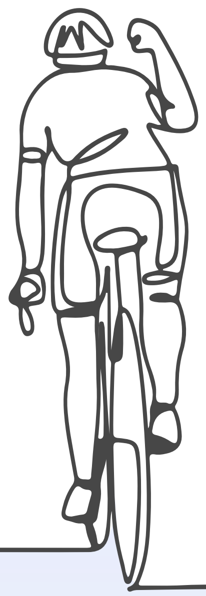
PEDAL PROPOSAL

Rohil J Dave & Kennard Mah



“empower cyclists and facilitate a smooth transition towards cycling, advocating for best practices and healthy decision-making...”

ROHIL AND KEN

Throughout each phase, our team communicated to ensure evenly distributed work, with individual learning goals. For example, Rohil wanted to focus more on learning R, while Ken delved into data’s implication for product development. As design engineers, our objective was to combine our technical skills with a product-centric approach, addressing questions guided by the Data Product Canvas framework. During pivitol design phases, such as the ideation and testing, we collaborated closely and consulted peers to enhance PEDAL. We are highly receptive to feedback and additional incorporations from passionate members from cycling communities! Please privately message us if you would like to contribute.

IDEATION RESEARCH

Abstract

In the wake of growing environmental concerns and the rising trend of fitness consciousness, urban communities like Boston are witnessing a notable uptake of bicycle commuting. This shift towards eco-friendly, healthier, and cost effective transportation has led to an increase in shared services, dedicated bike lanes, and parking facilities, further establishing accessibility. However, this expansion also underscores the need for enhanced safety and informed route planning for cyclists. This report is structured to frame the issue, then present a data product that addresses its challenges. It will detail the design and development, its future implication, and broader mission.

Why Boston?: Context and Trends

Boston, a tech innovation destination, presents a unique setting for this project for several reasons, ranging from its technology driven environment, progressive fast-changing culture, and shared values:

- **Cycling Culture**: Approximately 30,000 bike trips occur per day and 2.4% of people working in Boston commute by bike [1], indicating a significant cycling community that can benefit from our data product.
- **Vision Zero Movement**: This initiative, launched by the Boston Transportation Department, aims to eliminate fatal and serious traffic crashes in the city by 2030 [2]. It reflects a commitment to making traffic safety a priority and acknowledges the human and economic costs of traffic accidents.
- **Boston Cycling Union's (BCU) Efforts**: The BCU works towards transforming Boston's streets into equitable, inviting, and accessible spaces for cyclists. Their mission aligns with our project's goal to enhance cyclists' safety and connectivity.
- **Growing Demographic and 'Shift to Cycling'**: More people are moving to Boston and shifting to cycling, highlighting the need for tools to address this influx to keep busier streets safer in an inclusive way.

The development of Boston as a cycling hub, along with city-led initiatives, not only positions Bostonians as an ideal target audience but also emphasizes a user group that is likely to actively engage with our product.

Market Demographic Research

The current bike safety market is dominated by one-dimensional wearable and on-cycle gadgets focused on in-ride signaling. Cycling commuters and enthusiasts have limited access to comprehensible pre-ride tools that broaden their road awareness. Especially in urban environments, cyclists encounter hazards including traffic collisions, infrastructure inadequacies, and pollution emissions. Consequently, adopting a data-driven approach to bolster cyclist safety and assist in their route decisions has become increasingly crucial.

Extensive desk research, online Boston cycling forums, and four user interviews revealed a notable deficiency in awareness pertaining to streets with higher-than-average accident rates, the existence of designated bike lanes, the proximity of bike docks relative to specific locations, and metrics related to road-specific pollution. End-users need a consolidated platform wherein this information is accessible that enables easy visualisation and customisation. The data product aims to address these needs by leveraging crash, infrastructure, and pollution data in Boston.

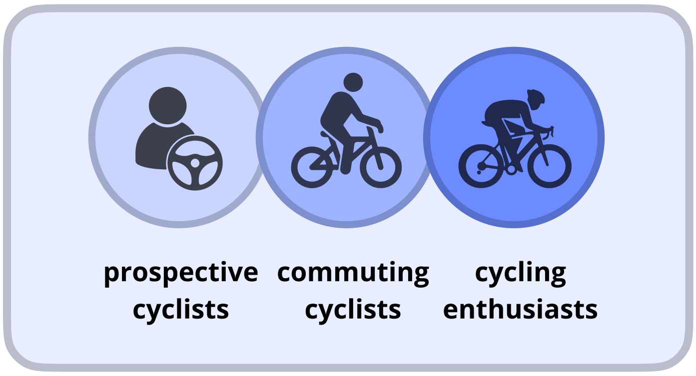


Figure 1: The Three Target Demographic Types

Three specific demographics within the overarching target group were identified based on cycling experiences (Figure X), each with overlapping pain points but different priorities.

Figure 2: Desk Research and Interview Insights

Figure 2 illustrates the unique painpoints that each types of commuter face. The underlying pain points includes lack of development and awareness of infrastructure, lack of visibility of pollution, and concerns regarding safety of cyclists (e.g., newer cyclists and congestion). Other minor pain points were the weather condition, theft concerns, and desire for personalisation.

Data-Driven Motivation

The data product is a response to a real and growing need for cyclist safety awareness in urban environments. By analysing bike crash and fatality data, the data product is able to identify areas to advise more caution in an effective way. Integrating infrastructure data enables users to highlight areas more tailored to their own specific needs and integrating traffic-based pollution data strengthens the link to environmental and health standards, further enhancing the product's relevance and impact. Ultimately, the product is aimed at all commuting cyclists, slowly contributing to a greener and safer future, with the growing shift to cycling and Vision Zero movement.

SOLUTION PRESENTATION

PEDAL

Designed to be the ultimate companion for urban cyclists, PEDAL offers essential insights to plan their journey. PEDAL's focus is on empowering cyclists to make informed decisions based on key factors like the availability of cycling infrastructure, pollution levels, and accident statistics.

When entering PEDAL, cyclists will find an interactive map with customizable layers. This personalized interface enables users to focus on aspects that matters most to their commute, such as pollution level for cyclists that may be more strict with their health. Moreover, the flexible website design enables the seamless integration of features in the future to further enhance the commuting experience.

Expected Impact and Mission Statement

Our mission is to empower cyclists and facilitate a smooth transition towards sustainable city, while advocating for best practices and decision-making to minimize cycling-related risks.

The mission statement aims to capture both the 'shift to cycling' initiative, to develop a product that encourages regular commuters to switch from single person vehicles to a more sustainable form of transport like cycling, and the informative decision-making aspects. PEDAL aims to achieve this by showcasing factors such as available infrastructure, pollution hotspots, and accident risks, that not only enhances existing cyclists' experiences, but makes the daunting transition from another transportation mode to cycling more comfortable. A major goal of PEDAL is to enable this 'first step to cycling,' that many prospective commuters struggle to achieve, while also improving the overall trip planning experience for commuter cyclists and cyclist enthusiasts.

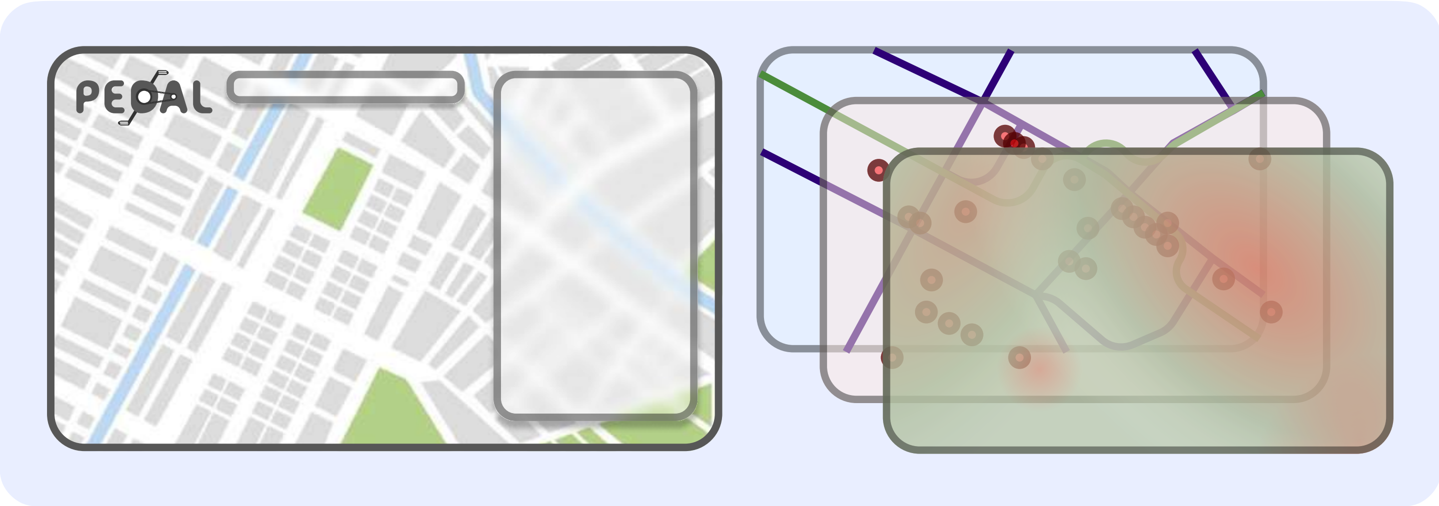


Figure 3: Interface Ideation for Conceptual Design

Conceptual Design

PEDAL takes a user-oriented approach, prioritizing the user need to define pain points and opportunities to build on. As indicated in the ideation, the important factors fall into the three categories—infrastructure, pollution, and safety—with differing priorities for each user group.

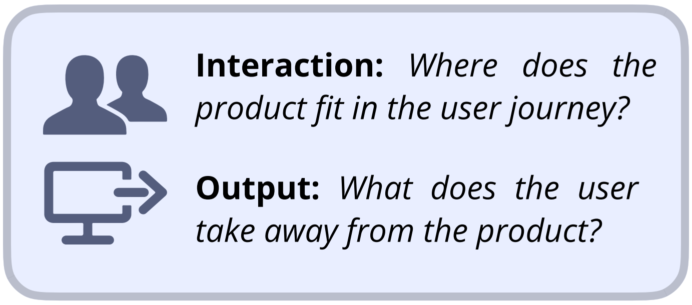


Figure 4: Conceptual Design Framework

The conceptual design can be isolated into two categories: the user interaction and the expected output/suggestions.

Interaction

To appeal to the wide range of audience, the approach of the product must allow for a diversification of interactions. This diversification enables users with varying needs to design a path that best fits their need.

The digital prototype of PEDAL's UI builds on an underlying map, with layers of the different geospatial factors, customizable for each user [Figure 3]. Each criteria, providing information that is clear to understand with careful considerations of its level of depth, design choices, and level of complexity.

Output

Once interacting with the product, it is crucial to understand what the general takeaway from the product is and how the product's impact can be measured. The output and its impact must be measurable through evaluating its KPI, performance, and impact. The clients using PEDAL are frequent city cyclists.

Figure 5: Community Contribution Option

Our team has established a shared repository on GitHub, inviting contributions from those passionate about PEDAL's mission (Figure 5). Future enhancements include in-app analytics for tracking user engagement metrics such as retention and frequency of use. A critical objective is assessing PEDAL's impact on encouraging cycling and promoting safe, healthy habits. To this end, we have looked into an in-app routing feature, leverages a Maps API for efficient routing based on user-specified locations and preferences.

To further personalize the user experience, PEDAL is considering implementing a Web-Identity Federation for social media account integration, enabling progress saving and customization. Additionally, we can utilize public data on bike-sharing patterns and cycling accident statistics to evaluate Boston's advancements in cycling promotion and safety.

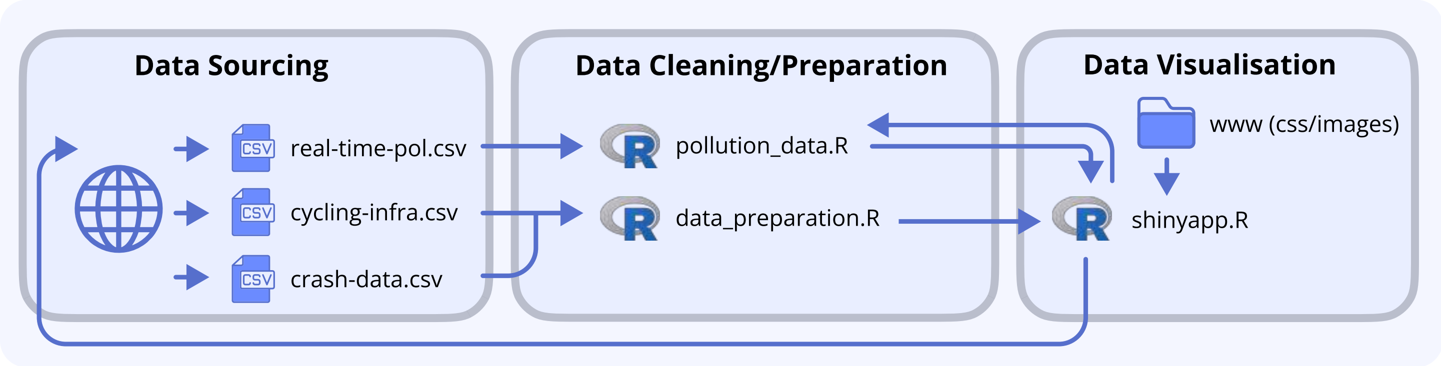


Figure 5: Data Sourcing, Preparation, and Visualisation Process

System Design

The system is designed to isolate each operation and join them in the final UI to make it easier to catch errors and debug (Figure 5). Therefore, even if one functionality is down, (e.g., the Pollution API experiences a crash) all of the other features of the app would function correctly. The system follows the pipeline of data being sourced (either as a csv file or scraped from an online source), prepared through cleaning and imputation, then visualised on the dashboard (Figure 5).

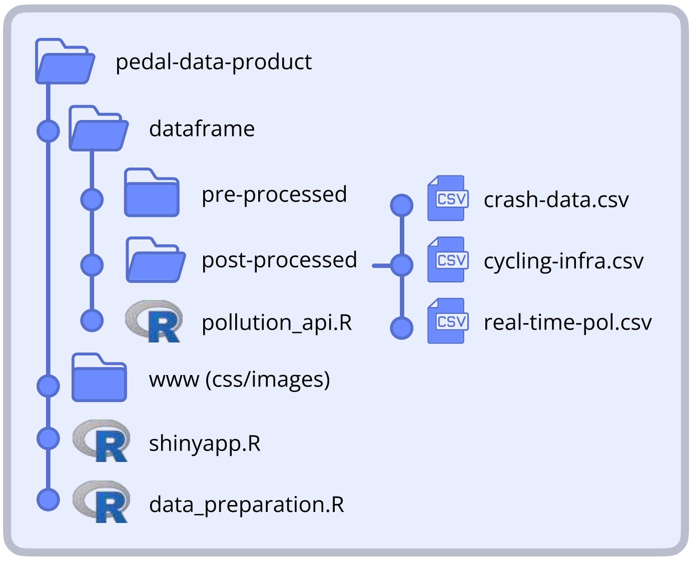


Figure 6: Ideal Repository Framework

The ideal repository structure (Figure 6) was designed to create a workflow that isolated the front-end and back-ends of the website for redundancy and swift collaboration. In the pre-processed dataframe, there are files, such as geojson and coordinates data, to process each data in 'data_preparation.R'. The 'www' folder contains the dependencies for the data product. The final repository structure follows the same structure but with more dependencies and multiple different file names.

TESTING & DEVELOPMENT

It is crucial to recognize how the user interprets the provided visualisations and how to cater the data product directly to their needs. To do so, PEDAL was developed using an iterative method and a feedback loop between three potential users. In doing so, changes were made to the initial interface (Figure 3) and are documented in this section with reason.

Accident Data

How can we inform 'safer' choices?

Utilizing accident data sourced from the Boston Council, the app can guide cyclists to exercise increased caution on certain streets. However, it's important to address a common misconception: the absence of accidents does not necessarily equate to safety. To mitigate this risk, PEDAL features a display of all bike-related accidents. These are represented with opacity, hence areas with frequent accidents are highlighted in a brighter red. A key insight gathered is the higher frequency of accidents at intersections. Currently, PEDAL does not distinguish between different types of accidents, but incorporating this feature is a key objective for our future development.

Figure 9: Final Design - Accidents by Coordinates

Infrastructure Data

How can we effectively suggest personalised *cycling routes?*

Regarding routes, we foresee the user need of knowing the different types of cycling lanes. The personalised element may be that different cyclists prefer different levels of separation with road vehicles. Our data source, shared by the BCU defines 14 different types of 'lanes.' Portraying this all separately would oversaturate the data product with unnecessary information. Instead, four types of cycling lanes were designed based on what the users preferences might be and to provide a good level of depth for real insights (Figure 8).

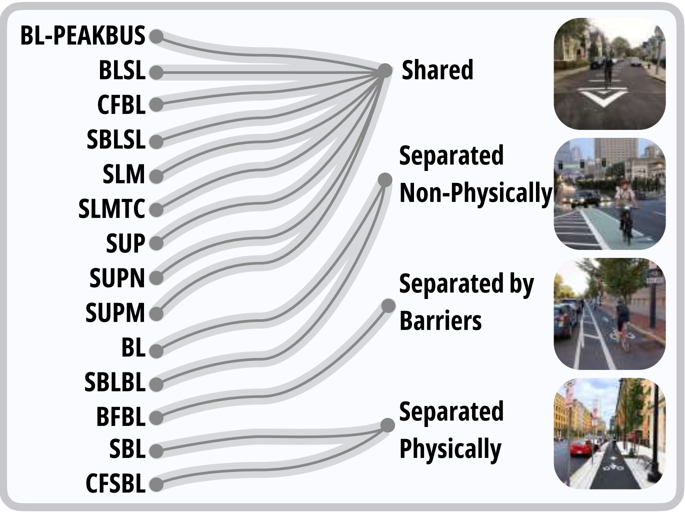


Figure 8: Redefining Cycling Lane Type Scope

The four categories were defined based on the preferences of cyclists, found through extensive user research. Some are comfortable cycling alongside other vehicles in a shared environment; whereas, others preferred a strong physical distinction between the lanes due to cars parking in the lanes and obstructing lanes that aren't physically separated.

Figure 9: Final Design - Cycling Lanes by Type

Pollution Data

What do the users want to know regarding pollution?

The visualisations must meet the requirements of what the target user wants to know; which in this case is the ***pollution level across Boston*** and the ***ability to plan ahead of time***.

To source that data, PEDAL uses an API that provides real-time and forecast data of pollution level across the US. To meet the needs of the user, the element of real-time was essential, as previous data would be useless and may be misleading, diminishing the trust of PEDAL.

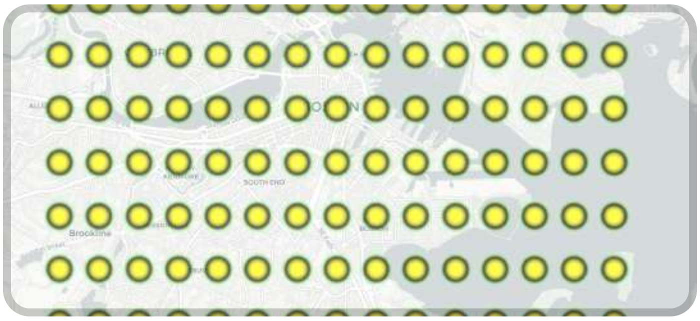


Figure 10: API Call and Heat-map Visualisation

Initially, PEDAL focused on mapping pollution geolocations to ascertain pollution levels across Europe. This effort began with the creation of a heat map using longitude and latitude coordinates, with values represented as gradients (Figure 10). However, upon analysis, we identified that the data was too sparse, offering limited insight between coordinates. This sparsity rendered the map difficult and impractical for cyclists to use for determining which paths to avoid.

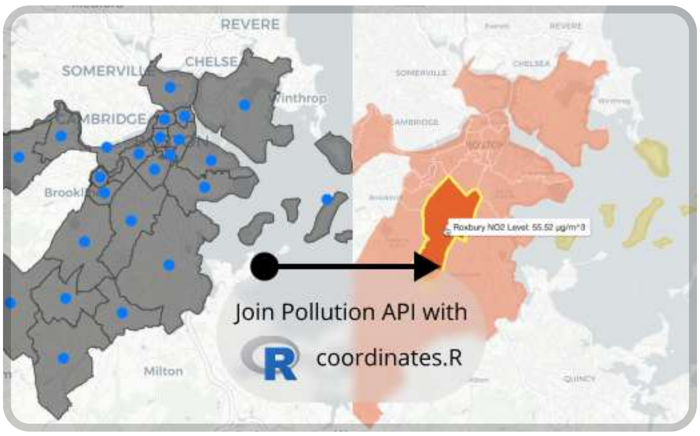


Figure 11: Choropleth Map for Pollution Levels

To resolve this issue, we looked at the possibility of distributing pollution by districts. PEDAL displays the average pollution level of a district, with a ‘hover’ feature to clarify details (Figure 11), in this case integrating a function that calculates the centroid, extracts data from an API, and joins its value with a GeoJson file.

	Good	Fair	Mid	Poor
$PM_{2.5}$	0 ~ 20	20 ~ 50	50 ~ 100	100+
NO_2	0 ~ 40	40 ~ 70	70 ~ 150	150+

Figure 12: Pollution Level Interpretation in µg/m³

Rather than using the maximum and minimum values of the data provided, PEDAL uses the health recommendations from online research (Figure 12) to define the ranges so as to to suggest the healthy range with better accuracy [11].

In future iterations, PEDAL aims to incorporate a time-series projection for each district, suggesting what pollution levels may be as one of the pain points were for Bostonians to be able to plan in-advance.

LIMITATIONS & DISCUSSIONS

PEDAL, while promising, exhibits several flaws and areas for improvement, particularly in data visualization and user engagement. As a user-centric product, our goal is to progressively refine existing features and introduce new functionalities to enrich the cycling experience in Boston.

Data Limitations

In terms of existing features, enhancements are possible both in the variety of visualizations beyond a standard map (e.g, including a pollution forecast for future insights) and in the underlying data quality, specifically its precision, accuracy, and reliability. A notable challenge, as depicted in Figure 11, is the limited granularity of the current API data. This limitation results in the display of pollution levels for only two distinct districts at a time. While this approach offers a broad overview of pollution levels, acquiring more detailed and precise data could enable PEDAL to provide real-time pollution monitoring and predictive forecasts.

Reflecting on the Outcome

The current data visualisation was developed by consulting students and new graduate commuters in Boston. This method, however, may introduce a bias towards individuals already acquainted with the city's layout, potentially not addressing the needs of the wider population. PEDAL plans to mitigate this by closely observing user interaction with the app and incorporating their feedback in future updates.

Future Steps

The BCU heavily emphasises the importance of collboration to reach its goals. Likewise, we envision PEDAL as a product ***created by cyclists for cyclists.***

Looking ahead, we aim to foster community engagement in cycling improvements. This includes integrating data on weather conditions, traffic congestion, roadblocks, and other factors affecting cyclists. Community participation is crucial in shaping PEDAL's development.

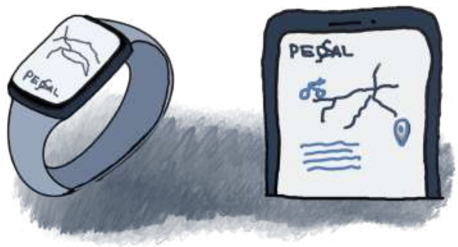


Figure 13: Potential Future Methods of Interaction

How do users interact with PEDAL? Beyond data enhancement, we seek to optimize how users interact with PEDAL. PEDAL’s vision is to become a data product that integrates seamlessly into a cyclist’s journey, whether it is through mobile apps, wearable technology like smartwatches, or partnerships with shared-cycle services (Figure 13).

Another ambition is to source better data to enhance granularity and precision, potentially through community collaboration. Looking at current transportation products like Waze, offering real-time traffic details with an engaging community and geo-gaming element, PEDAL can have a similar interface to improve its community-building features.

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Data Source

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9. Bike Network: https://data.boston.gov/dataset/existing-bike-network-2023
10. Geojson Boundaries: https://data.boston.gov/dataset/boston-neighborhood-boundaries-approximated-by-2020-census-block-groups
11. Pollution Data: https://openweathermap.org/api/air-pollution

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For User Feedback