Subway Announcement System

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***Abstract*—**Subway systems are essential to public transit, yet riders still struggle with accessing clear, reliable, and usable travel information. This gap is not trivial; it affects navigation, timing, and rider confidence on a daily basis. Our goal was to identify and understand the specific pain points that continue to disrupt the transit experience. We focused on three major issues: (1) lack of guidance on the train, (2) overdependence on mobile apps that often fail to reflect real-time conditions, and (3) unreliability of audio announcements in loud, crowded environments. Through interviews, surveys, and heuristic evaluations, we examined how these failures manifest and why existing systems often make the problem worse instead of solving it. From these findings, we developed a set of design alternatives that prioritize real-time accuracy, meaningful feedback, and accessibility. These solutions aim to address core breakdowns in current subway information systems and offer more dependable, rider-centered ways to navigate public transit.

1 INTRODUCTION

Public transportation is a fundamental lifeline for many people. Not everyone can rely on private transportation due to cost, access, or circumstance. Among the various forms of public transport, trains and subways play a crucial role in

helping people commute to work, return home, and access essential services. In many smaller or densely populated countries, governments actively encourage the use of rail systems because they can move people more efficiently than cars. According to Nunno of the Environmental and Energy Study Institute, numerous European and Asian rail networks employ High Speed Rail (HSR) capable of reaching speeds of up to 250 km/h (160 mph) (Nunno, 2018). These speeds far exceed those of typical automobile travel, making HSR a faster and more reliable option for long-distance commuting.

However, challenges arise during the boarding process within subway stations. Announcements are typically delivered exclusively through intercom systems, which can be difficult to hear due to ambient noise from trains and surrounding passengers. As a result, important information such as arrivals, delays, and platform changes may not be communicated effectively to riders. This project seeks to develop an **improved interface that enables passengers to easily check real-time subway information** and **perform related tasks without relying solely on audio announcements**. Our team selected this task domain because we regularly use subway and rail systems and recognize the importance of accessible and reliable transit information.

2 NEEDFINDING PLAN

The needfinding plan for this project will involve a user survey, interviews, and heuristic evaluation.

2.1 Activity 1: User Survey (See Appendix 4.1.1)

Survey Link: PeerSurvey – GT Version

Our first needfinding activity involves conducting a survey using Georgia Tech's PeerSurvey platform. The purpose of this survey is to understand how subway riders access and interpret transit information, including audio announcements, visual displays, and mobile transit applications.

2.1.1 *Participants and Recruitment*

Participants will primarily be students enrolled in CS 6750 (Human-Computer Interaction), recruited through the course's *Team Project (Needfinding) – Recruitment Megathread* on Ed Discussion, where survey participation is incentivized with course participation points. We will also recruit additional participants outside

of the class, including friends, family members, and peers who frequently ride public transit, through direct outreach via text or messaging platforms. This approach allows us to reach both frequent and infrequent subway riders, resulting in more diverse data.

2.1.2 *Survey Structure*

- **Nominal questions**
- **Ordinal questions**
- **Short-answer questions**

This balanced structure allows us to collect both quantitative and qualitative data to identify patterns and form insights.

Examples of Nominal Questions:

- When you are on the subway, which sources of information do you rely on most?
- Which types of information are most important for you to access clearly?

Examples of Ordinal (Likert) Questions:

- How difficult is it for you to hear audio announcements?
  (Very difficult $\rightarrow$ Very easy)
- How difficult is it for you to see or access visual display screens?
  (Very difficult $\rightarrow$ Very easy)

Examples of Short-Answer Questions:

- If you could improve one thing about subway information systems or apps, what would it be?
- What types of information (arrival time, line color, destination, etc.) are most important to announcement/PA systems?

All responses will be collected anonymously to encourage honest and unbiased feedback. Participants may exit the survey at any time.

By combining structured questions with open-ended responses, the survey helps us understand subway information retrieval patterns and behaviors, as well as frustrations riders have in real situations. These results will guide us in designing a clear and user-friendly mobile interface for subway riders.

2.1.3 *Bias Considerations and Mitigation*

Since most of our survey participants will be Georgia Tech students or people within our personal networks, the responses may lean toward users who are more familiar with technology and mobile apps. This reflects a form of **self-selection bias**, where participants who choose to complete the survey may already be more comfortable using digital tools. In addition, experiences may vary depending on which subway systems participants have used, since different cities have different levels of clarity and infrastructure. This introduces **geographic bias**, as riders from certain cities may report clearer or more confusing experiences than others.

To help balance these limitations, we will also conduct interviews and perform a heuristic evaluation of existing subway information interfaces. The interviews will help us better understand real situations that are harder to capture in a survey, while the heuristic evaluation allows us to look directly at the interfaces rather than relying only on participant memory. Using multiple methods together will help give us a more complete understanding of user needs, though some bias will still remain.

2.2 Activity 2: Interview

Our second needfinding activity will include interviewing participants through an individualized in-person or virtual (call or video call) space. The sample population from this group will include friends and family who often take public transportation. Participants will be incentivized through social desirability, as most people would want to help out others, especially if it is free of major time and money commitments.

2.2.1 *Biases*

However, certain biases may arise as a result of this activity. Because the interviewees all live in close proximity, the needfinding results may be overly specialized in a single geographic area, introducing selection bias. Furthermore, participants may unintentionally report tasks as easier or form favorable opinions due to long-term familiarity with local transit interfaces. Social desirability bias is a clear factor in this activity, given that some interviewees are friends or family members. Thus, some participants may feel pressured to give positive responses out of concern that negative feedback could affect their relationship with us.

2.2.2 *Bias Mitigation*

These biases can be addressed and mitigated. Selection bias can be mitigated by asking participants to recall themselves in different scenarios and different subways, so that their expertise reflects not one system but a broader judgment of any and all subway systems they have used. Social desirability can also be mitigated by first explaining to participants that their answers in no way shape or form will have an effect on the project's grades or overall relationship.

2.2.3 *Methodology*

The questions that will be asked within this interview will begin with questions found within Needfinding Questions. Because interviews are conducted on a face-to-face basis, follow-up questions and questions about responses can be used to gather more information about the task. Due to the nature of interviews, some language may be lost within transcription or responses as body language and tone cannot be easily recorded. A transcription of the interview will be provided within the results.

2.3 Activity 3: Heuristic Evaluation

Our final needfinding activity will involve a heuristic evaluation based on three of Nielsen's ten heuristics: **Visibility of System Status, Match Between System and the Real World, and Help Users Recognize, Diagnose, and Recover from Errors.** This evaluation focuses on the passengers' access to real-time and contextual information in subway environments such as on-train displays, station announcements, maps and mobile apps.

2.3.1 *Visibility of System Status*

To evaluate the visibility of system status, we will verify that the user can immediately understand the current situation on the subway or train. In detail, we will examine the following questions:

- Is real-time information (subway arrival times, delay information, and transfer notifications) clearly updated and communicated?
- Can users easily understand their current status (e.g., their location) and the train's status (e.g., arrival, departure, delay) at a glance?
- Do visual and auditory signals (e.g., colors, icons, sounds) provide consistent and immediate feedback?

- Is the information consistent across multiple interfaces (e.g., displays, announcements, apps)?

2.3.2 *Flexibility and Efficiency of Use*

To evaluate flexibility and efficiency of use, we will examine whether the subway system accommodates various user types, with different needs and expertise levels. In detail, we will examine the following questions:

- Does the system give experienced commuters minimal information, while showing novice riders or tourists more detailed guidance?
- How well does the system support accessibility (e.g., visual announcements for hearing-impaired passengers)?
- Does the system function effectively in environments without internet connectivity?
- Is it understandable to foreign or novice users?

2.3.3 *Error Prevention*

To evaluate the error prevention, we will review whether the system helps users preventing mistakes in the first place through design and feedback. In detail, we will examine the following questions:

- Does the system clearly notify the user when there is a delay or interruption and provide recovery options (e.g., other route, alternative transportation)?
- Does the system clearly distinguish the direction or lines to help users choose the right train or direction in the first place?
- Does the system provide reliable and frequently updated information to prevent confusion when displaying arrival times?
- Does the system correct or update inaccurate information in a timely manner?

3 NEEDFINDING RESULTS

3.1 Activity 1: User Survey

We were able to carry out the survey as planned using Georgia Tech's PeerSurvey platform. The survey was shared on the *Team Project (Needfinding) Recruitment Megathread* in Ed Discussion to reach classmates and provide participation credit. We also shared the public version of the survey with friends and family outside the class to diversify the participant pool. **In total, we collected 27 complete re-**

sponses, which provided a useful mix of frequent and occasional subway riders.

3.1.1 *Key Insights*

From the survey, we identified three key insights about what riders struggle with:

1. Riders need clearer guidance while they are actually on the train.
Many participants said they were unsure about which direction the train was going or when their stop was coming up, especially when transferring or riding unfamiliar lines. Several people mentioned missing stops or going the wrong way because the information was not clear in the moment when they needed it.

2. People use mobile apps a lot, but the information is not always accurate.
Most respondents use apps to check timings and plan their trip. However, many said the apps do not update reliably during delays or reroutes. Riders want real-time updates that match what is actually happening, not just scheduled times.

3. Noise and crowds make it hard to rely on just one type of announcement.
A lot of riders said that audio announcements can be hard to hear, and visual screens can be blocked or difficult to see during crowded times. This shows that important information should be provided in multiple formats—audio, visual, and mobile—so people do not miss it.

For full survey response data, see Appendix 16.2.

3.2 Activity 2: Interview

Transcripts of the interview can be found within the Interview Results of the Appendix. Certain portions have been redacted or adapted to maintain participant anonymity. The questions were asked in the same order as the ones provided in the Needfinding Plan.

3.2.1 *Insights*

There is a key feature between the interviewees and their responses. Many interviewees discussed the communication delay between their mobile application and the real-world system, noting that delays, emergency announcements, and schedule changes often go announced for many riders. Furthermore, many interviewees use a variety of different applications, not just the official application

provided by some carriers as they provide better route planning and tracking as well as real time updates. Several interviewees also explained that subway stations can be difficult to navigate because the physical mapping between location and the station is not always clear. This includes signage that is hard to see or inconsistently placed.

3.3 Activity 3: Heuristic Evaluation

We conducted a heuristic evaluation of the Toronto Transit Commission (TTC) subway system in Ontario, Canada. During this evaluation, we observed various forms of communication such as digital displays, audio announcements, and third-party apps to examine how well they align with Nielsen's heuristics.

3.3.1 *Visibility of System Status*

Under both normal operations and critical situations, the TTC and Seoul Metro frequently fail to communicate system status. While some stations have countdown displays to show train arrival times, many do not, including major ones such as Kipling station. This lack of displays, combined with the absence of an official mobile app, leaves passengers without any real-time updates or heavily dependent on third-party apps such as Google Maps.

This issue becomes worse during service interruptions. Riders often arrive at stations only to find unexpected track construction or reroutes requiring shuttle buses. This happens frequently because Google Maps does not accurately report subway disruptions. Although the TTC posts disruptions on their website, the information is difficult to navigate and often unclear regarding affected routes and time impact.

Seoul Metro shows similar issues. Disruption information is not provided consistently through on-train displays or apps; instead, users rely on push notifications, which may be delayed. As a result, the necessary information is scattered across different interfaces, creating a fragmented rider experience.

3.3.2 *Flexibility and Efficiency of Use*

Both the Toronto Transit Commission and Seoul Metro generally provide visual and audio information on board, offering a basic level of flexibility. However, beyond this, the user experience is largely identical for all users regardless of expertise. Critical limitations appear during underground breakdowns, where

only audio announcements are available due to lack of internet, which excludes passengers with hearing impairments.

Some Seoul Metro trains include screens, while others rely solely on audio announcements. Although transfer stations generally provide clear visual guidance—making it easier for novice riders to navigate—the system becomes more confusing when multiple train types operate on the same line. Most stations provide information in Korean and English, with major tourist hubs also offering Chinese and Japanese. However, when several train services share one line or when transfer routes are highly complex, passengers may struggle to determine which trains stop at which stations, resulting in significant navigation uncertainty.

3.3.3 *Error Prevention*

Seoul Metro does not consistently offer clear directional information to help riders choose the correct train. On Line A, for instance, the system displays the end station, the next station, or the major stations depending on the train—but not in a consistent manner. This inconsistency makes the interface confusing and prevents riders from confidently identifying the correct direction. In addition, delays are not always reflected in the schedule immediately, and the on-train display often shows only the current location rather than the expected arrival time.

4 INITIAL BRAINSTORMING PLAN

4.1 Approach

With the pain points and major user needs identified for the Subway Announcement System, the next phase of the design process is brainstorming. The goal of this phase is to generate a wide range of creative and practical design alternatives that could improve the travel experience for subway riders.

The team will use two brainstorming methods: individual and AI-assisted.

Individual Brainstorming: Each team member will come up with ideas on their own to freely explore different solutions without being influenced by others. Each session will last about 1–2 hours in a quiet setting, using free writing or quick sketches to jot down ideas. Team members will focus on the main user problems and avoid judging or filtering ideas too early. Everyone will aim to

come up with a good variety of ideas and share them on a shared Trello board. Since team members live in different parts of the world, Trello will function as an asynchronous collaboration space where dieas can be posted, reviewed, and discussed at any time. Everyone can post, review, and comment on ideas whenever they are available, and a deadline will be set for voting on the top three ideas to maintain project momentum.

AI-Assisted Brainstorming: To further expand the idea space, Large Language Models will be used to generate additional concepts. Prompts such as "Generate interface ideas to address confusion during subway travel" or "Suggest multimodal solutions for accessibility in noisy train environments" will guide the AI to produce relevant design directions. The AI-generated suggestions will then be reviewed, documented, and compared with the team's individually generated results.

4.2 Rationale

Combining individual and AI-assisted brainstorming allows us to get both human creativity and a broader range of ideas. Working individually helps ensure unique perspectives, while using a Large Language Model provides inspiration that team members may not have considered. The Trello board supports asynchronous collaboration across different schedules and time zones, helping maintain steady progress throughout the brainstorming phase.

4.3 Bias Mitigation

To reduce bias during brainstorming, the team will (1) generate ideas without initially judging or evaluating them, (2) compare each idea against needfinding results to ensure alignment with real user needs, and (3) rotate facilitation roles so each team members has an equal opportunity to guide discussions and share perspectives.

5 BRAINSTORMING RESULTS

Each team member was tasked with generating ideas to address the major pain points uncovered during our needfinding phase. These included:

- Riders need clearer, more timely guidance while they are actually on the train.
- Riders rely heavily on mobile apps, but the information is often inaccurate or delayed.
- Subway environments are loud and crowded, making it difficult to rely on a single modality for announcements (e.g., audio only).

During the brainstorming process, the team collectively generated approximately **19 ideas**. Examples included:

- "Use airline-style notifications: push alerts, text messages, and emails that keep riders continuously updated."
- "Integrate Google Maps–style navigation similar to Japan's transit apps used by tourists."
- "Interactive Map Mobile Application showing real-time train positions."
- "Progress Bar Map that displays live movement between stops and highlights transfers."
- "Vibration Alerts for upcoming stops, improving accessibility for riders with vision or hearing impairments."
- "Wrong Direction Alerts using live location tracking."
- "Crowd-Sourced Real-Time Train Status, similar to Waze but for subways."

Several ideas overlapped, so we consolidated them into distinct categories before voting. After all members shared their proposed concepts, we conducted a team vote and selected the top three ideas to move into the medium-fidelity prototyping phase.

5.1 Summary of the Three Selected Prototypes

The three chosen design alternatives address our needfinding themes by combining accurate real-time information, multimodal alerts, and reduced cognitive load:

- **Prototype 1 – Real-Time Navigation App with Haptic Alerts**
  A system-provided navigation app that includes live route guidance, service alerts, haptic feedback before stops, and error-recovery through wrong-direction

detection.

- **Prototype 2 – Crowdsourced Subway Information App**
  A mobile application where riders submit and verify real-time updates, delays, emergencies, and platform conditions, similar to a Waze-style transit experience.
- **Prototype 3 – Hybrid System: Real-Time + Crowdsourced Data + Enhanced Visual Guidance**
  A comprehensive system combining Prototypes 1 and 2, integrating official alerts, rider reports, progress bars, elevator/escalator status, exit photos, and multimodal cues to reduce uncertainty and cognitive load.

6 INITIAL PROTOTYPING

6.1 Prototype 1

This prototype, created with Figma Make, presents a mobile application where users interact with a map-based interface to input their current location and destination. From this information, the app will provide users with route guidance and real-time service alerts coming from the subway service provider itself.

This design is grounded in three core principles from the course: feedback, perceptibility, and tolerance. Feedback is implemented through haptic alerts that vibrate one stop before the user's destination, providing a non-visual cue that does not require constant screen attention. This helps provide a non-visual cue that does not require constant screen attention. The design also puts an emphasis on system perceptibility by giving users clear visual indicators of service alerts, track work, and delays displayed directly within route options. This aligns with our needfinding results that showed passengers sometimes arrive at stations unaware of service disruptions. Tolerance helps users recover from mistakes: if a user boards a train traveling in the wrong direction, the app detects this through location tracking and sends an immediate alert telling them what action to take to get back on the right track.

The design also intentionally embraces simplicity and keeps visual elements minimal to avoid overwhelming users. The map provides context without excessive detail, and route information appears in expandable panels rather than being displayed all at once. Overall, this aims to reduce the cognitive load associated with navigating unfamiliar or disrupted subway systems.

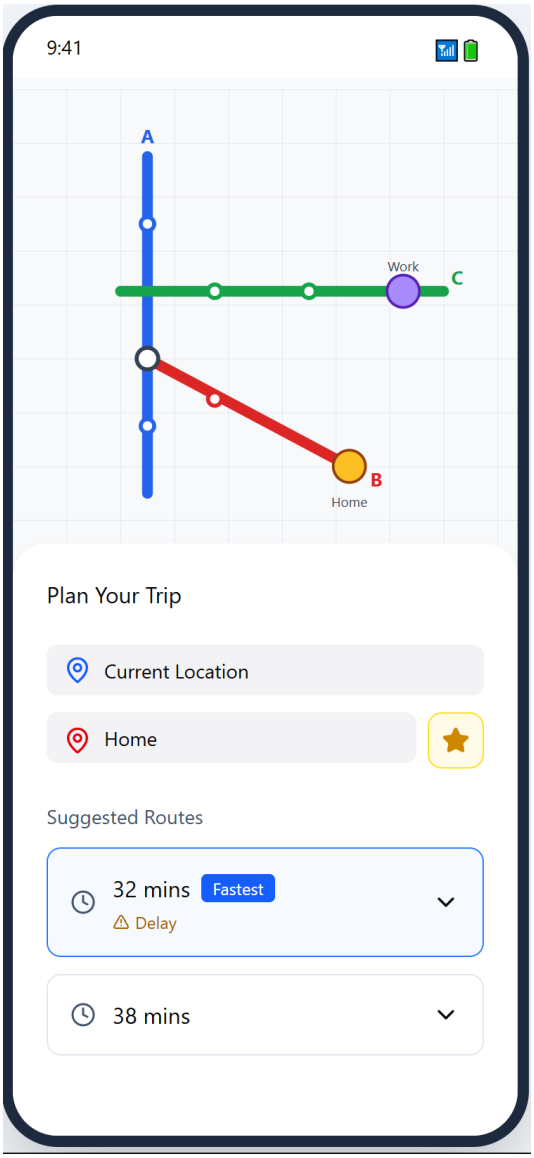


Figure 1—Prototype 1

6.2 Prototype 2

For this prototype, an approach to design a subway mobile application was used, but with a slight twist. This application allows users to view current timetables and routes. However, unlike most subway applications, information does not come from the subway. Instead, information is crowdsourced from other riders. This prototype can be viewed on Figma. Figures can be found within Figure 10. An example is shown below.

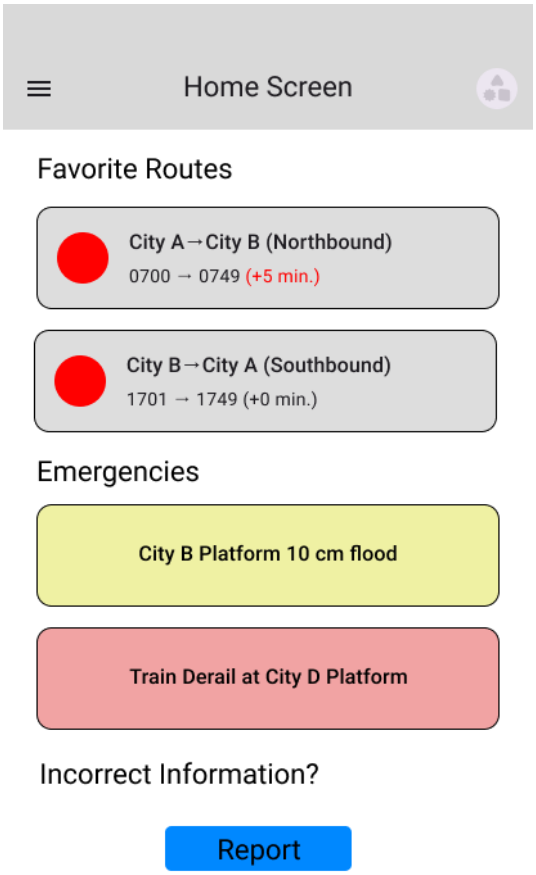


Figure 2—Home Screen

6.2.1 *System States*

Within this system, users are shown the home screen upon launching the app. The home screen displays any favorite routes they take or frequently used commutes, determined using a simple learning algorithm based on frequency and consistency.

The home screen will also display emergencies relevant to a user's route. For example, if a user takes Route A and another user reports maintenance-related delays, this information will be shown to everyone. Routes are color-coded to help users understand which line they need to take and the timing of that route, including delays. Emergencies are also color-coded by severity: yellow for minor impacts and red for major impact, affixed with timetables. Users can vote on reports to determine accuracy, and those who repeatedly submit false information will be barred from further reporting. Users who repeatedly dishonestly report false information will be barred from reporting any further issues.

The menu allows users to navigate to screens for reporting delays or emergencies. In the delay-reporting screen, users can select between early arrivals or delays and then input a number based on the hour, minute, and seconds. In the emergency-reporting screen, users report issues by selecting the route's platform, describing the issue, and providing severity information..

The route-creation screen allows users to search and plan new routes, as well as save them for easy access. This prototype aims to reduce cognitive load: during peak hours, stations can be noisy and signs difficult to see, which overwhelms users. This application allows users to access necessary information quickly and clearly, making it easier to determine where they are.

6.3 Prototype 3

Prototype 3, created with Figma Make, is based on Prototype 1's basic flow, but it focuses on reducing uncertainty and anxiety during transit by providing richer and more comprehensive information, including Prototype 2's crowd sourced updates. The core design intention is to provide an experience that allows users to clearly grasp "Where am I now?", "Where should I go?", and "What should I expect ahead?" This prototype can be viewed on the Figma link here.

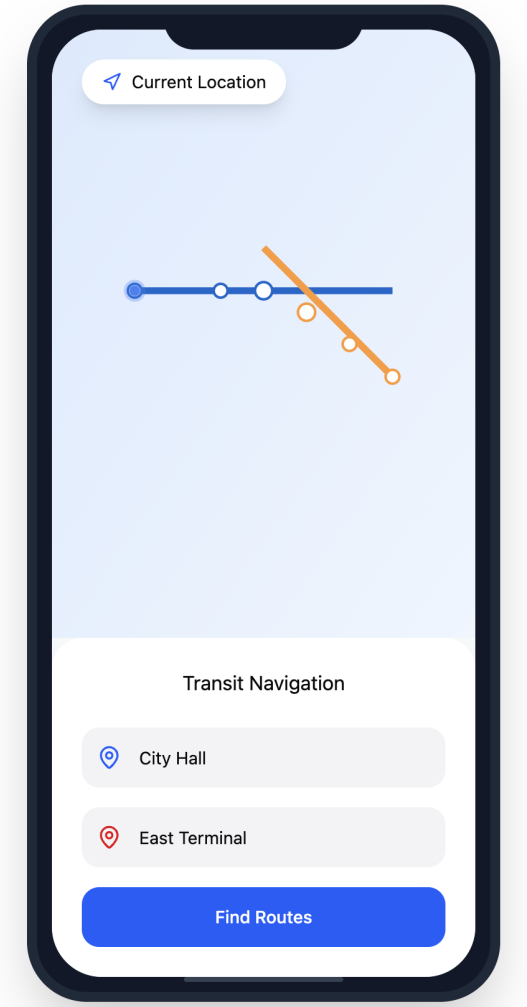


Figure 3—Prototype 3: Home Screen

6.3.1 *Key Features*

Users can enter their departure and destination on the map that displays their current location, and choose between multiple route options including recommended or shortest paths. When the trip starts, the user's current location and trip progress are intuitively displayed through the progress bar. A combination of crowd-sourced information and system data offers real-time updates on delays, elevator/escalator availability, construction, and other trip-relevant conditions. It also provides visual cues to minimize confusion during actual trips, such as photos of exits and transit areas, and surrounding terrain.

Users can also confirm their current location directly on the map, and if they move in the wrong direction, a warning will display with haptic feedback. Additionally, users can participate in the crowdsourced ecosystem by submitting updates on delays, congestion, construction, elevator/escalator status, exit photos, and more—expanding the shared information ecosystem.

6.3.2 *Design Rationale*

Multiple principles were embedded in Prototype 3: visibility of system status, error prevention, and recognition rather than recall.

Visibility of system status is essential. Progress bars, route color changes, and real-time notifications reduce uncertainty and prevent users from guessing the current state. This immediately addresses the question, "Where am I now?", often the highest source of transit anxiety.

Error prevention is supported through wrong-direction detection and prior-risk notifications. Users can avoid problems before experiencing them rather than reacting afterward.

Recognition rather than recall is implemented by providing visual elements such as exit photos, transfer structures, and surrounding terrain. These help users understand navigation cues at a glance without relying on memory, greatly reducing anxiety in unfamliar stations.

7 EVALUATION PLANNING

To assess the strengths and weaknesses of each prototype, our team will conduct a user survey. This survey will gather both quantitative and qualitative feedback from participants and help us determine which design to move forward with.

7.1 Recruitment and Logistics

The target population of this survey includes people who use the subway at least once per week. For this project, we will mainly rely on convenience sampling to find participants. This will be done through multiple channels, including the Ed Discussion forum, class Discord channels and personal connections.

Our main strategy to incentivize participation is through feedback exchange. In each recruitment post we will offer to fill out the surveys of other teams who participate in ours. The survey will be created using Georgia Tech's own PeerSurvey tool, which ensures that participants can easily receive their credits.

7.2 Evaluation Questions

In the survey, participants will be asked to view and try out our three interactive prototypes created with Figma. Afterwards, they will answer a series of questions, including both quantitative and qualitative ones. For each prototype, the quantitative portion consists of four 5-point Likert-scale questions, ranging from Strongly Disagree (1) to Strongly Agree (5):

- I could quickly figure out how to use this prototype
- I found the information clearly presented
- I would trust the information provided by this system
- I would use this solution if it were available

The qualitative portion of each prototype includes two open-ended questions:

- What do you like most about this design?
- If you could change something to improve it, what would it be?

After this series of individual questions on each prototype, participants will be asked which one they prefer and why. This will help us identify which design addresses user needs most effectively and can thus serve as the basis for our next iteration. Finally, participants will also rate their overall confidence in the ratings they provided across all prototypes using the same Likert scale. The survey is

expected to take approximately 10 minutes to complete. The full list of questions can be found in Appendix 16.4

7.3 Analysis Plan

For this plan of analysis, there is a plan to determine whether there is a difference between each of the prototypes. Four different null hypotheses will be postulated: The usability (clarity of information, trust of information, or ease of figuring out the system) will be equal between each prototype treatment. The alternative hypothesis postulates that each of these four factors will be unequal from treatment to treatment.

Using a χ^2 test is optimal here, as each quantitative data is ordinal (dependent variable) and each treatment, the prototypes, are categorical (independent variable). The p-value of the χ^2 test will be used, and this p-value represents the probability that the observed results occurred due to random chance. Thus, a p-value of 0.05 or lower will be used to help reject the null hypothesis; a p-value of 0.05 represents that the results are unlikely to occur due to random chance, and anything greater represents the likelihood of randomness playing a role.

If the χ^2 test fails to rule out any randomness, then the fallback question, "Which prototype is your favorite?", will be used to determine which prototype should be used in the next iteration.

8 EVALUATION RESULTS

Evaluation results can be found within Appendix's Figure 15 and Table 16.2.1.

8.1 Respondents & Recruitment

In total **15 respondents** completed the survey. Respondents were surveyed via Ed Discussions and PeerMark; this proved to be an effective recruitment strategy, as respondents were incentivized to answer through PeerMark to receive participation credit for Dr. Joyner's HCI class.

8.2 χ^2 Test

The p-values between each prototype's ease of figuring things out, clarity of information, trust of information, and likelihood of usage are **0.520, 0.803, 0.666, and 0.170**, respectively. Because the p-value is greater than 0.05 for each of the tests, the null hypothesis cannot be rejected in this case for any factor.

For future iterations, a larger sampling population should be used to reduce the likelihood of randomness. A larger dataset would lower deviation between data points and provide a more accurate representation of user responses.

8.3 Fallback test

However, in anticipation of this, a supplemental question was asked to respondents: "Which prototype is your favorite?" Using the mode of this dataset, it is discovered that **Prototype 3** is the most preferred. Thus, Prototype 3 should be used moving forward.

8.4 Qualitative Evaluation

Respondents liked *Prototype 1* for its simplicity, though many noted that the interface could be improved to better support routing and related tasks. *Prototype 2* was praised for its crowd-sourced features, trip-creation assistance, and overall UI, but respondents also pointed out that several buttons and interface components need refinement. Additionally, some participants mentioned that parts of the design were difficult to understand, which affected overall ease of use.

For *Prototype 3*, respondents appreciated the clean layout and how easily accessible the information was. However, several users felt the initial screen appeared cluttered and wanted **clearer navigation**, **notifications**, and **warning systems**.

8.5 Biases

Because this survey was optional and respondents mostly came from the HCI course, respondents are more likely to be tech-literate. Being tech-literate means that users may be more tolerant of modern or complex interfaces and less tolerant of the converse. Thus, voluntary response bias may have been introduced, as respondents may have stronger or more polarized opinions about how to respond.

9 SECOND ITERATION PLANNING

After completing the first iteration of the design life cycle—needfinding, brainstorming, prototyping, and evaluation—we now move into planning the second iteration. The quantitative evaluation showed that the χ^2 tests for ease of use, clarity, trust, and likelihood of use all resulted in p-values above 0.05, indicating no statistically significant differences among the prototypes. Because the statis-

tical results alone did not establish a clear "best" prototype, we relied on the fallback preference question to guide next steps. The fallback results showed that Prototype 3 was the most preferred overall, establishing it as the foundation for the next phase of design work.

9.1 Updated Insights From Evaluation

User feedback from the evaluation revealed several important needs that were not fully addressed by any single prototype:

- clearer navigation and reduced visual clutter (Prototype 3 feedback),
- better routing support and contextual guidance (Prototype 1 feedback),
- more intuitive UI components and clearer button meanings (Prototype 2 feedback),
- stronger notifications, alerts, and warning systems.

These findings highlight usability issues that now serve as the new needfinding for this iteration.

9.2 Plan for the Second Iteration

For the second iteration, we are mainly focused on improving the parts of the design that users had trouble with. We will still use Prototype 3 as our base, since most people liked how it looked and felt. However, rather than refining Prototype 3 in isolation, we will integrate high-value elements from Prototype 1 and 2 to strengthen the design.

For example, Prototype 1 had clearer routing help, which many users wanted, so we will bring that into Prototype 3. Prototype 2 introduced a more guided flow and more explicit button explanations, so we will adopt those improvements to make interactions easier to understand.

Along with combining the best ideas, we will also resolve the main usability issues identified in feedback. This includes cleaning up crowded screens, organizing information better, and making sure important details stand out. We will also update buttons and icons to make them clearer, and make sure the overall layout feels more intuitive. Routing guidance will be improved so users always know where they are and what to do next, and we will strengthen the alert system so important messages are easy to notice and understand.

By the end of this iteration, we aim to produce a prototype that is clearer, more

streamlined, and more aligned with the needs of real subway riders. After implementing these updates, we will conduct another round of evaluations to determine whether the revisions measurably improve usability and overall user experience.

10 FINAL PROTOTYPE

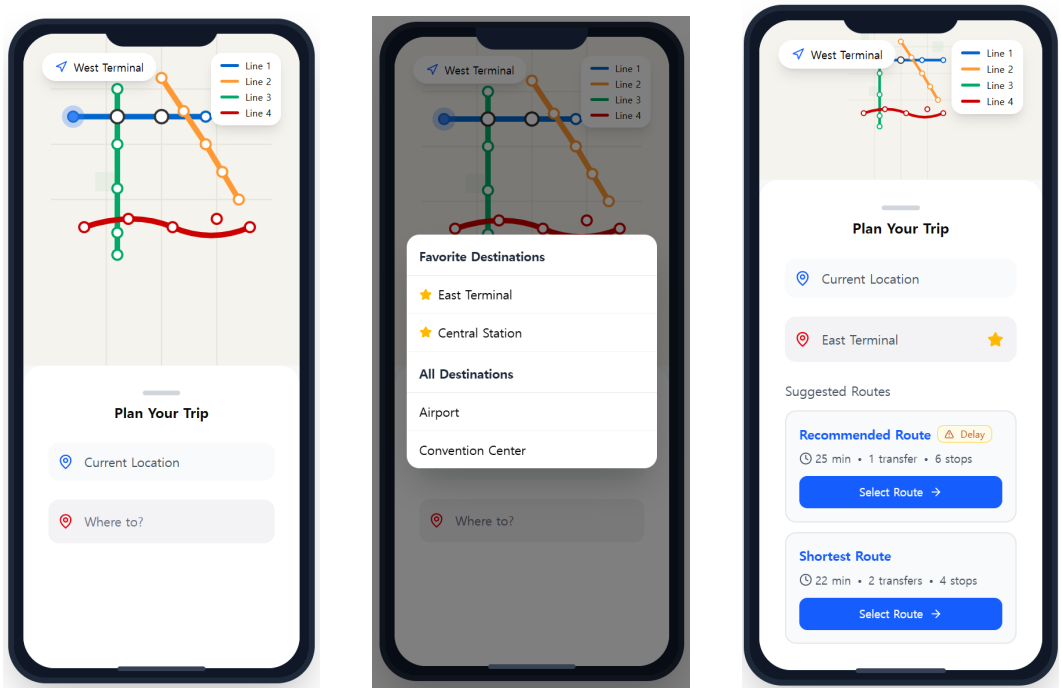
The final prototype is primarily based on Prototype 3, which received the highest number of positive evaluations, while integrating the clearer structure and simplified home screen layout from Prototype 1. We addressed the issue of dense route information by reorganizing the hierarchy so detailed content appears progressively, rather than all at once, allowing users to access depth when needed without being overwhelmed. The crowd-sourced information feature is preserved and refined to prioritize verified or essential updates, improving reliability. Overall, the design emphasizes surfacing the most actionable information first, while minimizing elements that interfere with the rider's experience.

10.1 Home Screen

The home screen is designed with an intuitive map-first layout. Users can immediately understand their current location through the map and the purpose of the app is clear with the Start and Destination input fields anchored at the bottom, mirroring common navigation app conventions. Adopting Prototype 1's clarity, favorite routes and recent trips appear only after the user opens the destination selector, keeping the main interface clean.

After searching, users can compare various options, such as recommended and shortest routes. Each route is marked with total time, number of transfers, station count, and delay status, making comparison effortless.

To better support situation awareness, the home screen displays real-time position, nearby stations, and system alerts directly on the map, matching the user's physical movement. The destination list and favorites minimize memory burden by surfacing frequently used places automatically, supporting efficient interaction. In general, the key is to clearly convey what users should do next the moment the app launches.



(a) Initial Screen *(b)* Destination Options *(c)* Route Selection

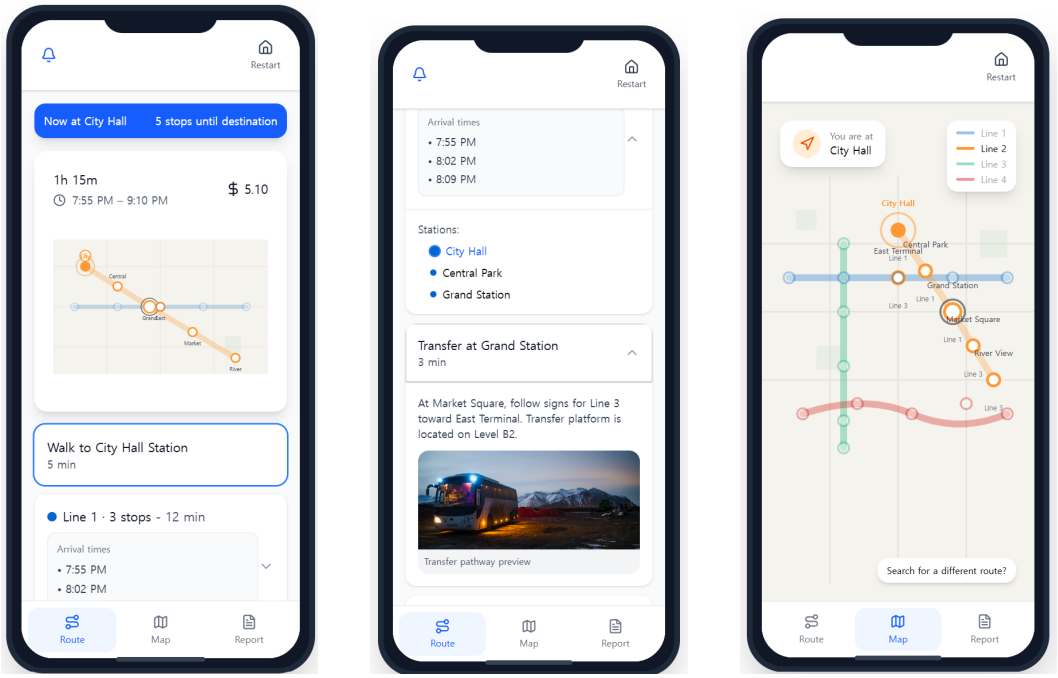
Figure 4—Final Prototype - Home Screen

10.2 Route and Map Tab

The Route tab follows the principle of offering enough information while preserving visual breathing room. At the top, essential information such as current station, remaining stops, and next transfer are immediately shown. The trip overview includes travel time, arrival estimate, fare, and a simple illustrated journey indicator.

Below this, each trip component is divided into expandable blocks containing more detailed information such as station lists, transfer photos, and exit guidance. The user's current segment is visually highlighted to make progress tracking effortless.

The Map tab complements the Route tab by offering a spatial, geography-based view of the journey. Only the current station and major route path are displayed to maintain clarity. Its main purpose is to help users quickly situate themselves geographically with minimal UI clutter.



(a) Route Tab *(b)* Route Tab Details *(c)* Map Tab

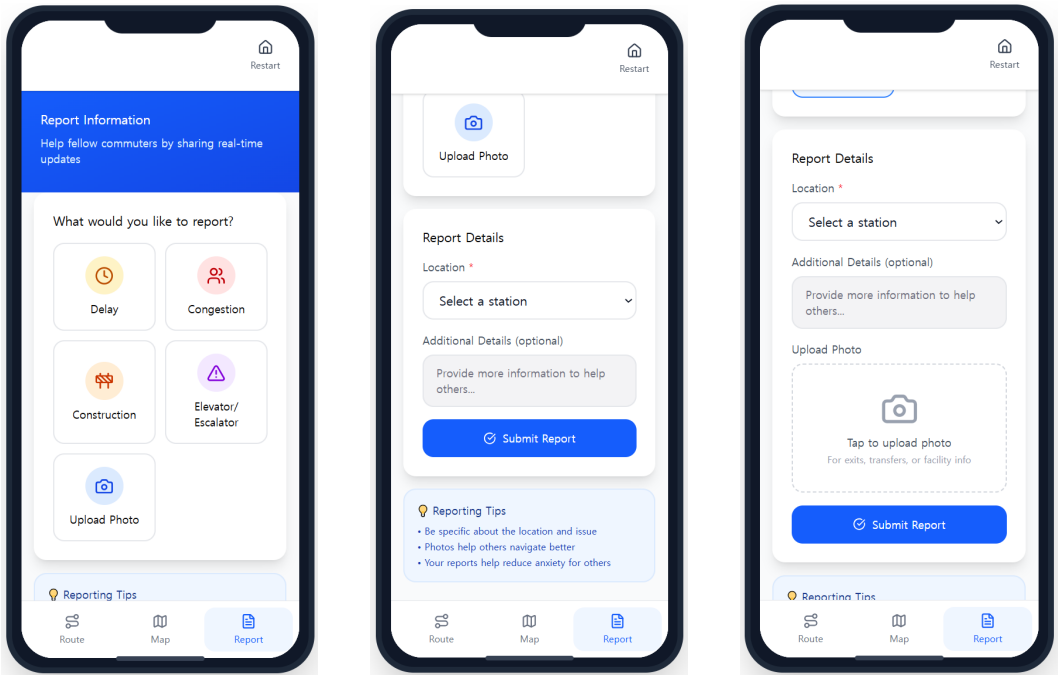
Figure 5—Final Prototype - Route / Map Tab

The Route tab adopts a progressive disclosure structure, showing only the most critical information first. Consistent card formatting and transfer visual reduce user confusion and prevent navigation errors. Highlighted boarding sections convey real-time status at a glance, while the Map tab reduces visual fatigue by showing only what is necessary.

10.3 Report Tab

The Report tab allows users to contribute real-time updates that enhance the overall reliability of the system. Users can report issues such as delays, congestion, construction, elevator/escalator status, or exit photos.

To improve clarity, users now select from category icons and then fill in details such as location and description. Since these functions may be unfamiliar, the Report tab includes inline guidance tips that explain how reporting contributes to system accuracy.



(a) Initial Screen *(b)* Default Input *(c)* Photo Input

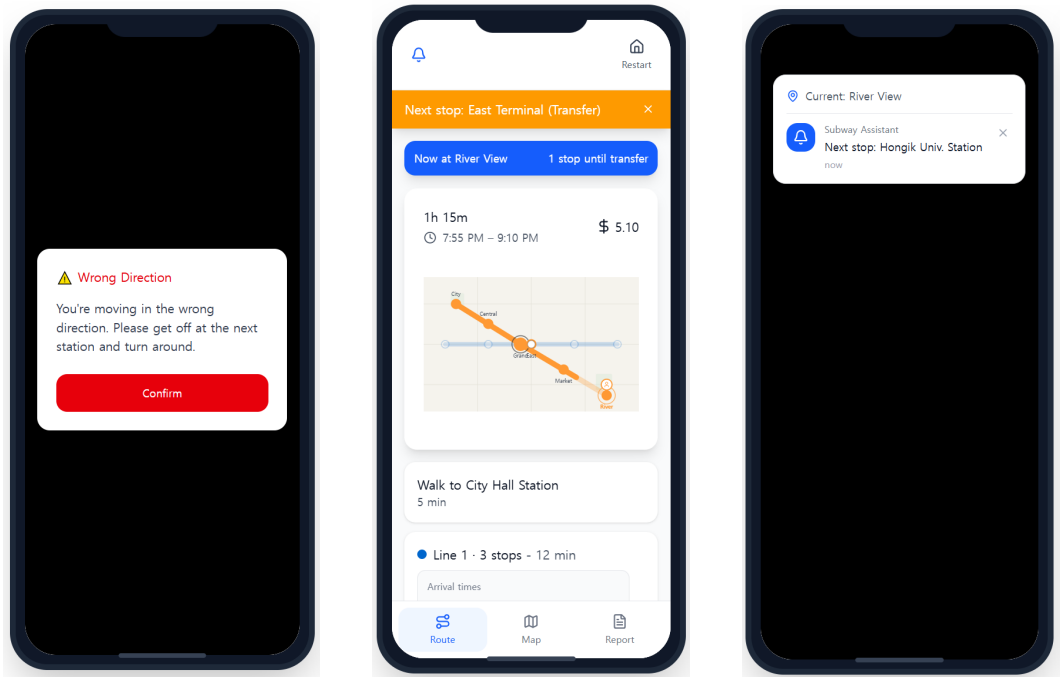
Figure 6—Final Prototype - Report Tab

The combination of user reports and system data provides a more complete and dynamic understanding of real-time travel conditions. This structure forms an ecosystem in which riders help each other and collectively improve system accuracy. Reported information is incorporated into the latest state of the system, boosting situational awareness and reducing avoidable mistakes.

10.4 Alerts and Notifications

The app uses multiple alerts and notifications to inform users of essential conditions. When users move in the wrong direction, an immediate warning with vibration is triggered. As transfers or arrival stations approach, the app again notifies the user with vibration and a modal alert.

Even when the app is minimized, lightweight persistent banners provide key information such as current station or remaining stops. Users may dismiss minor notifications, but the app will still display critical alerts, including transfer instructions, arrival notices, and wrong-direction detection.



(a) Initial Screen *(b)* Default Input *(c)* Photo Input

Figure 7—Final Prototype - Alert / Notification

Because wrong-direction mistakes are among the most disruptive subway issues, the app provides instant corrective feedback when detecting them. Notifications are designed to sustain awareness of system status, and less important alerts can be turned off, giving users a balance between assistance and autonomy.

11 VIDEO PROTOTYPE

11.1 Video Link

The Video Prototype can be accessed at Georgia Tech Mediaspace.

12 FINAL EVALUATION PLANNING

12.1 Recruitment

The recruitment process and survey structure will remain largely consistent with the previous round. We will again aim for approximately **20 participants**, mainly through Ed Discussion and personal networks. The survey will still be conducted through PeerSurvey to ensure automatic participation credit for students and to maintain full anonymity to anyone who participates. We will also continue incentivizing participation through survey exchanges, offering to complete other students' surveys in return.

12.2 Evaluation Questions

To assess whether our final prototype addresses concerns from the previous evaluation, we retained most of the questions, including:

- Four quantitative Likert-scale questions regarding ease of use, clarity of information, trust, and likelihood to use
- Two open-ended qualitative questions regarding what participants like most and what they would change

This consistency allows us to evaluate the final prototype using the same usability dimensions that guided earlier design decisions. This enables a direct comparison between evaluation and helps us determine whether meaningful improvements were achieved. We also added three new Likert questions targeting weaknesses identified in Prototype 3's feedback: the home screen, navigation, and notifications. This is further reinforced by an additional open-ended question asking participants to describe any issues they face with those three areas. The full list of questions can be found in Appendix 16.1.3

12.3 Hypotheses

The null hypotheses presented here are the ease of figuring things out, clarity of information, trust of information, likelihood of using the prototype, the organizational elements, navigational elements, and understanding of warnings and notifications will not show significant change compared to the previous evaluation. The null hypothesis can be rejected if the p-value is < 0.05, indicating the results are unlikely due to randomness. If rejected, this would support that the final prototype meaningfully improved usability.

12.4 Tests

A Wilcoxon test will be performed between the data. Because the data recorded is of an ordinal type and there is only a single prototype condition, a χ^2 test cannot be used. The Wilcoxon test will be used instead to properly evaluate results, allowing each metric to be measured against its midpoint to more accurately determine whether the null hypothesis can be rejected (Hessing, n.d.).

This prototype will also be evaluated on a qualitative basis to better capture information about user sentiments about this final prototype. Responses will be analyzed to identify recurring themes that represent widespread concerns versus individual preferences. These insights will help pinpoint remaining usability issues and validate the strengths of the current design.

13 FINAL EVALUATION RESULTS

Evaluation results can be found within Figure 16 and Table 16.2.1 for quantitative results and qualitative results, respectively.

13.1 Respondents & Recruitment

In total 20 respondents answered the survey. Respondents were surveyed via Ed Discussions and PeerMark; this was an effective recruitment strategy as respondents are incentivized to answer through PeerMark to receive participation credit for Dr. Joyner's HCI class.

13.2 Quantitative Analysis

The p-values for each metric: the ease of figuring things out, clarity of information, trust of information, usage of this prototype, the organizational elements, navigational elements, and understanding of warnings and notifications are $2.89 * 10^{-4}$, $7.93 * 10^{-5}$, $8.21 * 10^{-05}$, $1.92 * 10^{-4}$, $8.21 * 10^{-05}$, $1.17 * 10^{-4}$, and $1.26 * 10^{-4}$, respectively. Because the p-values were less than 0.05 for all metrics, it can be concluded that each null hypothesis can be disproved for all metrics, and the alternative hypothesis can be accepted for each measured metric: for a given metric, this prototype's design is unequal compared to a neutrally viewed prototype. Examining the results further, it is clear that inequality is a result of the final prototype's design exceeding in all metrics measured. Thus, this prototype's design can be seen as performing better than the median design.

13.3 Qualitative Analysis

Respondents generally enjoyed this prototype and offered minor suggestions for improvement. Users noted that the prototype was not entirely free of bugs, as some errors occurred during use. One user suggested that certain UI/UX elements should be revised because some information conflicted or was difficult to interpret, and another user recommended adding a feature that more clearly reminds riders when they are moving in the wrong direction.

13.4 Biases

Because this is an in-situ evaluation with predefined conditions and warnings, respondents may have responded more favorably than they would in a real-world setting. An ex-situ study may produce different reactions from users. Furthermore, because this survey was optional and respondents primarily came from the Human Computer Interactions course, participants may have a stronger knowledge of good design practices, which may influence their opinions more strongly. Thus, voluntary response bias may have affected the results.

13.5 Next Steps

This analysis concludes the second stage of the evaluation cycle. If this project continues in a higher-fidelity iteration, the next steps would include addressing user feedback by refining navigational flows, improving UI/UX elements, and incorporating additional features to support usability. The next evaluation phase should also involve testing the system in a real or simulated external environment to support ex-situ testing. This would allow designers and developers to better understand system performance under realistic conditions, where interface errors, recovery behavior, and contextual factors become critical to the user experience.

14 CONCLUSION

This project followed an iterative, user-centered design process to address the persistent challenges riders face when navigating subway systems. Needfinding revealed issues such as unclear guidance, inconsistent real-time information, and difficulty interpreting announcements in crowded or noisy environments. These insights informed the development of three initial prototypes, which were evaluated and then refined through structured surveys and user feedback.

While the first evaluation did not show significant quantitative differences across prototypes, qualitative responses helped us identify the strengths that shaped the final design direction. The second iteration improved the information hierarchy, navigation clarity, and alert mechanisms. The final evaluation showed statistically significant gains across multiple usability measures, indicating that the revisions meaningfully enhanced the system's overall effectiveness.

Ultimately, this project demonstrates the strength and necessity of an iterative, user-centered design approach in solving complex transit communication problems. By grounding every stage of development in real user needs, systematically testing our assumptions, and refining our prototypes through measurable evidence, we produced a system that is not only more usable, but fundamentally more supportive for riders navigating dynamic subway environments. As transit systems continue to evolve, solutions like ours highlight how thoughtful interaction design can meaningfully improve public transportation experiences.

15 REFLECTIONS

15.1 William Chen

15.1.1 *Contributions*

Within this project, I worked on brainstorming all survey questions. In addition to this, I developed Prototype No. 2 for the first round of evaluation. I also helped in writing some of the sections for this document (Appendix Figures, Prototype Figures, Tables, and Qualitative/Quantitative analyses). Lastly, I helped perform the χ^2 tests and Wilcoxon tests for the analysis of the surveys.

15.1.2 *Other's Contributions*

Cheng-I helped develop the needfinding survey, solicit responses for surveys, and helped with write-ups. Cheng-I also helped me with data analysis by retrieving data for analysis. In addition to this, Cheng-I helped with brainstorming questions for all surveys.

Woo Bin helped facilitate ideas and organizing things through Trello. Woo Bin also helped with proofreading and writing some sections of the document to ensure everything flowed smoothly and sounded correct. In addition to this, Woo Bin helped brainstorm survey questions and solicit responses from other users.

Quan Do Minh helped with brainstorming for every question through Trello. In addition to this, Quan Do Minh helped with writing out some sections of the team project. Quan Do Minh also helped create the first and second evaluation surveys and solicited for both surveys. Lastly, Quan Do Minh also helped out by creating Prototype No. 1, which was included in the survey.

Hye Ri Woo helped in brainstorming for every question through Trello. In addition to this Hye Ri Woo created both Prototype No. 3 as well as the Final Prototype for us to use for surveying. Hye Ri Woo also helped out in writing some sections of the final deliverable.

15.1.3 *Overall Reflection*

Overall, I believe our team worked well together as we all complement each other's strengths and weaknesses. All our deadlines for each check-in were met, and everyone contributed to the development of survey questions and the proto-

types. Something that could have worked better is our communication between what we needed to work on, but that is a problem of time zones as we are scattered across different time zones. I believe something that would have helped was a better understanding of the context and system that each person had a mental model of, as not everyone had the same idea of a subway as the other. Prior to the start of this project, I wish we had known what type of subway system we were prototyping this off of as we each come diverse backgrounds, as a result, it is hard to capture the strengths and weaknesses of other systems.

15.2 Cheng-I Ma

15.2.1 *Contributions*

For this project, I contributed by pitching in with project ideas and survey questions, and recruiting participants to complete the surveys. I also actively participated in group discussions, shared feedback on design decisions, and helped proofread my teammates' work to improve clarity and consistency across the report. For the written portions of the project, I worked on the Needfinding Plan and Needfinding Results for the survey portion, the Initial Brainstorming Plan, the Brainstorming Results, and the Second Iteration Planning section. Overall, my contributions were focused on research, writing, and coordination within the group, helping move the project forward while supporting my teammates along the way.

15.2.2 *Other's Contributions*

William Chen was mainly responsible for developing the survey questions and handling the survey analysis. He built Prototype 2 for the first round of evaluation and also helped with figures, tables, and analysis sections in the report. In addition, he ran the statistical tests used to analyze the survey data.

Woo Bin Park helped organize the team's workflow by managing Trello and ensuring tasks were clearly tracked. He also contributed to brainstorming survey questions, recruiting participants, and proofreading multiple sections of the report to improve clarity and flow. In addition, he created the video presenting the final high-fidelity prototype of the Subway Announcement System app.

Quan Do Minh Phan worked on both design and research tasks. He wrote the needfinding section for the TTC subway station, built Prototype 1 in Figma, and helped design both evaluation surveys. He also played a major role in collecting

survey responses and helping organize work through Trello.

Hye Ri Woo focused mainly on prototyping and visual design. She created Prototype 3 and the final version of the prototype used in the project, and also contributed to writing and editing sections of the final report.

15.2.3 *Overall Reflection*

I feel fortunate to have worked with a group of talented and hardworking teammates on this project. Everyone was easy to work with and eager to contribute, which created a positive and supportive team dynamic. Task distribution went smoothly, and whenever someone needed input or help, posting in the Discord group usually led to quick responses, suggestions, or feedback from others.

Working across different time zones was one of our main challenges. Because of the time differences, communication was sometimes delayed and discussions could take longer than expected. Still, everyone made an effort to respond when they were available, and we did our best to stay coordinated despite the distance.

If I could point out anything to improve, it would be learning earlier about some of the technical limits of tools like Figma. Even then, my teammates quickly found workarounds, and it didn't stop us from making progress. Overall, I'm grateful for the collaboration experience and proud of what our team was able to accomplish in producing a strong final result.

15.3 Woo Bin Park

15.3.1 *Contributions*

For this project, I was responsible for forming the team by recruiting members and coordinating early communication through email and private messages. I also held individual calls with teammates to establish rapport, clarify expectations, and ensure everyone felt aligned before work began. Throughout the project, I organized and maintained the Trello board, helping the group keep track of tasks, deadlines, and responsibilities. In addition, I proofread and rewrote multiple sections of the report to improve clarity and coherence across the document. My role focused heavily on team coordination, communication, and quality control to support overall workflow and keep the project running smoothly.

15.3.2 *Other's Contributions*

William Chen: William led the statistical analysis, created Prototype 2, and contributed to the survey design and evaluation.

Cheng-I Ma: Cheng-I contributed substantial writing, research, and coordination across needfinding and evaluation phases, including drafting multiple report sections and helping with survey development and analysis.

Quan Do Minh: Quan developed Prototype 1, designed surveys, and wrote major sections of the needfinding and design documentation.

Hye Ri Woo: Hye RI created Prototype 3 and the final high-fidelity prototype, and wrote parts of the deliverables as part of the documentation.

15.3.3 *Overall Reflection*

Our team worked effectively together, and I appreciate how everyone remained willing to communicate, share ideas, and support one another. Despite differences in schedules and communication styles, we stayed coordinated through consistent updates and shared tools.

One area that could have been improved was balancing our design discussions. Not all ideas aligned with the final direction at first, but we put in the effort to establish a shared vision of how the subway system should look given our varied backgrounds. These discussions were valuable, and they ultimately contributed to refining the final prototype.

Before starting the project, I did not have extensive experience with subways. My closest point of reference came from my experience with flight systems, since I frequently traveled internationally and became familiar with how different airports present informational interfaces. I am glad that we were able to adapt some of these ideas to a different context such as subway transit.

15.4 Quan Do Minh Phan

15.4.1 *Contributions*

I wrote the needfinding section covering the TTC subway station. In addition, I built medium-fidelity prototype 1 in Figma. I also designed both evaluation surveys and was primarily in charge of filling out other teams' surveys to get

feedback for ours in return. Beyond that, I participated actively throughout the project, voting on design decisions, and helping organize the Trello board.

15.4.2 *Other's Contributions*

William Chen: Conducted needfinding interviews, brainstormed survey questions, created Prototype 2, wrote and proofread various sections and performed all statistical analyses.

Cheng-I Ma: Designed the needfinding survey, recruited participants, wrote the Needfinding Plan/Results, Initial Brainstorming Plan, Brainstorming Results, and Second Iteration Planning sections, and proofread teammates' work.

Woo Bin Park: Formed the team, organized discussions and managed the Trello board, brainstormed survey questions, recruited participants, wrote and proofread various sections of the deliverable.

Hye Ri Woo: Came up with the idea for the project, participated in brainstorming sessions, created Prototype 3 and the final prototype, wrote and proofread various sections of the deliverable.

15.4.3 *Overall Reflection*

What worked well: Team members were responsive and took initiative on their parts without needing constant check-ins. In addition, since everyone had already done the individual project, we knew what to expect at each phase, which made things run smoothly. Overall, I feel very fortunate to be a part of this talented and responsible team.

What could have worked better: The initial prototyping phase could have been more coordinated. We didn't discuss which tools to use beforehand so the prototypes ended up with different styles.

What I wish I had known: If I'd known we'd be working on a mobile app prototype, I would have taken a course in mobile development so we could actually build and deploy a functional app instead of just mockups.

15.5 Hye Ri Woo

15.5.1 *Contributions*

I came up with the initial idea for this project and wrote the needfinding plan and the needfinding section covering the Seoul Metropolitan subway stations. I also built for medium-fidelity Prototype 3 in Figma and contributed to the write-up. Finally, I developed the final prototype based on the evaluation results.

15.5.2 *Other's Contributions*

William Chen: William participated in brainstorming survey questions, produced Prototype 2, and contributed mainly to statistical analysis and analysis-related documents.

Cheng-I Ma: Cheng-I designed needfinding surveys, and recruited responses, wrote several documents sections, and calibrated to improve the completeness of the report.

Woo Bin Park: Woo Bin coordinated team communication and scheduling, ran Trello, and contributed to remediation work to refine the flow and representation of documents.

Quan Do Minh: Quan produced Prototype 1, designed an evaluation questionnaire, and participated in recruiting responses and writing documents related to Needfinding.

15.5.3 *Overall Reflection*

Our team continued to collaborate by respecting each other's ideas and constantly exchanging opinions. As each person thought based on the subway system of the city they were familiar with, the concept and standards were slightly different in the beginning, and there was a lack of consistency, but through continuous discussion, we were able to organize common user experiences and unify the direction.

In the process of repeatedly improving the prototype, each team member's strengths were naturally revealed, and the results were significantly improved as various capabilities such as design, analysis, and organization were harmonized. In particular, we were able to quickly find better options because we were open to proposals and gave each other feedback.

Despite the overall time zone difference and the difference in working method, everyone played a responsible role and felt that the entire project went smoothly. I think this collaboration experience allowed us to gain a more practical understanding of prototyping and user experience design processes, and produced meaningful results as a team.

16 APPENDIX

16.1 List of Questions

16.1.1 *Needfinding Questions*

1. "How often do you typically ride the subway/metro?" **[Interval: 5+ times/week, 3-4 times/week, 1-2 times/week, 0 times/week]**
2. "When you are on the subway, which sources of information do you rely on most?" (Select all that apply) **[Nominal: Audio announcements, Screens inside trains, Screens on platforms, Mobile apps, Asking staff/passengers, Other]**
3. "Do you use mobile apps to get subway or transit information?" **[Binomial: Yes, No]**
4. "How often is it difficult for you to hear audio announcements?" **[Ordinal: Very Frequently, Frequently, Occasionally, Rarely, Never]**
5. "How often is it difficult for you to see or access visual display screens?" **[Ordinal: Very Frequently, Frequently, Occasionally, Rarely, Never]**
6. "Have you ever made a mistake (wrong line, direction, or stop) due to unclear information?" **[Binomial: Yes, No]**
7. "Which types of information are most important for you to access clearly?" (Select all that apply) **[Nominal: Next stop announcements, Arrival/departure times, Service delays / reroutes, Accessibility updates (elevator outages), Crowd levels, Emergency announcements]**
8. "What frustrates you most about the transit apps you've used? (Select all that apply) **[Nominal: Information is not real-time or accurate, Hard to understand during service changes, Too many steps to get basic info, Interface is confusing or cluttered, Doesn't help when there is no signal, Other]**
9. "If you could improve one thing about subway information systems or apps, what would it be?" **[Free Response]**
10. "What types of information (arrival time, line color, destination, etc.) are important to announcement/PA systems for when you take the subway/train?" **[Free Response]**

16.1.2 *Survey Questions for Initial Prototypes*

1. "Here's the link to prototype 1 (P1): https://log-cloth-17292886.figma.site/"
2. "I've viewed P1" **[Binomial: Yes, No]**

3. "P1: I could quickly figure out how to use this prototype" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
4. "P1: I found the information clearly presented" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
5. "P1: I would trust the information provided by this system" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
6. "P1: I would use this solution if it were available" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
7. "P1: What do you like most about this design?" **[Free Response]**
8. "P1: If you could change something to improve it, what would it be?" **[Free Response]**
9. "Here's the link to prototype 2 (P2): Link"
10. "I've viewed P2" **[Binomial: Yes, No]**
11. "P2: I could quickly figure out how to use this prototype" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
12. "P2: I found the information clearly presented" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
13. "P2: I would trust the information provided by this system" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
14. "P2: I would use this solution if it were available" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
15. "P2: What do you like most about this design?" **[Free Response]**
16. "P2: If you could change something to improve it, what would it be?" **[Free Response]**
17. "Here's the link to prototype 3 (P3): https://lion-rerun-62307328.figma.site/"
18. "I've viewed P3" **[Binomial: Yes, No]**
19. "P3: I could quickly figure out how to use this prototype" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
20. "P3: I found the information clearly presented" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
21. "P3: I would trust the information provided by this system" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
22. "P3: I would use this solution if it were available" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
23. "P3: What do you like most about this design?" **[Free Response]**
24. "P3: If you could change something to improve it, what would it be?" **[Free**

Response]

25. "If you had to choose one prototype, which one would you choose?" **[Nominal: Prototype 1, Prototype 2, Prototype 3]**
26. "Why did you choose it?" **[Free Response]**
27. "Overall, I'm confident in the ratings I provided across all prototypes" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**

16.1.3 *Survey Questions for Final Prototype*

1. "Here's the link to the final prototype: https://lion-rerun-62307328.figma.site/"
2. "I've viewed and interacted with the prototype" **[Binomial: Yes, No]**
3. "I could quickly figure out how to use this prototype" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
4. "I found the information clearly presented" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
5. "I would trust the information provided by this system" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
6. "I would use this solution if it were available" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
7. "The home screen feels visually organized" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
8. "I can easily navigate between different sections of the app" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
9. "Warnings and notifications are easy to understand" **[Ordinal: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree]**
10. "Please describe any issues you encounter with the home screen, navigation, or notifications" **[Free Response]**
11. "What do you like most about this design?" **[Free Response]**
12. "If you could change something to improve it, what would it be?" **[Free Response]**
13. "Any other thoughts or feedback?" **[Free Response]**

16.2 Needfinding Results

The full raw survey responses are included below in CSV format.

16.2.1 *Tables*

Needfinding: Why mistakes happen

Respondent	Response
1	No Answer
2	No Answer
3	No Answer
4	The app make it seem as if the 2nd to last stop is the last stop at first glance. I got off at an earlier stop
5	No Answer
6	when there are many transfer lines, I've missed several trains because I kept going back and forth due to unclear or insufficient information.
7	This happens in the SF subway or Muni when there is two major transports - the underground and the Muni which goes over-ground, switching between the two is difficult because you might miss a turn to get to your destination because of the crowd
8	Sometimes I have gone the wrong way in the beginning because its hard to tell which side I need to get on
9	Unclear signs in terminals
10	No Answer
11	No Answer
12	No Answer
13	No Answer
14	I misheard the announcement about the local train becoming an express
15	No Answer
16	information overload, not clear which direction the train is going, or the next stop if you take a side of the train
17	meant to go uptown but went on downtown instead - same train line
18	No Answer
19	No Answer
20	No Answer
21	No Answer
22	No Answer
23	Sometimes routes change due to holidays and it's not clearly communicated even if I search it online.

24	"My city has two different lines that intersect. Sometimes I would get onto a line, but the train would be heading the wrong direction because I don't notice whether it's ""Inbound"" or ""Outbound"" (to/from Downtown)"
25	No Answer

Needfinding: Improvements

Respondent	Response
1	Giving a heads up when your stop is arriving
2	Easier methods to know if you are at the correct station
3	More screens or displays for the stops
4	The time estimates it provides is often wrong. I almost always reach my destination later than it shows on the app. Accuracy could definitely be improved.
5	Like a step by step app that detects your location and shows simple steps on where you are and what you should do next
6	I'd like to always be able to see where I am and which direction the train is going, physically inside the subway, not just on the app. And in the app, it would be great if it clearly showed which line I'm on when multiple lines share the same route. It gets really confusing when I'm in an unfamiliar area.
7	It would probably be accessibility, which is typically bad - especially with the Tube, or the London underground. Walking to an elevator could take 20+ minutes
8	More real time information and better visualizations to understand which way I need to go
9	Have clearer signage of train terminals, including the current and next stop and which direction the train is traveling in
10	"Non-reliance on cellphone data
11	Having crowd level information
12	Make it more real-time and shorter announcements so that it's easier to catch on.
13	crowd level so i can see how crowded certain stops/trains are

14	public announcements and notifications on mobile app are not in sync
15	information to be real time
16	Something very clear of where the next stop is, and an accessible way to real time tracking
17	clearly display delays, reroutes, skipping stops, etc.
18	When using navigation apps on the subway, it would be nice if there was an option for the time calculations to be more lenient to give more time for walking between platforms and stations
19	no idea
20	Improve the PA system - most stations are too loud during peak hours
21	nothing
22	real time info accuracy
23	I think it would be clearer emergency service changes updates
24	No Answer
25	noise level

Needfinding: Pertinent information

Respondent	Response
1	arrival time and destination are the most important
2	Line color and arrival time
3	arrival time and destination
4	Arrival time and destination are most important. I want to know how to get to where I need to be and when I will get there.
5	Arrival time, line color, steps needed
6	I think the most important information includes the current and next stations, arrival time, direction or final destination, which side the doors will open (though it's sometimes unclear what "left" or "right" means), the crowd level with clear visual displays.
7	When elevators are broken, or there are delays on a train
8	I don't listen anyway because it is so hard to hear but I guess service changes and next stop anouncements

9	arrival time
10	use networks that broadcast underground instead"
11	Timings , line color etc because personally l have difficulty finding the right platform and right train , l get confused
12	current stop, next stop and any service delays
13	destination and line
14	arrival time
15	arrival time , next stop
16	arrival time, line color, destination, stops in between final destination
17	next stop info
18	Destination
19	arrival time and announcement
20	Arrival time, destination, safety
21	Arrival time and station name
22	arrival time, destination, and reroutes
23	arrival time, line color, destination are all important to me
24	Line color and destination
25	destination

Prototype 1: What do you like most about this design

Respondent	Response
1	Easy to understand and navigate
2	Simplicity
3	Intuitive UI
4	super simple
5	Simple design
6	I like how there are more suggestions.
7	It's simple
8	
9	very minimalistic

10	For one, it would prevent me from going in the wrong direction (which is a very real concern I have on the rare occasion that I take public transit). I also REALLY like the next stop alert —I've accidentally gotten off before my stop out of anxiety of missing my stop.
11	How simple and usable it is
12	the wrong direction reminder

Prototype 1: What can be improved

Respondent	Response
1	The alert should appear over any other app that you're opening
2	Arrow showing direction heading
3	Include info on how to navigate from one train line to another in large subway stations
4	reroute options
5	Nothing
6	It seems a bit cluttered, maybe have it compact.
7	More color, options, and maybe a map? It seems simple, but not enough features to be worth downloading or useful
8	
9	better color theory
10	Frankly, my only suggestion is for the demo itself: it's easier to showcase the different alerts (stop and wrong direction) if the origin and destination are already typed in (like you're doing in P3). At this stage in the prototype design, it doesn't have to feel as fully featured.
11	"The option of ""I'll turn around"" is kind of weird... What if I just cancel? Then what?"
12	holding some texts thats more important

Prototype 2: What do you like most about this design

Respondent	Response

1	Crowd-sourced information for reporting emergency, quick way to viewing delays to expected traveling time.
2	Hot buttons for common trips
3	Ability to access favorite routes
4	the report process is helpful
5	Nothing
6	It seems easy to make routes.
7	Color and options. Live events
8	
9	not really
10	It's nice that it tells you if there's a problem with the transit route and why.
11	Kinda like self-reported traffic
12	there is emergency report on the front page

Prototype 2: What can be improved

Respondent	Response
1	
2	Report button is a bit obtrusive
3	Recommend alternate routes if favorite routes are unavailable
4	not sure how useful is reporting emergency vs calling police/-transit authority
5	The colors and font style
6	Its confusing to operate.
7	Trip planning, visual map
8	
9	it's too confusing to look at

10	"The red dot on the routes is so intense that it distracts from the emergency messages on the same page, which use a faint red and yellow. The current use of colors and lack of different font weights and sizes places a lot of cognitive load on the user, who now has to read and interpret everything on their own. Instead of being able to rely on good use of information hierarchy. Additionally, the demo is broken: if one goes to the ""Report Error"" section in the menu, you get stuck: it's not possible to go anywhere else or do anything on that frame."
11	I'd add ability to not only report incorrect info but also add a report
12	save favorite route feature

Prototype 3: What do you like most about this design

Respondent	Response
1	I like how all the information is summarized.
2	Its the most thorough but still minimal
3	Alerts for wrong direction
4	its clean and easy
5	Everything
6	I like how there are multiple visuals.
7	Designed for phone screen.
8	
9	the colors are nice when showing route info
10	The transfer instructions are a nice feature, along with the inclusion of alerts for problems with the trip.
11	Good design but a lot to grok right away
12	there is different color for different type of alert

Prototype 3: What can be improved

Respondent	Response
1	

2	I don't understand what the different color circles and lines around them mean
3	
4	none
5	
6	None.
7	Emergency warnings like the previous app
8	
9	the beginning is confusing to look at
10	It contains too much information on the same screen. [Redacted]
11	Some onboarding
12	add tabs to the home page

Favorite Prototype

Prototype No.	Reason
Prototype 3	Presents a lot of information in a way that's easily understood
Prototype 3	It's the most complete interface
Prototype 3	Very clear alerts
Prototype 3	because its clean
Prototype 3	I like the interface
Prototype 3	It is simple to use and has a lot of information needed.
Prototype 3	Map and visuals, designed for phone
Prototype 2	
Prototype 1	because it is familiar design
Prototype 1	It's simple and effective and notifies of the upcoming stop and has a clear alert when going in the wrong direction.
Prototype 2	I really like the reporting idea
Prototype 2	It seems to have the most intuitive design

Final Prototype: Issues Encountered

Response
No issues.
I liked the overall aesthetic and usability.

The bottom two notification options seem to be a bit broken, and clicking reset to start doesnt seem to work.
none
no issues
No issues
No Answer
Some sections feel slightly text-heavy, especially during service alerts. When multiple updates stack, the hierarchy becomes less clear. Navigation drawers could also use stronger visual emphasis for the currently selected section.
No Answer
No issues
Might be nice to easily see different transportation options
No Answer
all good
No Answer
Not really anything major but perhaps a different color for pre-arrival vs a system notification?
No Answer
No Answer
the 'your location' sometimes if i'm planning a trip i'd like to have the option to manually enter my starting point. this design did not give me that option.
No Answer
No Answer

Final Prototype: What do you like most about the design?

Response
everything looks great.
Maybe increase the font size slightly for better readability.
I like the steps laid out cleanly by default with the option of expanding each step individually for more detail.
the layout
suggested routes that fit the user's needs.
I like the route tab, clearly showing the stops and how i can expand sections to see more details

Wrong Direction, Arrival Alert, and System Notification
The real-time disruption notifications stand out—they're prominently displayed, easy to interpret, and provide immediate actionable information. The color-coding and iconography help reduce cognitive load during stressful travel moments.
Easy to interact clean design
Every function is helpful and there are valuable signifiers.
The clean and simple design
Gives me much more confidence navigating a subway transit system
organized and logical
No Answer
Love the wrong direction alert!
layout
the interface
very neat and easy to navigate
No Answer
UI was nice

Final Prototype: Improvements

Response
No need anything changes.
The features are well thought out and useful.
would like if the blue current location status was stickied at the top.
nothing
the ability to tap on the map and show its info
I dont think the Report section should be a different tab. I think you can have a hovering button here similar to how google maps does it.
Not sure if it can remind users before they board a train going in the opposite direction
I would add an interactive route preview with upcoming stops and transfer points. This would reinforce trust and help users anticipate station changes without relying solely on textual announcements.
more feedbacks
A way to see how long a delay is. And Dark mode :)

Make it clear where I am in relation to the different options
If the subway doesn't take me directly to my destination, displaying that I'll need to walk or take an uber for the rest of the way
all good
No Answer
I would make the pre-arrival alert more impactful!
nothing
No Answer
definitely let the user pick their starting location as well as giving them the option to use 'my location', also maybe a option to save routes
No Answer
Navigation

Final Prototype: Other thoughts or feedback

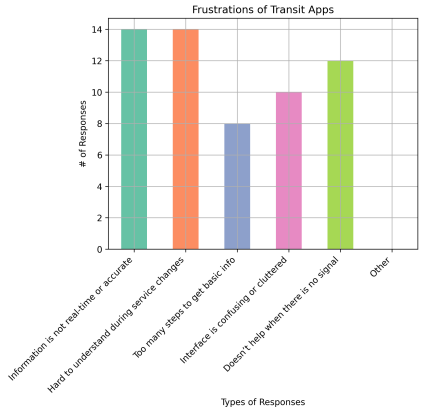
Response
design is great so no need to change anything
Great job on the prototype! It works well.
No Answer
none
no
No Answer
No Answer
Overall, the system feels modern and commuter-friendly. Adding personalization—such as saving frequent routes or enabling alert preferences—could make the experience even more efficient for daily riders.
No Answer
No Answer
No Answer
No Answer
No Answer
No Answer
Nope!
No Answer
No Answer

No Answer

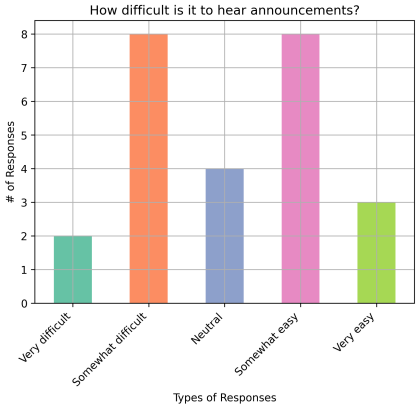
No Answer

No Answer

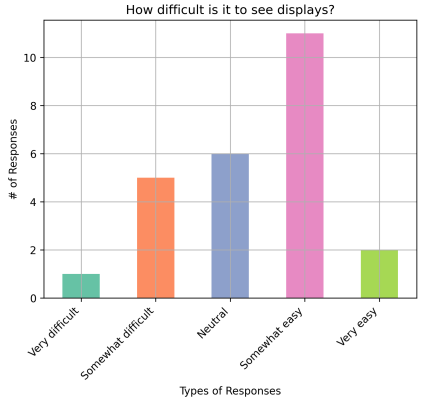
16.2.2 *Figures*



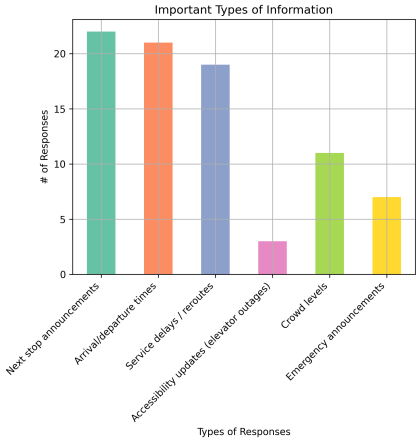
(a) Mobile App Usage Frustrations



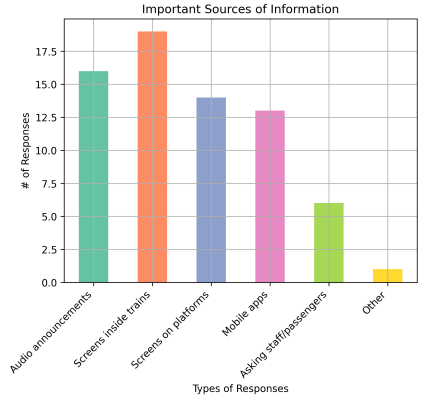
(b) Difficulty Hearing Announcements



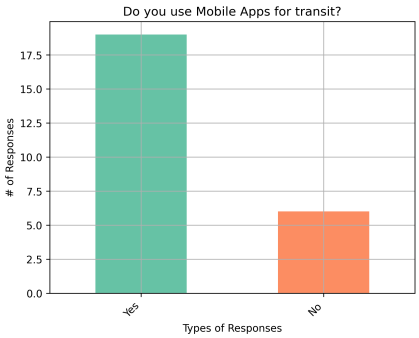
(c) Difficulty Seeing Displays



(d) Important Info to Transit Riders

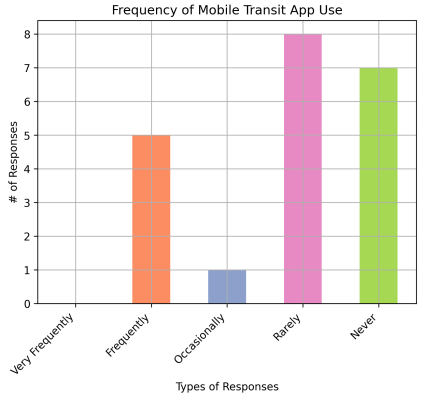


(e) Important Sources of Information

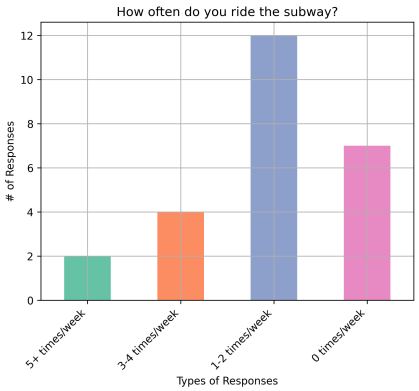


(f) Respondents that use a mobile application for transit

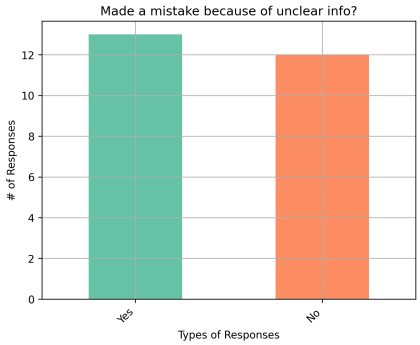
Figure 8—Needfinding Results



(g) Transit App Usage Frequency

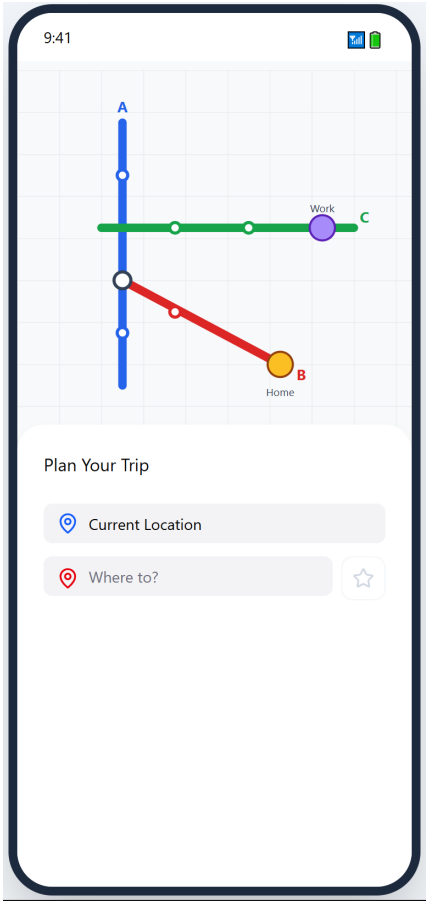


(h) Frequency of Transit System Usage

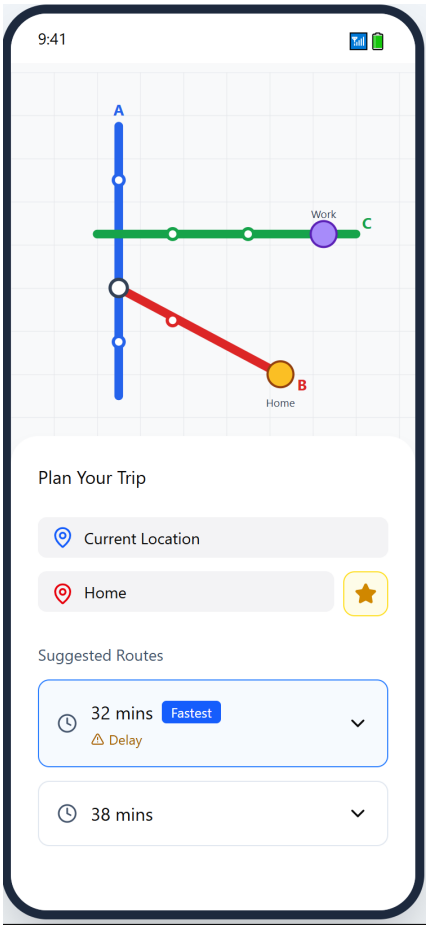


(i) Have You made a Mistake due to Unclear Info?

Figure 8—Needfinding Results (Continued)

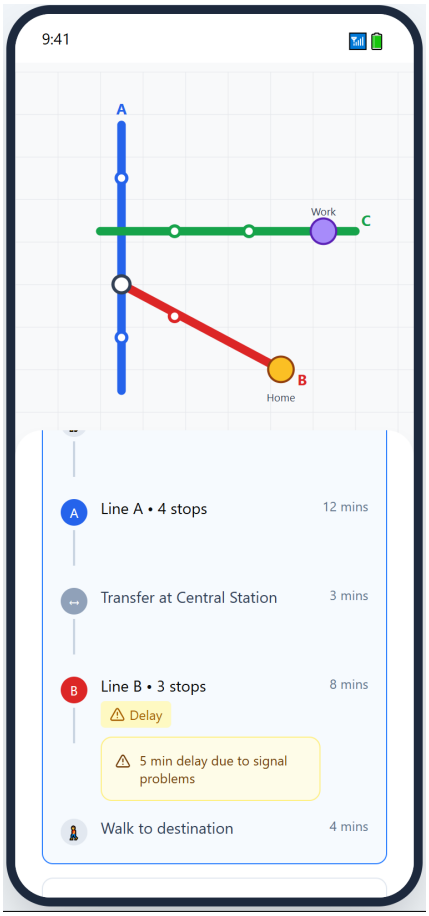


(a) Home Screen

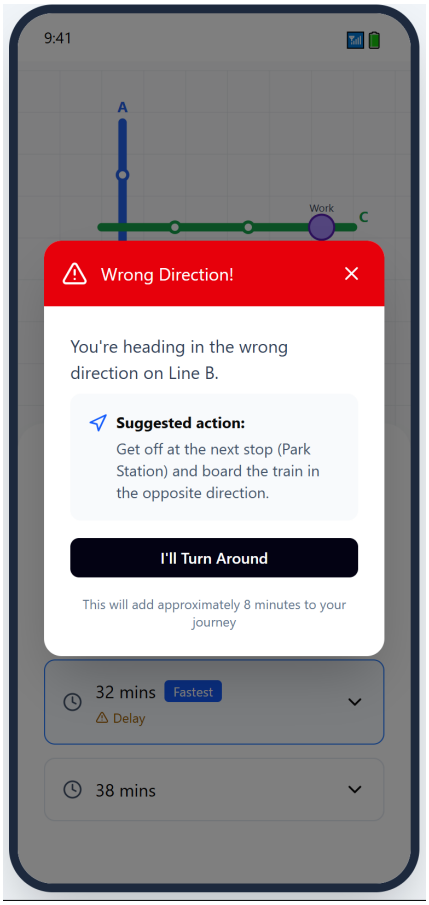


(b) Route Suggestions

Figure 9—Prototype 1

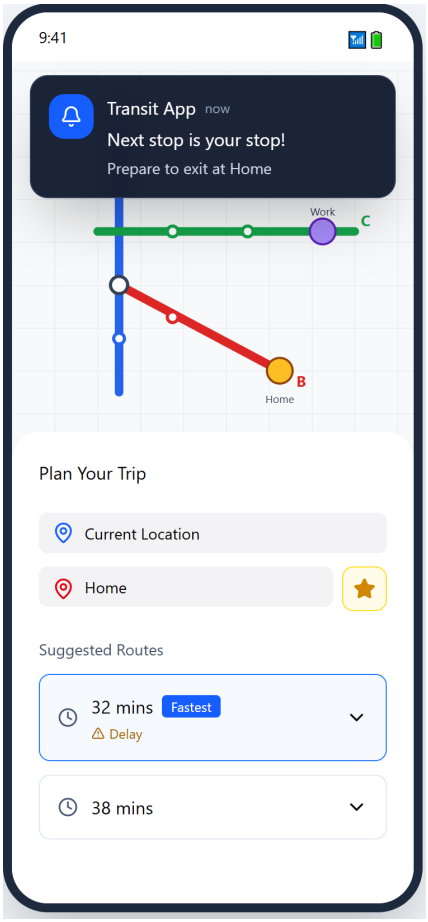


(c) Service Disruption Alert



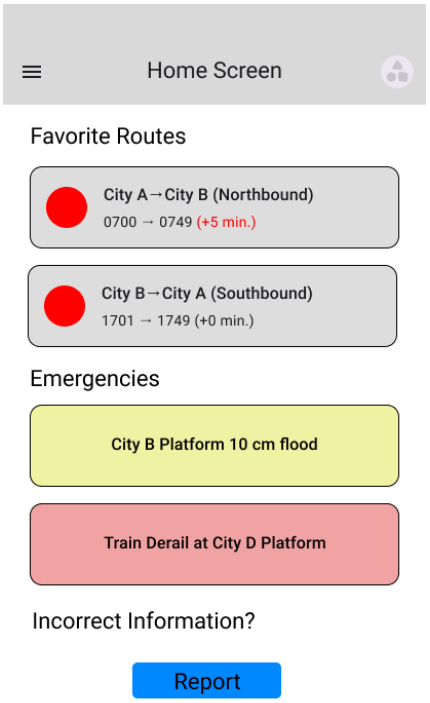
(d) Wrong Direction Alert

Figure 9—Prototype 1 (Continued)

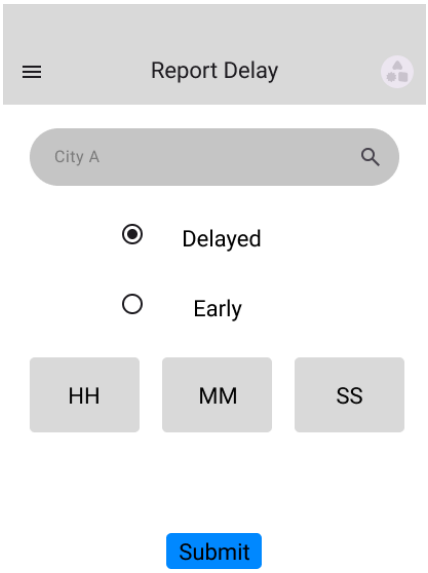


(e) Next Stop Alert

Figure 9—Prototype 1 (Continued)

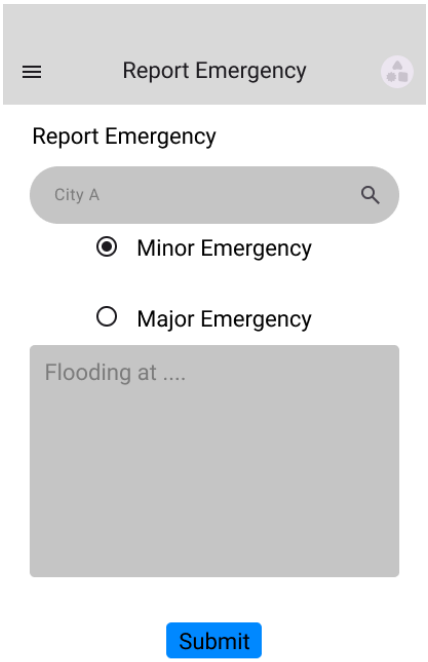


(a) Home Screen

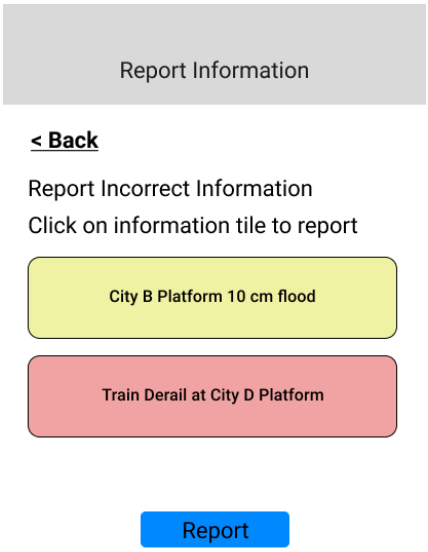


(b) Report Delay

Figure 10—Prototype 2

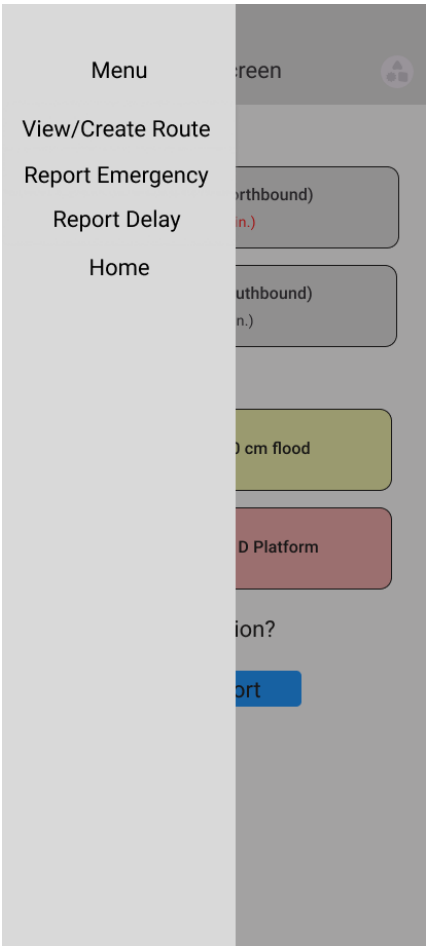


(c) Report Emergency



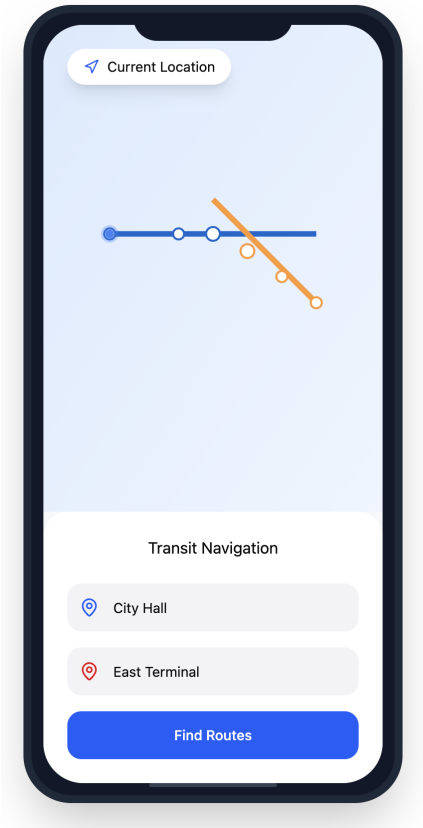
(d) Report Inaccuracy

Figure 10—Prototype 2 (Continued)

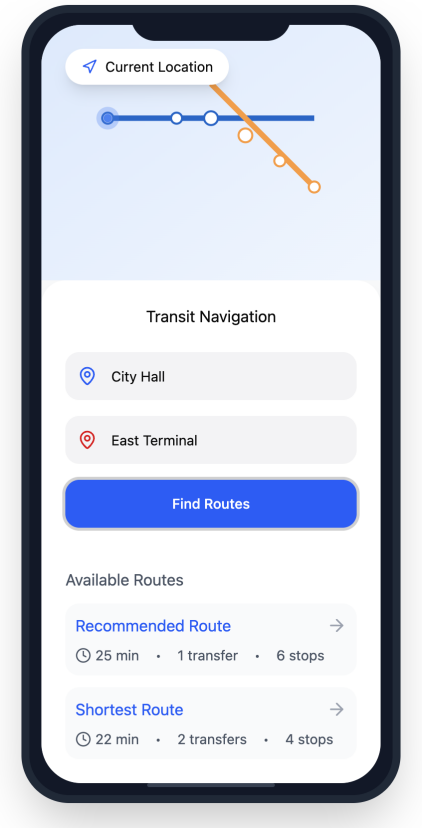


(e) Open Sandwich Menu

Figure 10—Prototype 2 (Continued)

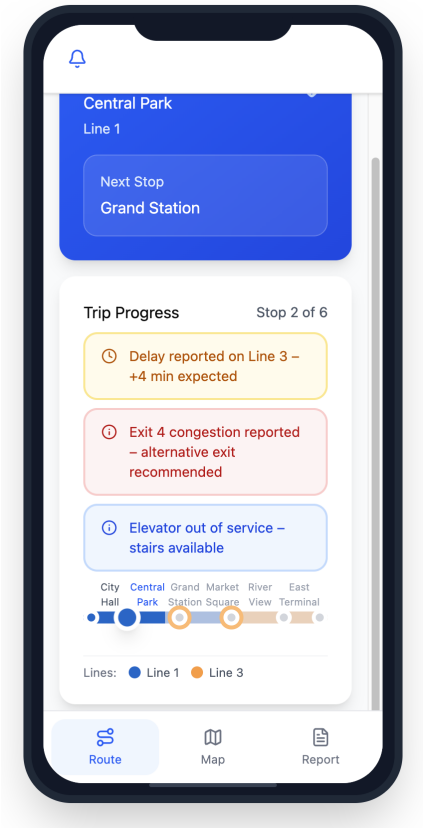


(a) Home Screen

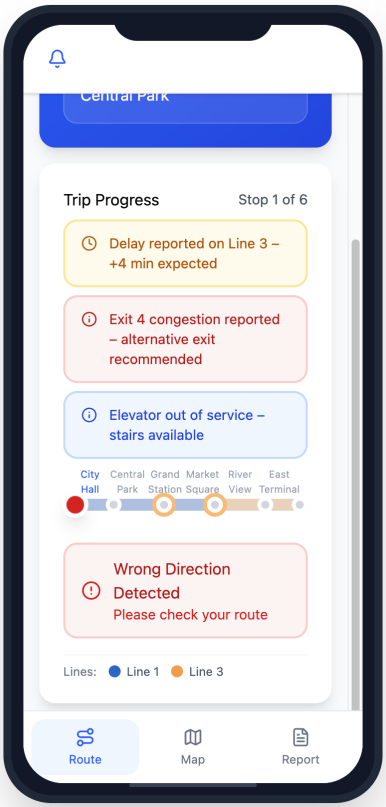


(b) Report Delay

Figure 11—Prototype 3

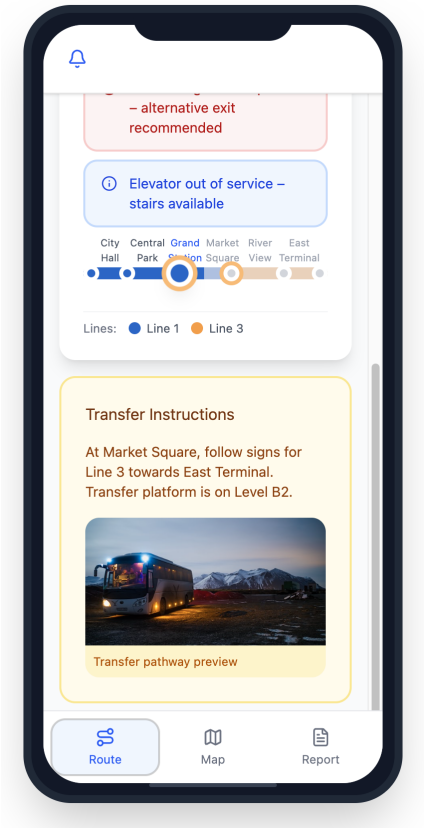


(a) Home Screen

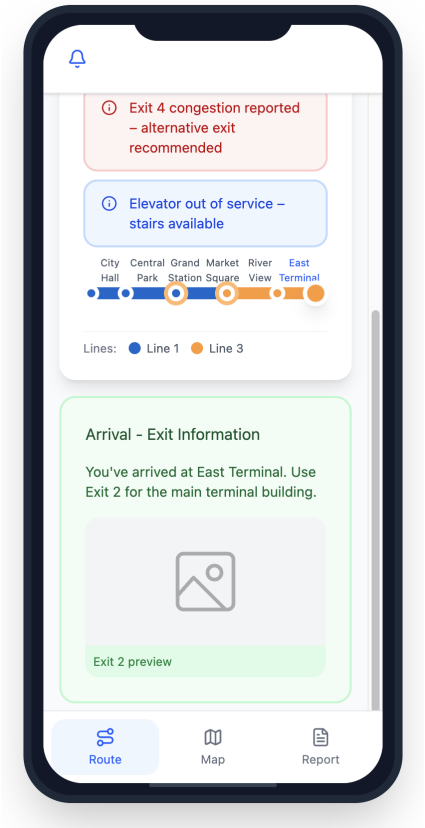


(b) Report Delay

Figure 12—Prototype 3



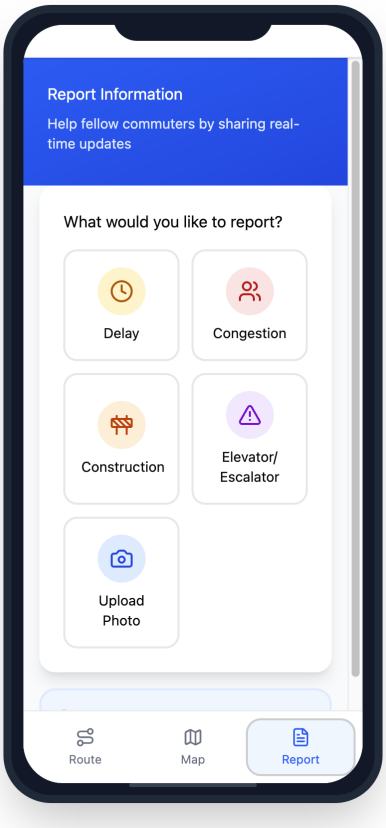
(a) Home Screen



(b) Report Delay

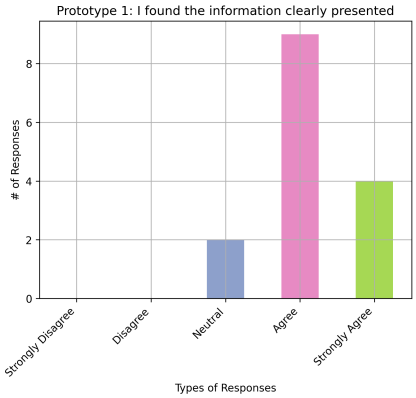
Figure 13—Prototype 3

(a) Home Screen

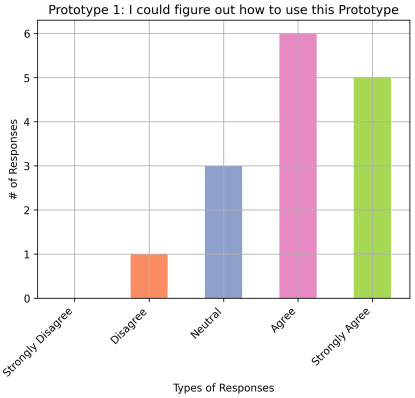


(b) Report Delay

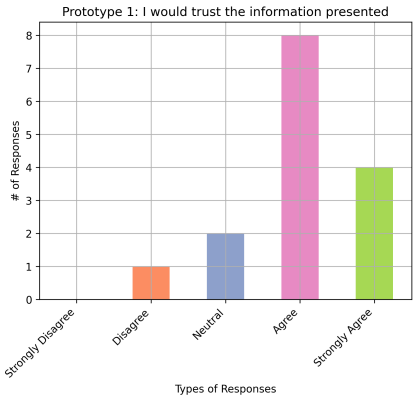
Figure 14—Prototype 3



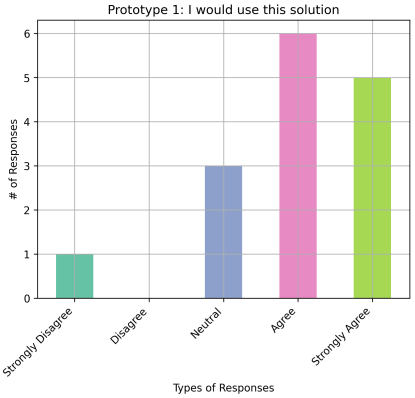
(a) Prototype 1: Clarity of Information



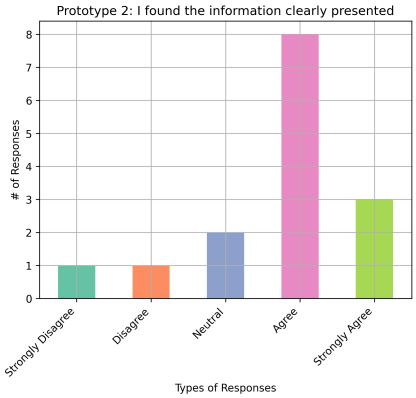
(b) Prototype 1: How easy it is to figure out information



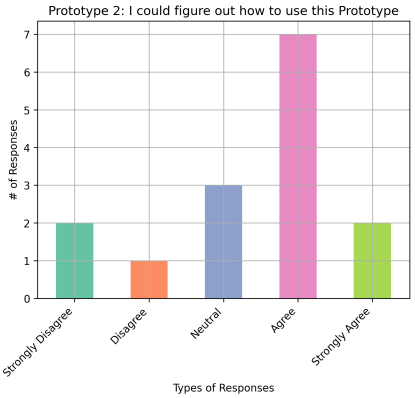
(c) Prototype 1: How trustworthy is the information



(d) Prototype 1: This is an application I would use

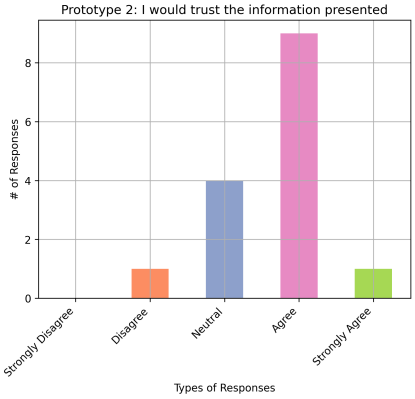


(e) Prototype 2: Clarity of Information

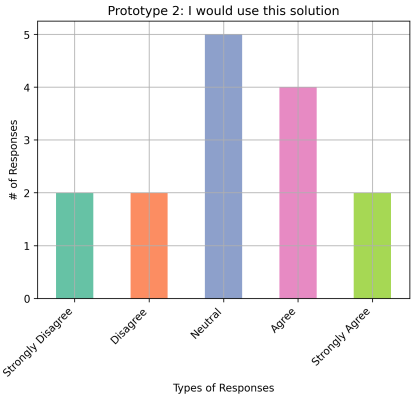


(f) Prototype 2: How easy it is to figure out information

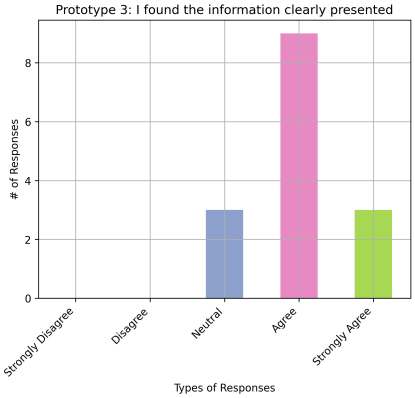
Figure 15—Evaluation Results



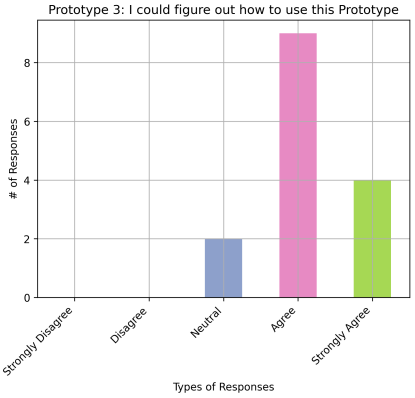
(g) Prototype 2: How trustworthy is the information



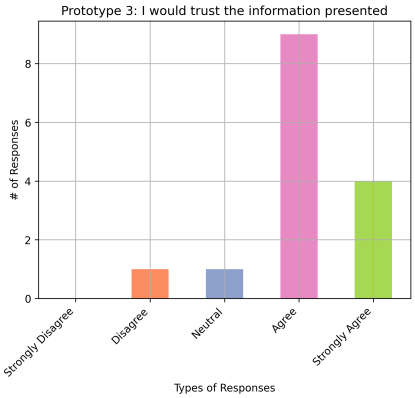
(h) Prototype 2: This is an application I would use



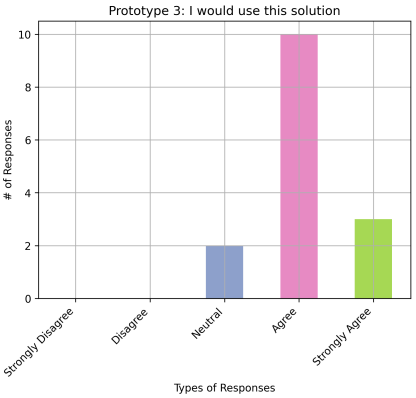
(i) Prototype 3: Clarity of Information



(j) Prototype 3: How easy it is to figure out information

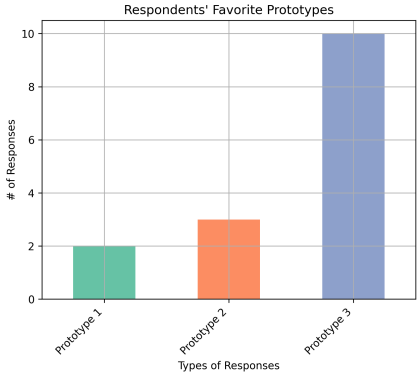


(k) Prototype 3: How trustworthy is the information



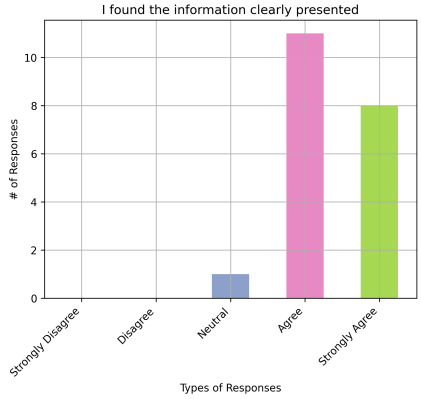
(l) Prototype 3: This is an application I would use

Figure 15—Evaluation Results (Continued)

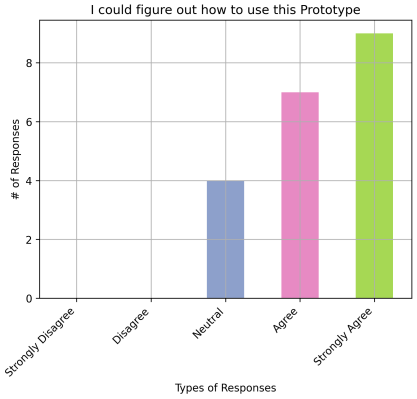


(m) Respondent's Favorite Prototype

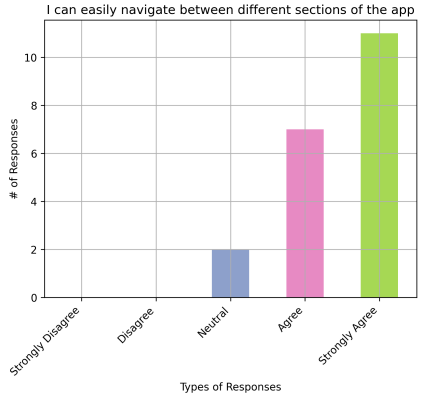
Figure 15—Evaluation Results (Continued)



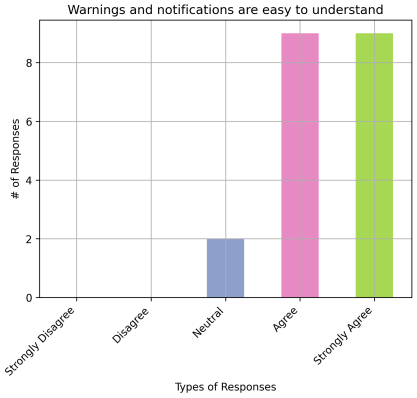
(a) Clarity of Information



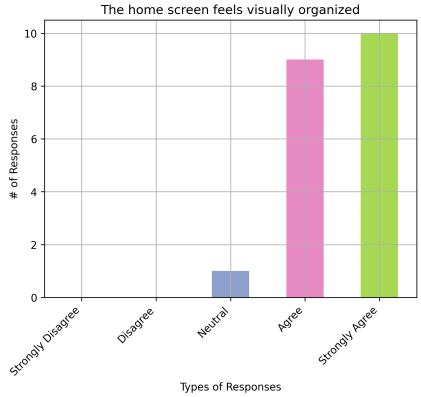
(b) Ease of Figuring things out



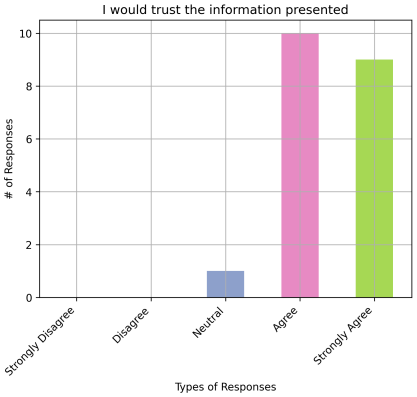
(c) Navigational Ease



(d) Understanding of Notification

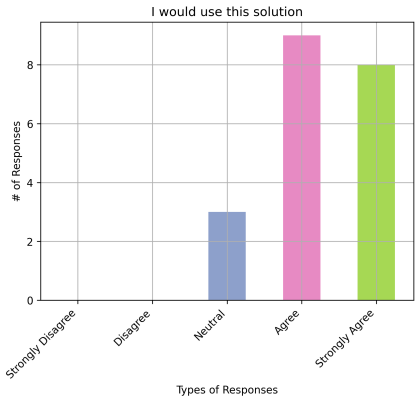


(e) Goodness of Organization



(f) Trustworthiness

Figure 16—Final Evaluation Results



(g) How likely respondents are to use this

Figure 16—Final Evaluation Results (Continued)

17 REFERENCES

[1] Hessing, Ted (n.d.). *1 Sample Wilcoxon Non Parametric Hypothesis Test*. Accessed: 2025-10-30. URL: https://doi.org/10.1145/2470654.2481344.

[2] Nunno, Richard (2018). *Fact Sheet | High Speed Rail Development Worldwide*. URL: https://www.eesi.org/papers/view/fact-sheet-high-speed-rail-development-worldwide.