided if the participant does not have one).

Prototype Setup:
Before the test begins, the participant will be asked to wear the physical components—either the **lightweight fingerless gloves** or the **adjustable bracelets**. The two **vibration components** are then securely taped to the corresponding physical parts, maintaining the same relative positions as before (left actuator to the left glove/bracelet, and right actuator to the right one). The **software application** is installed on the participant's own phone or, if needed, on a preconfigured device provided by the examiners.

A **moderator** operates the switches of the haptic actuators. Using a reference of the user-selected route, the moderator guides the participant throughout the test by activating and deactivating the actuators to simulate haptic navigation cues.

Examiner Roles and Conduct:
While the moderator manages the haptic signals, the other **one or two examiners** are responsible for collecting both quantitative and qualitative data. They will record:

- Time taken for the participant to react to a haptic signal
- Whether the participant checks their phone (Calm Technology metric)
- Number of missed or misunderstood signals
- Time spent completing application-related tasks

Examiners will also note any observable user behaviors, confusion, or spontaneous feedback relevant to usability.

Instructions to Participants:
Participants are only to be given the **task statements** and any **essential clarifications** required to perform them. Examiners **must not provide verbal guidance** on how to use the prototype, nor offer explanations about system functions during the test.

Examiner Limitations:
Examiners must **avoid influencing** the participants' actions or expectations in any way. They

should not suggest corrections, reveal expected outcomes, or discuss design intentions. Measurements are to be recorded **in real time**, beginning at the start of each task and ending upon task completion.

Ethical and Safety Considerations:

Examiners should ensure that all participants are comfortable and informed of their right to withdraw at any time. For tests conducted in biking or walking scenarios, appropriate safety precautions must be taken—such as performing trials in a controlled or low-traffic environment. Participants should also be given short breaks between tasks if needed, as **long-distance walking, biking, or running can be physically tiring**, and **extended focus on haptic feedback may also lead to temporary loss of attention**.

Summary:

This procedure ensures that an independent evaluation team can reproduce the usability test consistently, collect reliable quantitative data, and provide meaningful feedback on the prototype's performance and user experience.

Reporting

Recording Instructions:
During each usability test session, examiners should record all relevant measurements systematically using a standardized data table, as illustrated below. This ensures consistency across trials and facilitates later quantitative analysis.

Task	Time Spent on Application (s)	Missed / Misinterpreted Signal (count)	Reaction to Signal (s)	Phone Check (count)	Comments
1. Start Route					
2. Known Route					
3. Unknown Route					
4. Dual Task					

Measurement Guidelines:

- **Time Spent on Application (s):** Begin timing once the task has been explained and confirmed as understood. Stop the timer when the participant successfully completes the task or abandons it.

- **Missed / Misinterpreted Signal (count):** Record each instance where the participant fails to respond to a haptic signal or responds incorrectly (e.g., turns right when a left-turn vibration is indicated).

- **Reaction to Signal (s):** When the moderator activates the haptic actuator, start the timer simultaneously and stop it once the participant initiates the turn.

- **Phone Check (count):** Note each instance in which the participant checks their phone during the navigation task.

- **Comments:** Record any noteworthy observations, such as confusion, hesitation, verbal remarks, or environmental factors affecting performance.

Reporting Format:
All collected data should be compiled into a consolidated results table identical in structure to the one above. This format enables direct comparison across participants and tasks, supporting both quantitative analysis and qualitative interpretation. Examiners are also encouraged to provide brief summary notes for each participant highlighting observed behavioral patterns or usability challenges.

Design Team Expectations and Potential Implications:
The design team expects the following baseline outcomes for satisfactory usability:

- **Time Spent on Application:** $\leq$30 seconds on first use; $\leq$15 seconds once familiar with the interface.

- **Missed / Misinterpreted Signal:** $\leq$1 instance per navigation session.

- **Reaction Time:** $\leq$2 seconds after receiving a turning signal.

- **Phone Check:** $\leq$1 per navigation session.

Deviations from these thresholds suggest potential usability issues, most likely related to the **vibration intensity or physical attachment quality** (e.g., straps too loose, low actuator power, or user-adjusted vibration too weak). These findings will directly guide further refinement of the prototype's hardware and feedback calibration.

Summary:
This reporting structure ensures that all examiners collect and present data in a uniform and analyzable format, allowing the design team to identify specific weaknesses in both the haptic design and user interaction workflow.

Usability Evaluation

Evaluation Methodology:
The usability evaluation will consist of a **heuristic evaluation** conducted by an independent group of evaluators. Each evaluator will individually inspect the prototype—both the physical wearable and the iOS application—against a defined set of usability heuristics. Evaluators will document any violations or usability concerns and assign a **severity rating** (from 0 = no problem to 4 = usability catastrophe) following Nielsen's standard severity scale.

After individual evaluations, the examiners will meet to **consolidate findings** and produce a combined summary report highlighting recurring issues, design strengths, and suggested improvements.

Evaluation Tasks:
To ensure consistent coverage across the prototype's main interaction paths, evaluators will complete the following tasks before or during inspection:

1. **Adjust physical wearable:** Fit the fingerless glove or adjustable bracelet to assess ease of setup and comfort.

2. **Search and select destination:** Use the app's interface to search for a destination and confirm route selection.

3. **Navigate a known route:** Follow haptic feedback cues along a familiar path.

4. **Customize vibration settings:** Modify the vibration intensity and timing within the app's customization menu.

5. **Navigate an unknown route:** Use only haptic guidance to reach an unfamiliar destination.

6. **Dual task:** Perform an additional attention task (e.g., holding a short conversation while navigating) while navigating, to assess cognitive load and distraction resistance.

Heuristics and Assessment Criteria:
The evaluation will focus on the following heuristics, chosen for their relevance to a wearable haptic navigation system:

- **Calm Technology:** The system should remain unobtrusive, allowing users to focus on the environment rather than the device. Evaluation will note how often users feel compelled to check the phone or are distracted by feedback.

- **Match Between the System and the Real World:** The vibration patterns and app icons should follow intuitive real-world analogies (e.g., left-hand vibration → left turn). Evaluators

will assess how naturally users interpret these cues.

- **User Control and Freedom:** Users must be able to easily stop, restart, or adjust feedback intensity and duration. The evaluation will verify the visibility and accessibility of these controls.

- **Recognition Rather Than Recall:** Interface elements and feedback patterns should be intuitive enough that users do not need to memorize how to operate the system or interpret vibrations. Evaluators will assess whether users can recognize functions and meanings immediately through design cues rather than relying on prior memorization.

Evaluation Output:
Each evaluator will submit an annotated checklist containing their heuristic ratings, observed issues, and recommendations. The consolidated report will summarize:

- Total number of violations per heuristic category

- Mean severity ratings

- Suggested design revisions

Summary:
This evaluation plan provides independent examiners with clear procedures, task descriptions, and criteria for judging usability. By combining heuristic inspection with focused task testing, it ensures a comprehensive assessment of both the app's interface and its physical interaction design.

Conclusion

This milestone represents a significant step in the development of our glove-based haptic navigation system. The computer prototype successfully integrates both hardware and software components to provide a realistic sense of the final product's look and feel, allowing users to experience haptic guidance with minimal reliance on Wizard-of-Oz techniques.

Through a combination of refined design decisions, detailed usability goals, and a comprehensive evaluation framework, the project now establishes a solid foundation for independent usability testing. The outlined test and reporting procedures ensure that quantitative and qualitative data can be collected consistently, while the heuristic evaluation plan provides structured insights into the system's intuitiveness and effectiveness.

Together with the accompanying user manual, this deliverable equips the evaluation team with the information and tools necessary to assess the prototype independently, identify usability challenges, and guide the next iteration toward a more refined, user-centered design.