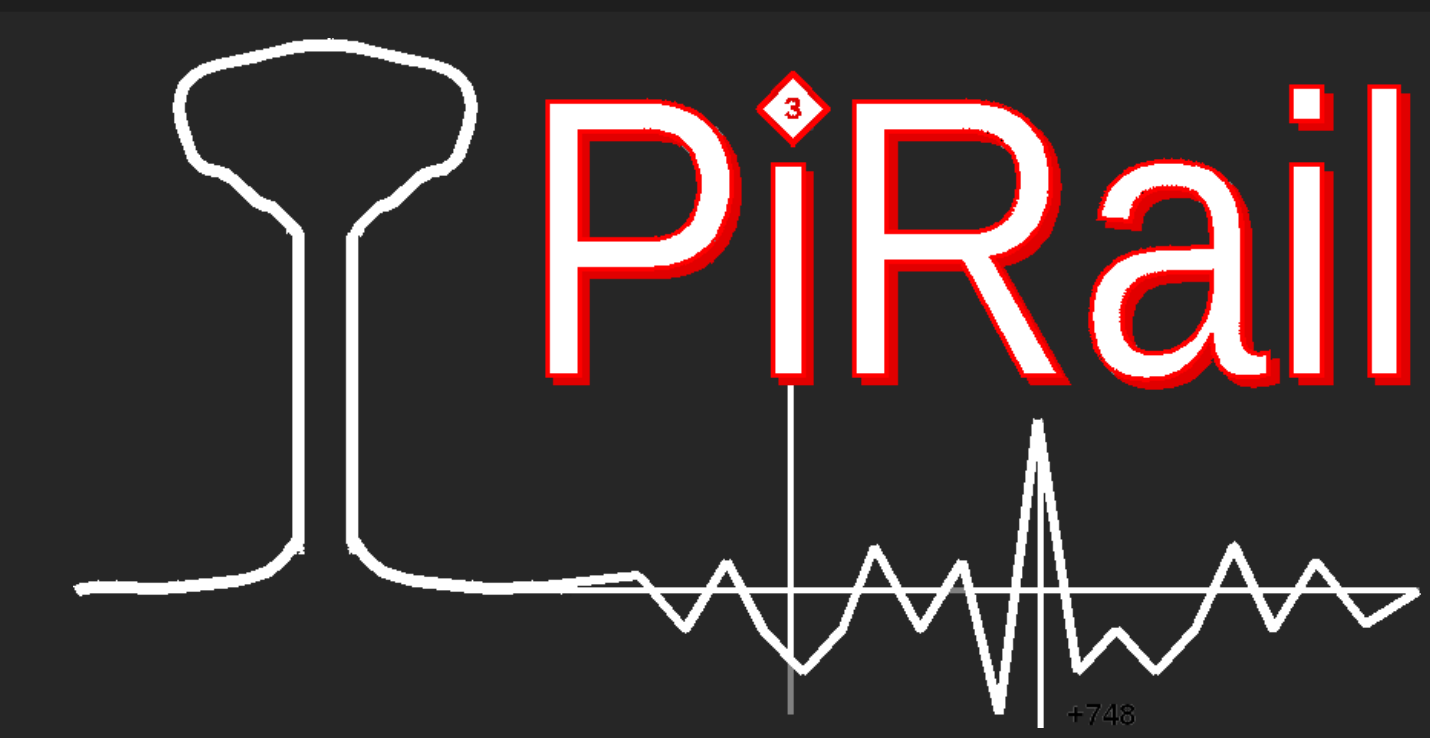




PiRail: Data Simulation and Visualization

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Introduction

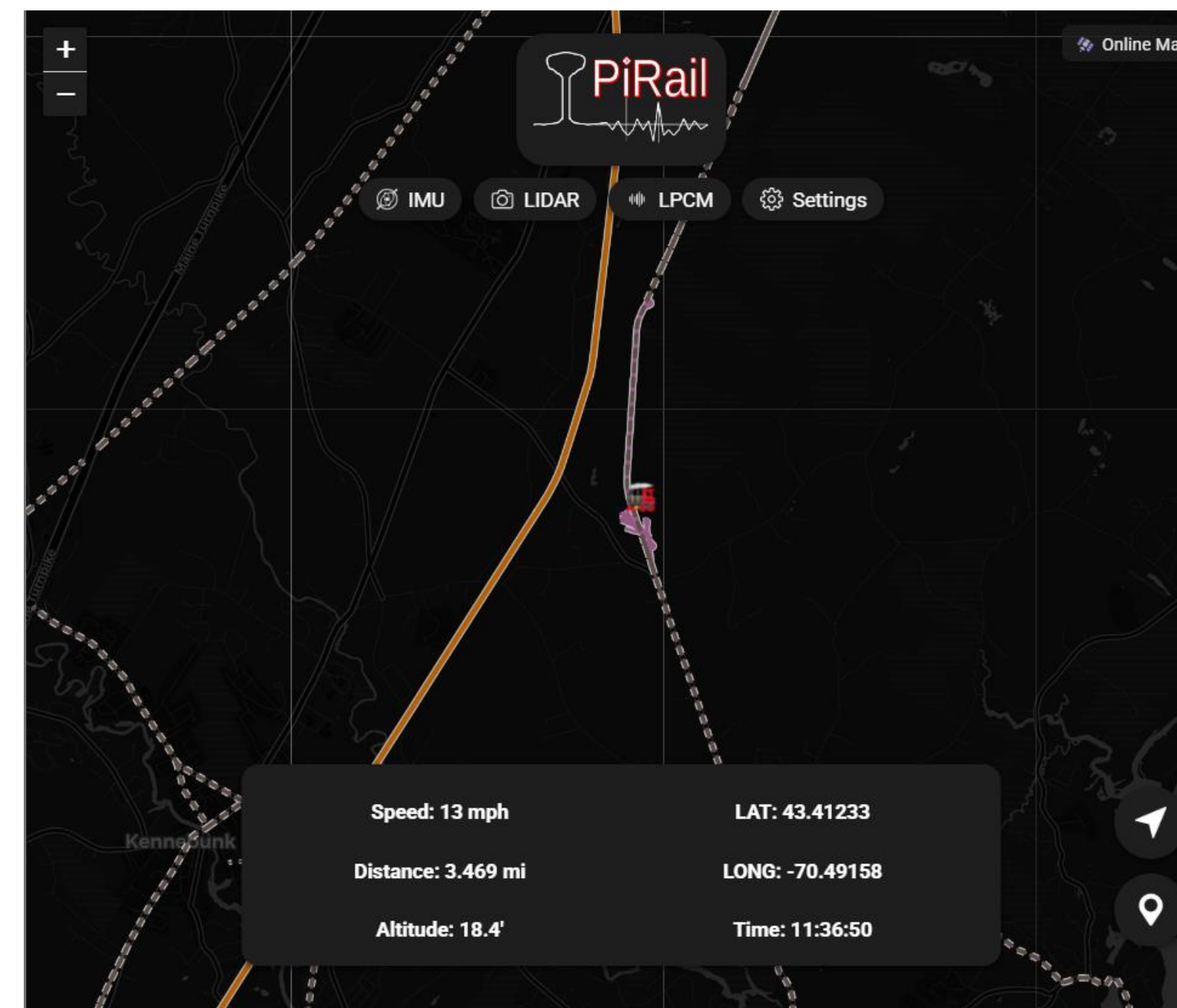
PiRail is a budget-friendly system designed to **improve railway infrastructure monitoring** through efficient data collection, real-time visualization, and a usability-driven interface. Built with single-board computers, low-cost sensors, and open-source software, PiRail offers an accessible yet powerful tool for both field operations and post-analysis. This year's development focused on creating a **modern mobile user interface that simulates and displays live sensor data, GPS location, and railway mapping in real time**. With simulator integration, users can upload JSON files to review previously collected data, enabling thorough analysis without needing to be in the field. Designed for flexibility across devices, ranging from tablets to desktops, PiRail's interface mimics familiar navigation apps to reduce the learning curve and support intuitive use. A **strong emphasis on user testing** ensures that feedback directly informs improvements, leading to greater usability, functionality, and performance.

User Interface

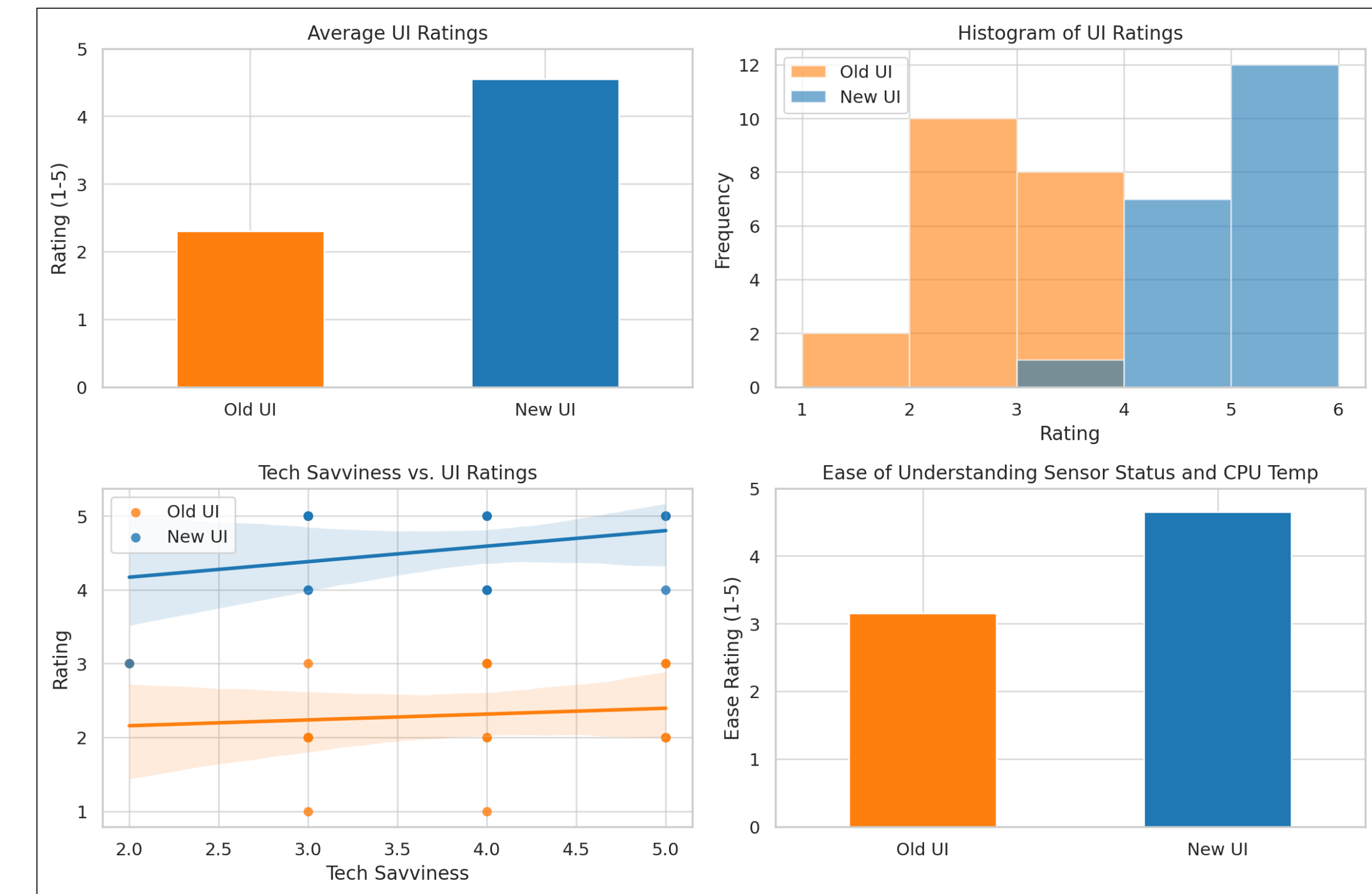
Features in the new UI are:

- Interactable map using Leaflet.js (OpenRailMap and OpenStreetMap)
- Info and selection boxes are screen-size responsive
- Dark and Light-mode
- Imperial and Metric selection
- Can display live and simulated data (updates every second)
- Modernized-toggles for hardware and "help" sections
- Unique pop-ups when taking user input

Home Page (GPS) in Dark Mode



Results



Tools Used

Hardware:

- Raspberry Pi – Single-board computer for data collection
- Low-cost sensors – GPS, LiDAR, and LPCM

Software & Development:

- React.js – For building the user interface
- Python – Backend processing and data handling
- Node.js – Server-side functionality
- GitLab – Version control and project management

Mapping:

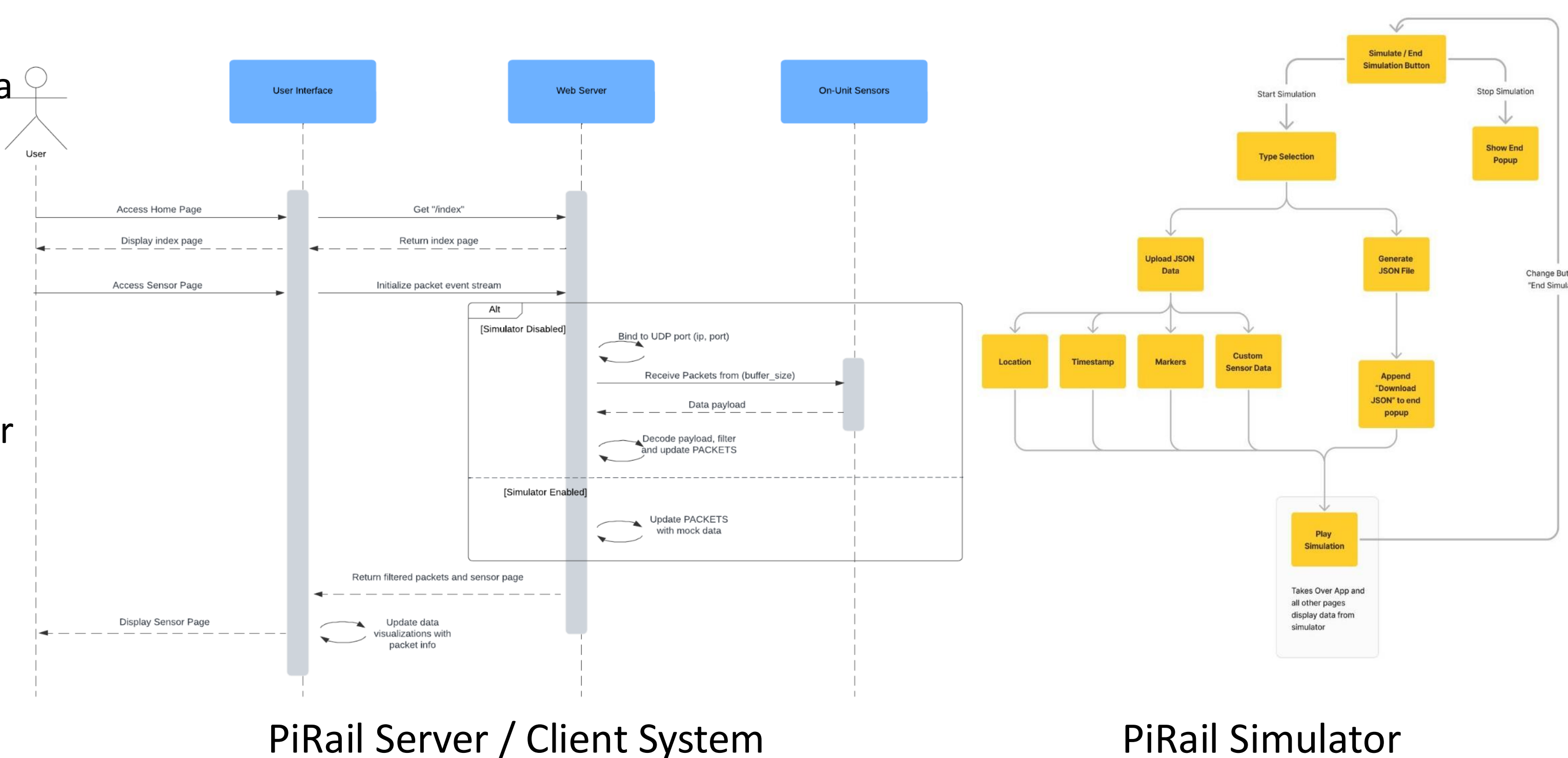
- OpenStreetMap & OpenRailMap – Mapping visualization

Testing & Usability:

- Microsoft Forms– Evaluating user experience
- Figma – UI/UX design and prototyping

Data and Simulation

- On-unit sensors stream device data to web server
- Web server forwards these packets to the client (UI)
- In "simulator mode", web server either reads packets from pre-recorded data stream or generates random packets



Conclusions

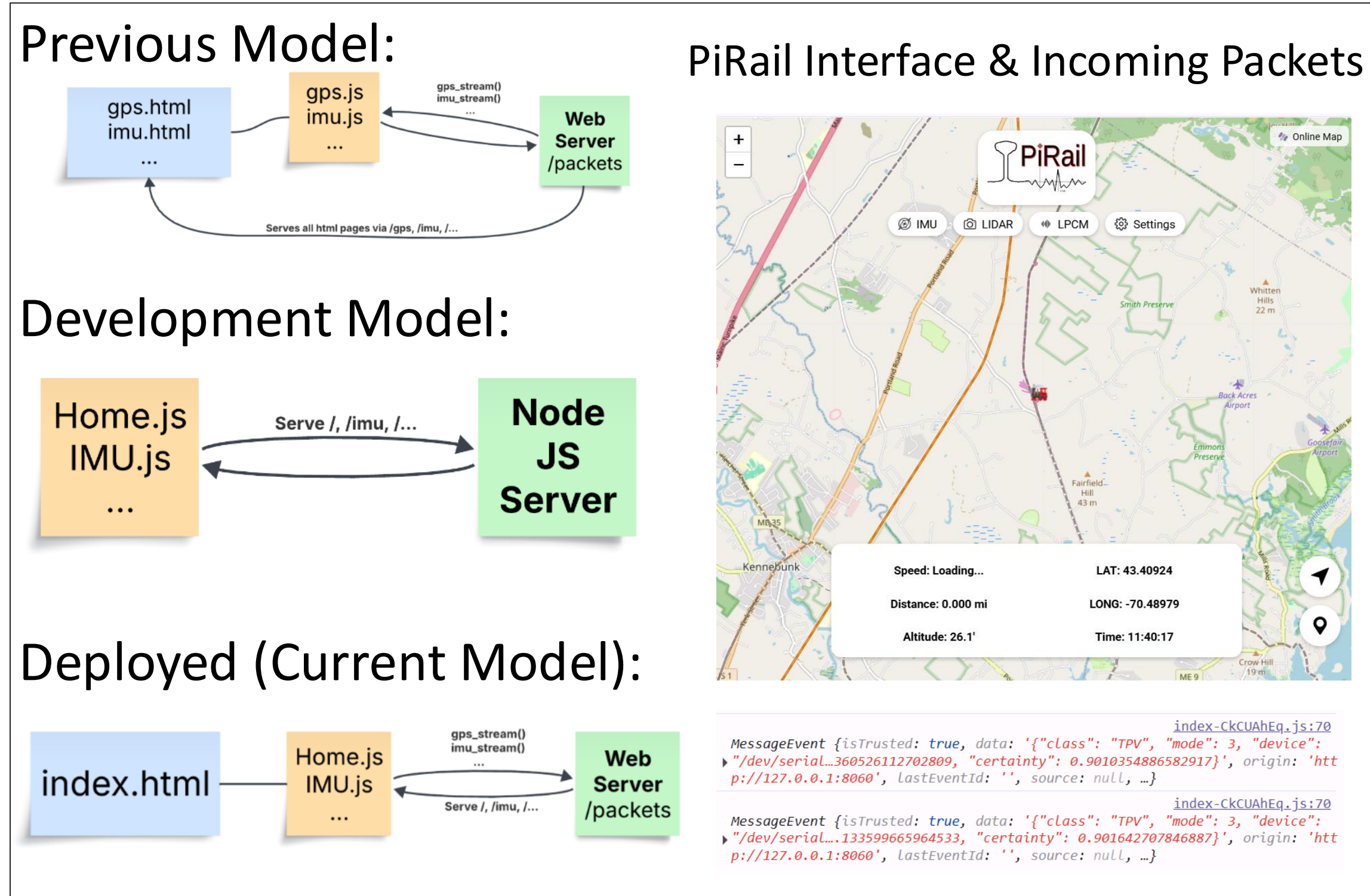
Based on the results of our user testing and graphical analysis, the new PiRail user interface (UI) has clearly met and exceeded our **Measure of Value (MOV)**: "Success will be achieved with a 75% user interface or experience approval rating via user-testing, which takes ease-of-use, look, and feel into account." Throughout the study, users consistently rated the new UI significantly higher than the old one across all major evaluation criteria.

The average rating for the new UI was approximately 4.5 out of 5, which translates to a **90% approval rating**. In contrast, the old UI averaged below 2.5 out of 5. This trend was reinforced by multiple visualizations, including bar charts, histograms, and comparative ease-of-use metrics. The new interface not only scored higher in overall satisfaction, but also outperformed the old version in specific categories like sensor readability, CPU temperature monitoring, and general usability.

Users with higher levels of tech-savviness tended to rate the new UI even more favorably, suggesting that the improvements resonate strongly with more experienced users. However, even **less technical participants showed a clear preference for the new interface**, indicating broad usability across user groups.

In conclusion, the project has clearly **achieved its intended success criteria**. The improvements in design, clarity, and functionality have led to a markedly better user experience, strongly supporting the adoption of the new interface moving forward.

Design



User Testing

Objective: Ensure the new interface is user-friendly and intuitive.

Participants: A diverse group, including students and family members.

Key Features Tested:

- Interactive map
- Real-time alerts
- Updated settings page

Tasks Given:

- Toggle dark mode
- Switch measurement units
- Add Points of Interest (POI)

Results & Improvements:

- Identified usability struggles
- Made final tweaks based on feedback
- Enhanced ease of use and functionality

Microsoft Form for User Testing

Acknowledgements

A special thanks to our Product Owner, **Jonathan Miner**, for his guidance and insight, and to our Scrum Master, **Lisa Henry**, for her leadership in facilitating the Agile development process.

A heartfelt thank you to all usability testing participants whose valuable feedback helped refine and improve the user experience. **Your insights were instrumental in ensuring the continuous development of our interface.**