Cyclist Routing Algorithm for Network Connectivity (CRANC Tool)

Requirements Specification

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Accepted as Baseline Requirements for the Project

For the Client	For the Team
_____	_____
Signature / Date	Signature / Date

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1. Introduction

The **Cyclist Routing Algorithm for Network Connectivity (CRANC)** tool is a research-driven platform that evaluates and visualizes bicycle network connectivity. The tool provides interactive maps that show accessibility and connectivity levels for cyclists based on network data.

Currently, CRANC operates on **OpenStreetMap (OSM)** data and is limited to the **Arizona** region. The large and complex nature of OSM files has made scaling and performance difficult. Additionally, the Isochrone visualization tool currently shows reachable areas but lacks contextual features and user interactivity.

The project aims to address these limitations by introducing:

- A transition from OSM to the **General Modeling Network Specification (GMNS)** format to streamline data and support scalability.
- Enhancements to the **Isochrone visualization** with **Points of Interest (POI)** pins.
- Development of a **mobile application** that mirrors web functionality while adding **live route narration** and **GPS tracking**.

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2. Problem Statement

The existing CRANC tool's limitations prevent it from scaling efficiently and offering rich user interaction.

Key problems:

- **Data inefficiency:** OSM data includes unnecessary attributes, causing slow processing and limited scalability.
- **Limited context:** The Isochrone tool shows distance-based zones but not what's accessible within them.
- **No mobile accessibility:** The platform lacks a mobile experience and live navigation features.
- **Minimal personalization:** Users cannot currently save preferences, routes, or track ride metrics.

Problem Summary:

Issue	Impact
OSM data bloat	Slows processing and prevents scaling
No POI integration	Reduces practical value of accessibility data
Web-only design	Limits field usability for cyclists
Lack of user profiles	Prevents personalization and route saving
No live route narration	Restricts app's use as a real navigation tool

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3. Solution Vision

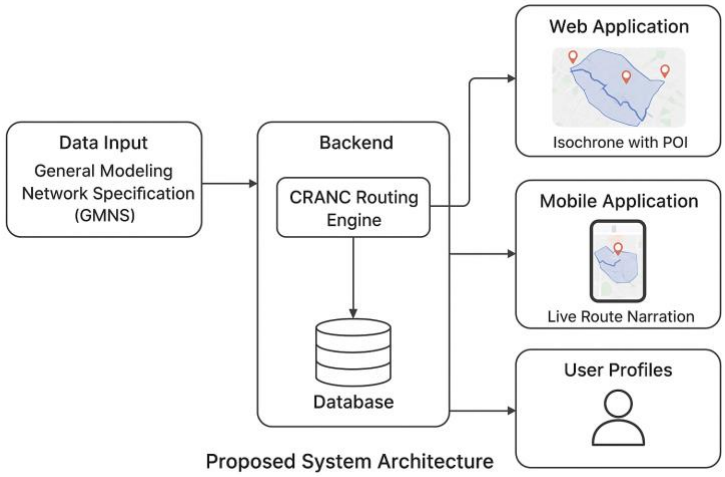
The CRANC enhancement project will deliver an **integrated ecosystem** consisting of:

1. **GMNS Data Conversion Module:**
    - Replace OSM data processing with GMNS for reduced data overhead and scalability across multiple states.
2. **Enhanced Isochrone Visualization:**
    - Add interactive **POI pins** showing key destinations within reachable areas.
3. **Cross-Platform Mobile Application:**
    - Provide feature parity with the web app while introducing **turn-by-turn narration**, **real-time GPS tracking**, and **offline caching** for route guidance.
4. **Advanced User Profile System:**
    - Enable account creation, route history saving, ride analytics, and preference settings for custom Isochrone queries.

Benefits:

- Reduced data complexity and faster load times.
- Seamless scalability to other U.S. states.
- Real-world usability for cyclists via mobile devices.
- Personalized data visualization and route tracking.

Proposed System Architecture (Placeholder):



Proposed System Architecture

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4. Project Requirements

4.1 Domain-Level Requirements

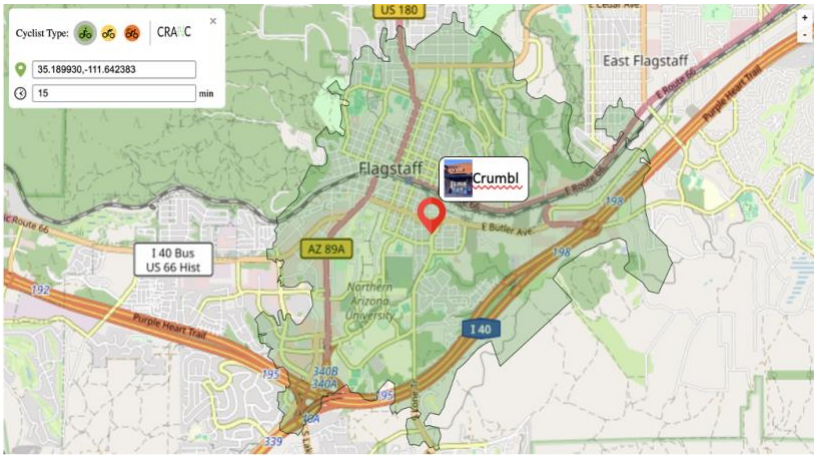
- Replace OSM with GMNS data input format for scalability.
- Implement Isochrone visualization with POI overlays.
- Develop mobile app with the same features as web interface.
- Add live voice navigation and GPS tracking to mobile app.
- Build user profiles with route saving and analytics features.
- Maintain consistent user experience across platforms

4.2 Functional Requirements

MUST

Title: Isochrone with POI

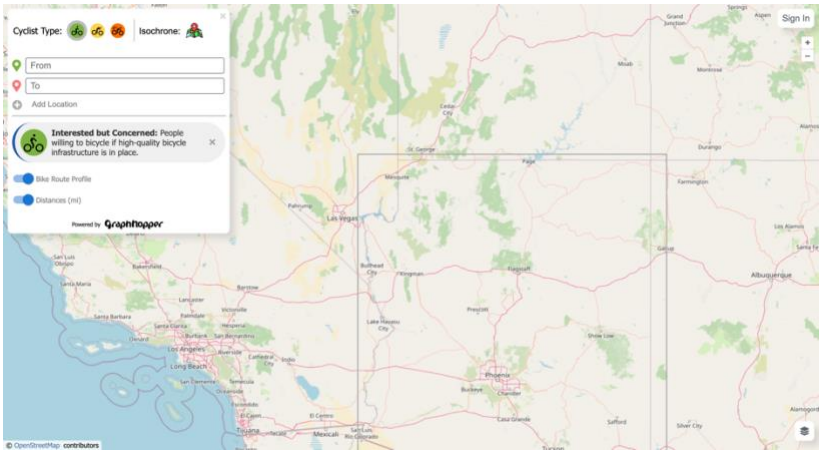
Description: Isochrone maps must include POI pins for reachable destinations.



MUST

Title: User Profiles

Description: Users should create accounts, save routes, and store ride data on both Mobile and Web apps.



SHOULD

Title: GMNS Conversion

Description: CRANC must import and process GMNS files for routing data.

SHOULD

Title: Mobile Application

Description: Mobile app must replicate web app functionality with a responsive UI.

SHOULD

Title: GPS Ride Tracking

Description: Record ride metrics such as distance, time, and average speed.

COULD
Title: Live Route Narration
Description: The app must provide real-time turn-by-turn voice guidance using GPS data.

COULD
Title: Offline Navigation
Description: Allow pre-downloaded routes for offline use.

WON'T
Title: Multi-user Route Sharing
Description: Not in scope for current version.

4.3 Performance (Non-Functional) Requirements

- GMNS import time ≤ 45 seconds per dataset.
- Mobile app route recalculation ≤ 5 seconds after deviation.
- Voice guidance latency ≤ 2 second between GPS update and spoken instruction.
- Map rendering (web/mobile) ≤ 5 seconds for a typical viewport.
- 99% uptime on hosted backend services.

4.4 Environmental Requirements

- Backend: Python/Flask and PostGIS database.
- Frontend: React (web) and React Native (mobile).
- Mapping: Leaflet or Mapbox for web; Mapbox SDK for mobile.
- Mobile: Android and iOS compatibility.
- Data: GMNS schema-compliant datasets derived from OSM.
- Hosting: Existing CRANC infrastructure on NAU servers.

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5. Potential Risks

Risk	Likelihood	Impact	Mitigation
GMNS data conversion inaccuracies	Medium	High	Validate with known OSM samples.
POI data overloading map performance	High	Medium	Use marker clustering and dynamic loading.
Mobile GPS precision variation	Medium	High	Implement correction algorithms and signal filters.
Voice navigation SDK integration complexity	Medium	Medium	Use open-source libraries (e.g., Mapbox Navigation SDK).
Multi-platform sync issues	Medium	Medium	Use a shared backend API for data and sessions.
User privacy/GPS data storage	Low	High	Anonymize user data and comply with privacy policies.

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6. Project Plan

Milestones

Weeks 1–2: Begin mobile application development in parallel with backend work. Establish the foundational app structure, connect to existing CRANC APIs, and implement base routing and map rendering functionality.

Weeks 3–4: Develop and validate the GMNS data conversion pipeline using the osm2gmns tool. Test conversion accuracy, ensure compatibility with CRANC's routing logic, and clean unnecessary OSM data for improved efficiency.

Weeks 5–6: Integrate the GMNS dataset into the CRANC backend routing system. Refactor routing algorithms and verify that results remain accurate and performant across test datasets.

Weeks 7–8: Expand the Isochrone feature to include Points of Interest (POI) overlays within the reachable area. Optimize performance for real-time filtering and display of POIs on both web and mobile platforms.

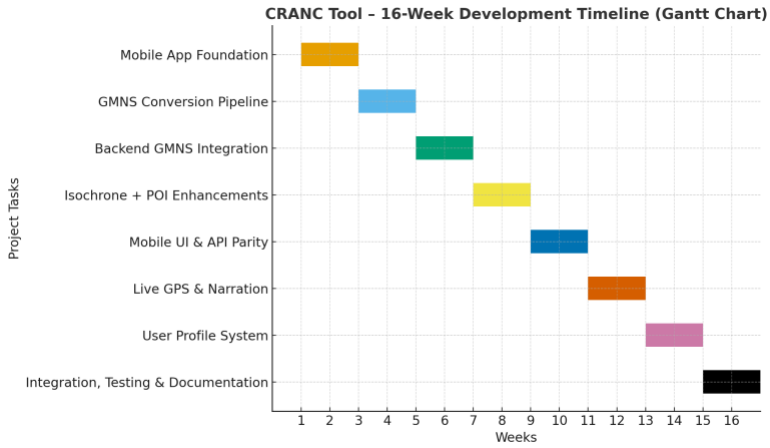
Weeks 9–10: Continue mobile development by adding user interface improvements and ensuring API data parity with the web application. Prepare the groundwork for advanced features like live navigation and tracking.

Weeks 11–12: Implement live GPS tracking and turn-by-turn narration for mobile users. Test navigation accuracy, audio timing, and smooth transitions between route segments.

Weeks 13–14: Build the enhanced user profile system, enabling account creation, route saving, and ride history synchronization between web and mobile versions. Include security and usability testing.

Weeks 15–16: Conduct comprehensive integration, testing, and optimization across all systems. Allocate time for debugging, performance improvements, and documentation. Finalize deliverables and prepare for client demo and submission.

Gantt Chart:



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7. Conclusion

The enhanced CRANC project aims to transform an existing web-based research tool into a scalable, cross-platform ecosystem capable of real-time navigation and interactive visualization. Through GMNS integration, mobile app development, and advanced user personalization, the project will expand the CRANC tool's reach, usability, and impact on regional and national bicycle network planning.

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8. Glossary

Term	Definition
CRANC	Cyclist Routing Algorithm for Network Connectivity
OSM	OpenStreetMap — global geospatial data source
GMNS	General Modeling Network Specification — simplified network model format
Isochrone	Map showing reachable areas within a specific time or distance
POI	Point of Interest — notable map location (e.g., park, store, café)
GPS	Global Positioning System — used for route tracking and live location
Narration	Voice-guided turn-by-turn instructions for navigation

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9. Appendices

- Appendix A: Example GMNS network schema
- Appendix B: CRANC system architecture
- Appendix C: Prototype screenshots (web + mobile)
- Appendix D: Testing plan outline