

MSc in Computer Science - Team Project

Interim Report

**Group 2 – SafePath App**

*More than Navigation, Smarter, Safer journeys*

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# **Introduction**

The goal of this project is to make a safety-first navigation app for cyclists and walkers that is easy to use, looks good, and works well. The app was first called "SafetyCyclePath" and then changed to "SafePath" to give it a more modern brand identity. We looked at three different logo ideas for the app: (A) a wordmark with pictures of a cyclist and a walker, (B) a shield with a route and a location pin, and (C) a shield with a road and a checkmark. We also chose the colour scheme for the app. After a short UI survey, users said that (Design C) was the clearest and easiest to remember. We then used it as the final logo and made the app's theme match those colours.

A blue shield with a road and a check mark

AI-generated content may be incorrect.A logo for a company

AI-generated content may be incorrect.A circular sign with green text and a person walking a bicycle and a person

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**Figure 1 - Logo C**

**Figure 2 - Logo B**

**Figure 3 - Logo A**

The app has a lot of features, such as routing that takes safety into account (Safest / Balanced / Fastest), the ability to report hazards with pictures, buddy matching for shared trips, and map-first browsing with clear, easy-to-understand safety signs.

The goal of the resulting application is to help Vulnerable Road Users (VRUs) feel less anxious when travelling through cities by making it easier for them to make smart decisions about their safety and route planning. We looked at different navigation tools and used survey data to find out what problems everyday cyclists and pedestrians face. This helped us come up with important user-driven features like visible safety ratings, easy-to-use controls for managing route trade-offs, and clear, believable explanations for suggested routes.

The project uses OpenStreetMap OSM data as a base for its road network data. It also includes several London-specific datasets, such as feeds on roadworks and infrastructure updates, available lighting data, publicly available crime figures, and hazards highlighted by the community. These different types of information are turned into map-aligned attributes like infrastructure quality (like protected bike lanes and pedestrian crossings), lighting coverage, the chance of recent incidents (like roadworks or obstructions), environmental risk factors (like rain or wind), and crime exposure levels that change over time. Along with this, user profiles are made where users provide permission to save their routing preferences, saved routes, frequently visited places, and search history. This lets users personalise their experience by choosing things like well-lit streets, calmer routes, or avoiding busy crossings. Users will be able to select and compare routes and get a clear Safety Score for each segment by combining this data. This will give them a useful way to see how safe a route is under the present conditions. The FindBuddy feature, which is optional, will also assist users find friends who are going the same way at the same time. It does this by matching their locations and schedules in a way that keeps their privacy safe.

The main goal of SafePath is to create an easy-to-use online tool that shows routes and safety overlays clearly on both desktop and mobile devices, lets users report hazards, and gives users preset options for the safest, most balanced, and fastest courses.

The MVP puts a high value on clear data, fast interaction, and safety cues that are easy to understand. This goes beyond what traditional navigation applications do and sets the stage for more advanced features like lighting/crime integration, weather modifiers, and buddy matching in future versions.

# **User Scenario**

## **Identifying the Target Users**

SafePath system was designed with a specific goal in mind: to help people who live in cities and deal with safety issues every day to understand it. We used user research, surveys, and persona development to find key categories of vulnerable road users (VRUs) whose experiences contributed to developing the project's vision. The system is aimed at people who live in cities and rely on walking or biking to go around every day, but who have problems with safety, awareness, and infrastructure. Early UX research and surveys found the following key user groups:

### Personas

SafePath primarily serves pedestrians and cyclists in urban areas, particularly those who rely on walking or cycling as a sustainable and cost-effective means of transportation. Personas assist developers and artists understand the types of individuals for whom they are creating content. You don't just consider a general "user." You consider real persons with real requirements. Within this group, we identified five main user categories:

* **University students** and young commuters frequently walk or cycle to class and come home after dark.
* **Working professionals** looking for a safer daily commute can cycle or walk to neighbouring offices or transportation hubs.
* **International residents** and visitors who are unfamiliar with community safety patterns want credible counsel.
* **Community people** can report problems like poor lighting and hazardous crossings to improve public safety data.
* **City planners and local councils** use aggregated reports to improve infrastructure and public safety measures.

As part of the Explore phase, we created three unique personas based on study results, user survey data, and problems:

**Expert Cyclist – Alex Byrne**

A professional software developer and seasoned biker who prioritises efficiency, fitness, and control. Alex exemplifies the performance-driven yet safety-conscious commuter who frequently cycles to work and utilises digital tools to track progress.

* **Goals:** include improving cycling performance, designing safe routes, and reducing reliance on cars.
* **Wants and Needs:** Safe and efficient routes, weather-aware maps, and real-time warnings for accidents and hazards.
* **Pain points** include poor bike lane lighting, imprecise map data, and risky road crossings.

SafePath assists Alex by providing data-driven route ideas, real-time rerouting, and safety heatmaps to enable confident and informed decision-making.

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Figure 4 - Persona – Expert Cyclist

**Daily Walker – Eliza Chen**

A retired art curator who takes daily walks for fitness and community connection. Eliza symbolises the active older user who prioritises simplicity, safety, and social belonging.   
**Goals:** Daily walks promote physical and mental well-being, social connection, and safe exploration of the community.   
**Wants and needs** include well-lit walking pathways, easy navigation for low-vision persons, and a simple, intuitive design.   
**Pain points** include poor lighting, difficult route interfaces, and worry over secluded regions.   
SafePath provides Eliza with route visualisations, real-time safety alerts, and easily accessible interface settings (bigger icons, simple layout, high contrast).

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Figure 5- Persona – Daily Walker

**Wheelchair Pedestrian – Daniel Murphy**

A library assistant and wheelchair user who values accessibility, freedom, and seamless travel experiences. Daniel symbolises users who have limited physical mobility in typical route planners.

* **Goals:** Use technology to plan accessible and efficient journeys while maintaining confidence and autonomy during travel.
* **Wants and Needs:** Accurate data on curb heights, ramps, and crossings, a smooth app experience, and consistent accessibility upgrades.
* **Pain points** include incomplete accessibility data, insufficient path surface mapping, and a lack of inclusive design in current navigation apps.   
  SafePath offers Daniel accessible route options, audio advice, and community feedback tools for reporting inaccessible places.

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Figure 6 - Persona – Wheelchair Pedestrian

### **Collective Insights**

Analysing all three identities, Alex, Eliza, and Daniel, reveals that, despite their disparate lifestyles and abilities, they share several basic needs and expectations. When selecting routes, all users emphasise personal safety and reliability over speed, demonstrating a strong preference for safety-first navigation. Each user prioritises clarity and accessibility in the app's design, which includes readable maps, clear visual cues, and straightforward interactions that reduce confusion while travelling. Another common discovery is the value of community participation; users are motivated to give hazard reports or comments when they see how their contributions improve collective safety. The addition of the "Find a Mate" feature promotes users' desire for social connection and reassurance, especially when travelling at night or in unknown locations. Finally, all personas highlight the importance of reliable, data-driven recommendations—they want a system that appears intelligent, responsive, and credible in offering route options that accurately represent real-world safety situations. These findings support SafePath's objective to build an inclusive, user-centred platform that caters to a variety of needs while encouraging safety, awareness, and confidence in urban mobility.

## Why They Are Important?

These users represent the growing number of people who prefer active, environmentally friendly ways of transportation. While walking and cycling promote sustainability and health, many people avoid them due to perceived or actual risks. Every day, we face unsafe crossings, poorly lit streets, high-crime neighbourhoods, and a lack of riding lanes. SafePath's focus on this diverse, yet safety-conscious demographic directly promotes the aims of urban safety, inclusion, and environmental sustainability.

**UX Research and Surveys**

User survey and data collected by the team revealed that **75 % of respondents preferred safe routes over fast ones**, and **73 % were willing to report hazards**.

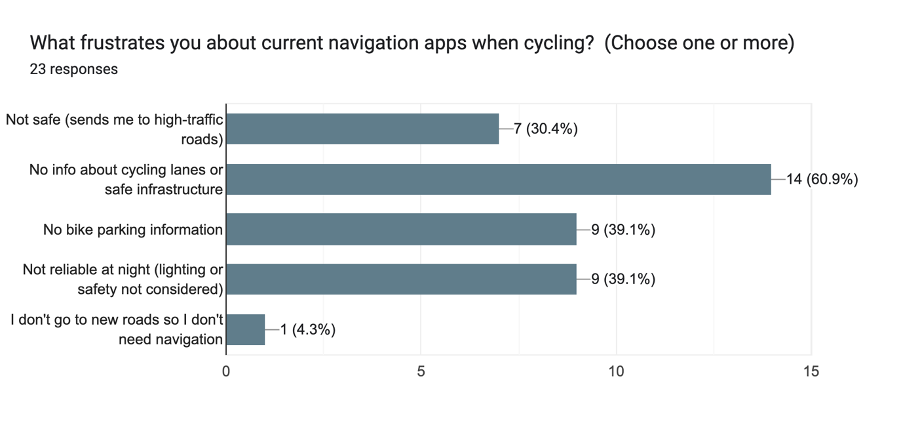


Figure 7- Frustrations about Current Apps

A graph of different colored bars

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Figure 8 - Valuable Navigation Apps Features

**Key Findings:**

* 91% are beginners or intermediate riders → focus on ease and confidence.
* Top frustrations:
  + Lack of info on cycle lanes/safe infrastructure (61%)
  + Missing bike parking and night safety features (~39%)
* Desired features: real-time hazard alerts, secure parking, and offline data.
* 75% prefer safest routes over fastest.
* 96% would use cycle parking finder.
* 75% open to connecting with others if privacy is protected.

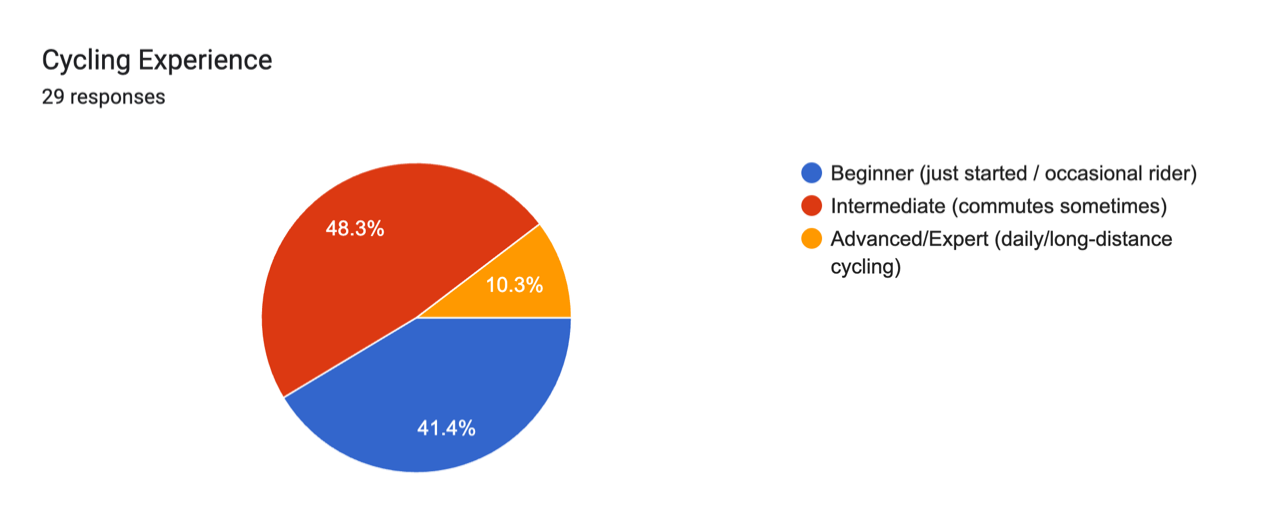


Figure 9- Cycling Experience

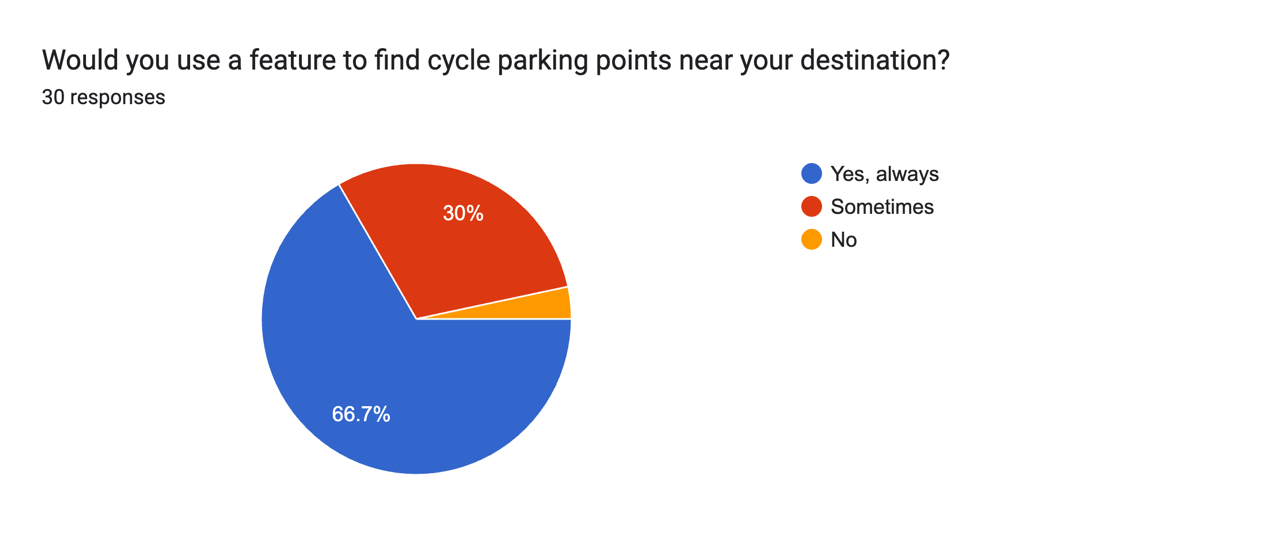


Figure 10 - Pike Park Feature

**Pedestrian Insights (48 responses)**

* Main Takeaways:
* 61% walk daily; walking is part of routine mobility.
* Top frustrations:
  + No hazard alerts (50%), poor lighting info (45%), and lack of safety awareness (39%).
* Most valuable SafePath features:
  + Safe routes (61%)
  + Real-time safety alerts (61%)
  + Safer crossings (50%)
* 85% prefer safe or context-based routes over fastest.
* 100% open to real-time alerts (with smart control).
* 75% open to connecting with walking groups (if privacy protected).
* 73% willing to report hazards, supporting community-driven safety.

Forms response chart. Question title: How often do you walk as part of your daily or weekly routine?

(e.g., to school, work, shops, or transport stops). Number of responses: 48 responses.

Figure 11- Walking Experience

A pie chart with numbers and a few red and blue circles

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Figure 12 - Reports Hazard Feature

A pie chart with text

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Figure 13 - Find buddy Feature

A graph with numbers and text

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Figure 14 - User Most Valuable Features

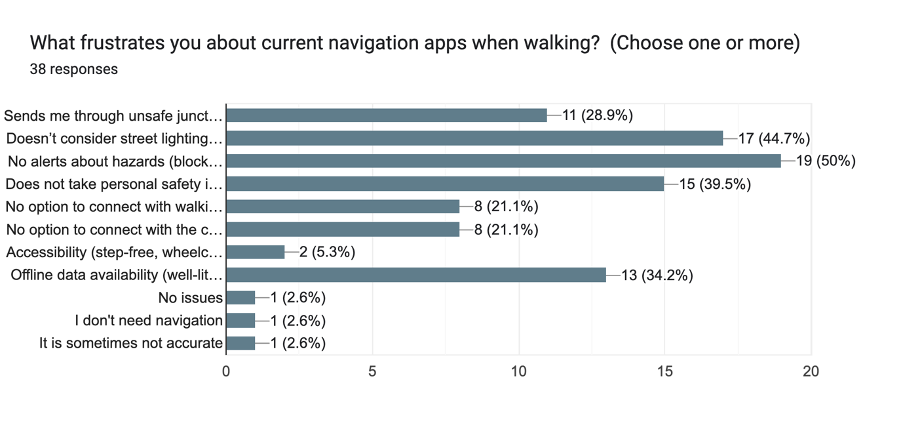


Figure 15 - Current Navigation Apps Experience

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Figure 16 - User Interest in App Download

Forms response chart. Question title: How important are these features to you? 

(Rate 1–5: Not Important → Very Important). Number of responses: .

Figure 17 - App Features Importance Diagram

* **Main Takeaways:**
* Preferred **alert type:** non-intrusive — 41% only when app is open, 34% push notifications.
* Most important features: **Safe routes, real-time alerts, offline maps**.
* **59% likely or very likely** to download SafePath; **90% positive or neutral** overall.
* Encouraging factors:
  + **Free to use (82%)**
  + **Unique safety features (52%)**
  + **Trust from local councils or universities (32%)**
* Awareness channels:
  + **Social media (59%)** and **friends’ recommendations (55%)** are key.

These findings confirm strong user motivation for a system that values safety and community participation.

Current navigation apps, such as Google Maps, Waze, and Strava, focus on time and distance rather than safety. They fail to consider real-world facts such as criminal density, lighting quality, and accident frequency. As a result, even the quickest path may expose a pedestrian to hazardous conditions.   
SafePath fills this void by aggregating several datasets—crime, infrastructure, lighting, weather, and user reports—and assigning a Safety Index to each route segment. Users can evaluate the fastest and safest routes and choose based on their comfort and context. The system also promotes friendship with a "Find a Mate" feature that matches users with comparable routes and schedules, improving both physical and psychological safety.

# **Technical Problem**

## **Core Technical Problem**

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Figure 18 -Technical Component Diagram

The idea for this app went through multiple iterations before the current format was finalised. Starting from discovering suitable datasets for urban mobility, first for pedestrians, then for cyclists. We iterated on feasibility and coverage and ultimately combined both to serve mixed-mode users. The concept of a safety-first routing application, SafePath combining hazard-aware navigation with an optional buddy feature was chosen for a variety of reasons.

SafePath covers a common gap we found in our competitive analysis with the help of this app comparison article(Portus, 2024). It says that most navigation tools, even those made for cycling, only focus on time or distance, with little thought given to personal safety (for example, they only have "quiet" or surface-type filters). This means that people who walk and ride bikes have to figure out how to stay safe on their own instead of using evidence-based risk models. This disparity is essential since the environment and infrastructure have a clear effect on how likely it is that bikers and pedestrians may get hurt. For instance, having protected or separated facilities, well-designed streets, and enough light all make people less likely to get hurt and more likely to walk or cycle (Reynolds et al., 2009)(Teschke et al., 2012)(Vidal-Tortosa & Lovelace, 2024).

A table with text on it

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Figure 19 - Competitive Analysis Sample

Our user research supports this reason. The interview guide focusses on the interface's readability, the user's perception of safety, and their expectations for features like "Find Buddy." These are exactly the areas where current services don't do enough for vulnerable road users (VRUs). The survey was given to students, engineers, healthcare workers, teachers, and other people in the community. This shows that there is a lot of interest in safe, everyday cycling beyond just sport riders.

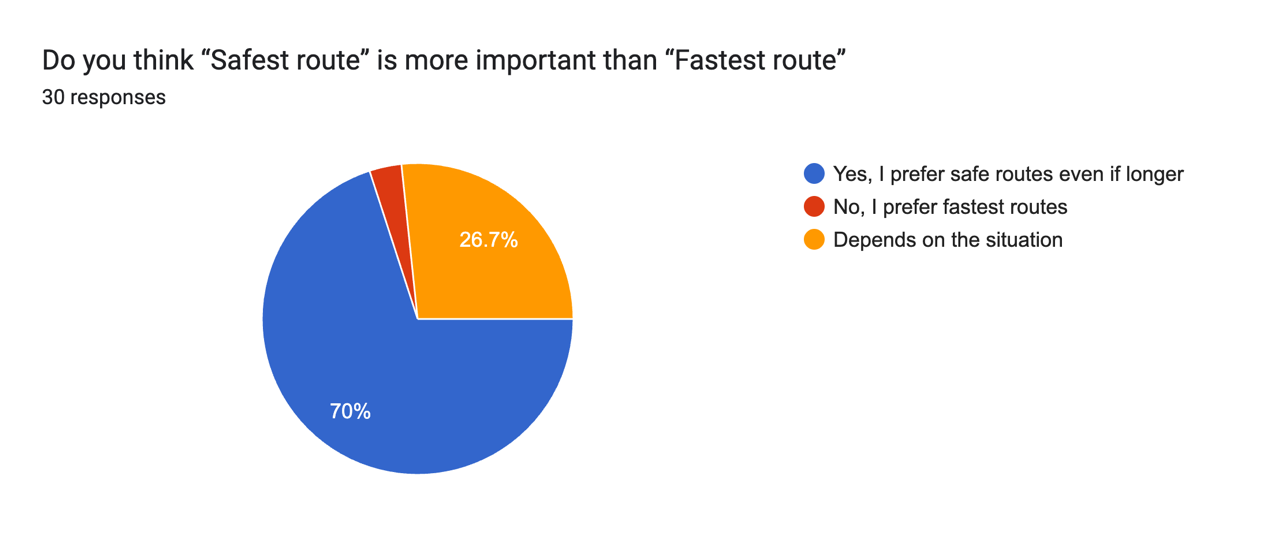


Figure 20- Safest vs Fastest

Research indicates that "near misses" are common and provide insights into risk, yet are never included in official datasets; crowdsourced reporting can address this gap(Nelson et al., 2015)(Branion-Calles et al., 2017). Adding community hazard reports to official feeds is not simply a nice-to-have feature; it is critical for safe routing.

Finally, safety situations change all the time. Patterns in the weather, visibility, and time of day change the level of danger; for example, rain, low visibility, and peaks all raise the risk of a crash, and changes in the weather change the number of cyclists and the chance of an accident(Myhrmann & Mabit, 2023)(Pazdan, 2020). A static "fastest route" model can't deal with these changing exposures; SafePath's purpose is to do so.

## **User Interface and Frontend Experience**

## **Architecture and Deployment**

## **Data**

## **Review of Existing Solutions**

# **Technical Solution - The Plot**

* 1. **System Functionality**

Safepath is an all-in-one navigation system aimed at aiding pedestrians and cyclists in London with safety-optimized routing through the cooperation of numerous data sources as well as advanced algorithms. It works by merging crime rates from data.police.uk, infrastructure condition indicators from the National Cycle Network, traffic accident reports from the STATS19 system, and real-time user-reported hazards into a safety scoring system that produces customized routes depending on the user's tolerance for risk and the situation around him/her (Agarwal et al., 2024). This sophisticated solution has managed to overcome the most significant drawback of traditional navigation systems able to simply choose the fastest or shortest route but often compromising personal security, thus providing a very large urban navigation approach that offers safety along with practicality (Wang et al., 2021).

**4.2 System Architecture and Algorithm**

The Safepath system is built on a complex architectural structure that is capable of processing different types of safety data sources and thus generates routing decisions that are ready for action. A modified A\* pathfinding algorithm is being used in the system to calculate the shortest path with safety scores being the edge weights, so it is possible to configure the risk tolerance settings for the trade-off of safety optimization and route efficiency (Delling et al., 2017). Moreover, the system uses kernel density estimation to extract crime hotspots from historical police data, computes the score of infrastructure quality depending on the presence of features like separated bicycle lanes and pedestrian crossings, and evaluates the danger of accidents with recent weighting of historical STATS19 data (Kang & Kang, 2017).

**Figure 3.1**: *Safepath System Architecture Diagram (Detailed)*

A diagram of a company

AI-generated content may be incorrect.**Note.** Detailed system architecture illustrating the complete technology stack, including load balancing, microservices architecture, database replication, caching layers, and external API integrations for comprehensive functionality.

The individual risk factors are weighted and summed up to arrive at a composite safety score where crime exposure contributes 30%, infrastructure quality 30%, collision risk 20%, and real-time hazard density 20% (Al-Omari et al., 2025). The routing algorithm subsequently provides several path alternatives through Yen's k-shortest paths algorithm, giving the users a selection of different routes that signify the varying trade-offs between safety and efficiency (Zhu, 2022).

**Figure 3.2:** *Safety Scoring Algorithm Flowchart*

*A diagram of a standard of quality

AI-generated content may be incorrect.****Note.*** Algorithm flowchart demonstrating how multiple safety factors are processed in parallel and combined using weighted percentages to generate a normalized composite safety score for each route segment.

## **4.3 Front-End Technologies**

Next.js 14 was utilized for the front-end implementation of the web application and a progressive web app (PWA) framework for mobile access which provided offline capabilities and push notifications. React components and Tailwind CSS were used to create the user interface which included an interactive map supported by Leaflet.js that showed route options with safety ratings represented by different colors (Quercia et al., 2014). Among the main interface parts were a route planning interface where safety preferences could be adjusted, a hazard reporting tool that allowed submission of photo and description, an emergency alert system that included live location sharing, and a travel buddy matching service that offered GPS tracking (Garg et al., 2025). To provide real-time updates and notifications, the system made use of WebSocket connections, thereby guaranteeing that users are instantly informed about the newly reported hazards that are in their vicinity.

## **4.4 Back-End Architecture**

The back-end architecture includes a microservices-based system that is deployed on a highly available clustered infrastructure with load balancing. The API gateway is built using Express.js and it consists of authentication middleware, request validation, and rate limiting in its structure. The business logic is spread across different services according to their specialization, such as a Route Planning Service that performs pathfinding algorithms and safety score calculations, a Hazard Management Service that verifies and processes user reports, a Buddy Matching Service that manages location-based pairing requests, and a Notification Service that oversees push notifications, emails, and SMS alerts (Kumar et al., 2024). All these microservices are talking to each other via internal APIs and event-driven architecture, and Redis is utilized as a cache layer for active sessions storage and often accesses route data.

A diagram of a system

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Figure 21 - Database Entity-Relationship Diagram

Note. Database schema using crow's foot notation to illustrate relationships. PostGIS geometry fields enable spatial queries for proximity analysis and route calculation.

# **Evaluation**

# **Conclusion**

## **6.1 Project Management Strategy**

The Safepath project management plan is based on a structured, milestone-driven strategy with phases and deliverables clearly defined throughout a 14-week period. The methodology mixes Agile development and traditional project management to some extent, thus enabling iterative progress while still being answerable to major milestones (Marshall & Ferenchak, 2019). The entire project is spread out into seven iterations of two weeks each, with each iteration being dedicated a certain task: weeks 1-2 for data collection and API configuration, weeks 3-4 for data merging and processing, weeks 5-6 for safety factor modeling, weeks 7-8 for development of machine learning, weeks 9-10 for routing algorithm application, weeks 11-12 for user study conducting, and weeks 13-14 for statistical analysis and final report preparation.

**Figure 5.1:** 14-Week Project Timeline (Gantt Chart)

*A timeline with numbers and letters

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Note. Project timeline with seven two-week sprints aligned Project schedule (September 19 - December 19, 2025). Milestone markers indicate critical deliverables including project plan submission, database population, interim report (35%), operational pipeline, trained ML models, functional routing system, final demonstration (65%), and completed final report.

The phased method guarantees orderly advancement and at the same time it gives room to deal with the technical problems in the moment that they arise (Delling et al., 2017). The timeline incorporates regular assessments of progress, and specific milestones that include project plan submission by week finalized population with initial datasets by week 2, interim report and demonstration by week 6, an operational integrated data pipeline by week 4, validated safety scoring algorithms by week 6, trained and evaluated machine learning models by week 8, a functional routing system by week 10, completed user study data collection by week 12, final demonstration by week 13, and finalized statistical analysis and final report by week 14.

**Figure 5.2:** Milestone Dependencies Network

A diagram of a data preposition

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Note. Network diagram illustrating dependencies between major project milestones. The critical path (red) identifies activities that directly impact project completion, while parallel activities optimize resource utilization.

## **Current Challenges**

At present, the most significant problems that the project is encountering are the complexity of data integration, the optimization of real-time performance, and the recruitment of users for the study. Heterogeneous data sources from 43 UK police departments, Transport for London, OpenStreetMap, and user surveys form the basis of the research, and the data normalization, spatial alignment, and temporal consistency are the areas that face the most significant challenges (Novack et al., 2024). The real-time route calculation that needs to be performed with sub-second response times while safety scores processing across thousands of route segments is going to require sophisticated algorithm optimization and caching strategies (Zhang et al., 2019).

### Figure 5.3: *Risk Management Matrix*

A diagram of data analysis

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***Note.*** Risk assessment matrix prioritizing project challenges. High-impact, high-probability risks (red quadrant) receive immediate attention, while lower-priority risks are monitored throughout the project lifecycle.

User study recruitment that is representative of the target user groups, i.e. pedestrians and cyclists of different age groups, genders and experience levels, is quite challenging logistically, especially when it comes to getting a big enough sample for valid statistical results (Sohrabi & Lord, 2022). Moreover, having data up-to-date and at the same time conducting monthly updates from numerous sources need strong automated pipelines that can tackle data quality problems and format changes (Kang & Kang, 2017).

## **Timeline and Deliverables**

For successful results with the remaining time, the project will give priority to the realization of the essential technical parts and at the same time, it will impose strict evaluation standards. The author will first develop the data integration pipeline and safety scoring algorithms, then proceed with the work on the modified A\* routing algorithm with safety heuristics (Al-Omari et al., 2025). At the same time, the user study recruitment will start with outreach to cycling advocacy groups, university mailing lists, and social media platforms, aiming for a diverse pool of participants (Wang et al., 2016).

The remaining timeline gives a space for comprehensive testing and improvement of every part separately before putting all of them together, with special focus on performance enhancement and user interface usability (Quercia et al., 2014). Continuous progress evaluations will keep the project on track with the milestone plan, and the last few days are reserved for technical issues that were not anticipated. This project management style, together with the constant focus on the important tasks, will result in the delivery of a complete safety routing system that has undergone thorough assessment and that achieves the research goals (Zhu, 2022).

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# **Appendix**

## 1. User Scenario: The Characters (500 words approx.)

* Who is your target user?
* Why are they important?
* What problem are you solving for them?

## 2. Technical Problem: The Setting (1,000 words approx.)

* Why does your system exist?
* What is the core technical problem? (provide an example, an image or a diagram that describes the technical components)
* Can you review other existing systems or products that address this problem? (how do they meet or fail to meet the needs of your target users)

## 3. Technical Solution: The Plot (1,000 words approx.)

* What does your system do?
* How does it work? (System diagram)
* Front-end: Technologies, User interface components including interface mock-ups
* Back-end: Technical components
* Data: What data resources are you going to use and how will you access, collect, and store them?

## 4. Evaluation: The Reviews (500 words approx.)

* What does success look like for your system?
* How will you evaluate the system that you built?

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## 5. Conclusion: The Plan (500 words approx.)

* What is your project management strategy?
* What are the biggest challenges you are currently facing?
* How will you use the time remaining to achieve a successful outcome?

## 6. References and Key Resources

* List of resources (software, papers, tutorials, books, stats, business indicators)