

Software Design Document for **Artificial Intelligence and Data Science for Air Pollution Prediction and Visualization**

Version 3.0 approved

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NASA and LA City

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Revision History

Name	Date	Reason for Changes	Version
First Draft	12/7/2021	Initial Draft of Doc	2.0.0
Second Draft	12/8/2021	Detailed System Design Update	2.0.1
Third(Final) Draft	5/10/2022	Final Changes	3.0

1. Introduction

1.1 Purpose

This document aims to explain in detail the functions of the application. The document will inform the reader on the purpose, and functions of the application. The purpose of the application is to provide users with an easy to understand, user-friendly website with general air quality, weather, and pollution data. The application will also use machine learning and data science to provide predictions of air pollution and air quality.

1.2 Document Conventions

Bullet points will indicate sections being talked about. External links will be underlined blue.

1.3 Intended Audience and Reading Suggestions

The intended audience for the Software Requirements Specification document are software developers, project managers, and data scientists.

1.4 System Overview

I. Air Pollution in Los Angeles County Data Visualization (Web App)

- This application is used to show the measured levels of air pollutants and weather around Los Angeles County. Currency, the utilization of temporal layers in ArcGIS, accompanied by tile layers allows for visualization of air pollution predictions. The utilization of several APIs allows for live data and air pollution to be shown within the United States.

II. Air Pollution in Los Angeles County Data Visualization (Mobile App)

- This application is used to show the measured levels of air pollutants and weather around Los Angeles County. Currency, the utilization of temporal layers in ArcGIS, accompanied by tile layers allows for visualization of air pollution predictions. The utilization of several APIs allows for live data and air pollution to be shown within the United States.

2. Design Considerations

The following section details the Assumptions and Dependencies, General Constraints, Goals and Guidelines as well as the Development Method of the applications.

2.1 Assumptions and Dependencies

I. Air Pollution in Los Angeles County Data Visualization (Web App) •

- The following software uses the ArcGIS Online JavaScript API and assumes that any browser allows the proper permissions for it to work.
- The following software is reliant on the ArcGIS Online and assumes that the Feature Layers used remain public and in the same format
- The following software is reliant on using ArcGIS to represent data and assumes developers have an ArcGIS license
- The following software is developed by gathering data from various APIs and assumes that API keys are provided to the developers

II. Air Pollution in Los Angeles County Data Visualization (Mobile App)

- The following software uses Android Studio, ArcGIS, and Kotlin as our main language.
- The following software is reliant on the ArcGIS Online and assumes that the Feature Layers used remain public and in the same format
- The following software is reliant on using ArcGIS to represent data and assumes developers have an ArcGIS license
- The following software is developed by gathering data from various APIs and assumes that API keys are provided to the developers

2.2 General Constraints

Listed below are the general constraints for each application of this project.

I. Air Pollution in Los Angeles County Data Visualization (Web App) • Software Environment

- Developers are required to have a functioning ArcGIS Pro license
- Developers are required to have basic knowledge of HTML
- Developers are required to have basic knowledge of CSS
- Developers are required to have basic knowledge of the JavaScript language
- Developers are required to have knowledge of the React framework

- **End-User Environment**
 - A web browser is required to use and view the web application
 - A mouse, keyboard, monitor, and desktop/laptop are required for user inputs and outputs.
- **Interoperability requirements**
 - Data is gathered from ArcGIS Pro
 - Data is gathered from various APIs
- **Performance requirements**
 - Application should load maps and their datasets in less than 5 seconds
 - Application should load graphs in less than 5 seconds
 - Application should load current weather in less than 5 seconds
- Application should load current weather change in less than 5 seconds

II. Air Pollution in Los Angeles County Data Visualization (Mobile App)

- **Software Environment**
 - Developers are required to have a functioning ArcGIS Pro license
 - Developers are required to have knowledge of the Kotlin framework
- **End-User Environment**
 - A mobile device is required to use and view the mobile application
- **Interoperability requirements**
 - Data is gathered from ArcGIS Pro
 - Data is gathered from various APIs
- **Performance requirements**
 - Application should load homepage in less than 10 seconds
 - Application should load graphs in less than 10 seconds
 - Application should load air quality map in less than 10 seconds
- Application should load forecast map change in less than 20 seconds

2.3 Goals and Guidelines

I. Air Pollution in Los Angeles County Data Visualization for web and mobile app

- The data gathered from ArcGIS should be accurate
- The GUI should be user-friendly
- The data gathered from the various APIs should be accurate
- The application should effectively visualize predicted and current data

2.4 Development Methods

The developers have split into two teams; one team is responsible for the development of the web application's maps and the other team is responsible for the APIs and overall design of the website. Both teams split tasks among individual team members in order to complete small updates each week successfully. Regularly, bi-weekly meetings are conducted in order to assess the progress and changes that have been made and to further improve the website by allotting new tasks for the following meeting.

3. Architectural Strategies

I. Air Pollution in Los Angeles County Data Visualization (Web App) • Use of a particular type of product (programming language, database, library, etc.)

- ArcGIS
- JavaScript
- HTML
- CSS
- React
- Reuse of existing software components to implement various parts/features of the system
 - This software was based on the 2021 Artificial Intelligence and Data Science for Air Pollution Prediction and Visualization teams software.
- Future plans for extending or enhancing the software
- User interface paradigms
 - A computer and internet connection is required to use the application as well as a mouse and keyboard to navigate the web application

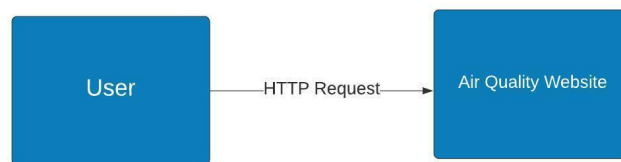
II. Air Pollution in Los Angeles County Data Visualization (Mobile App)

- Use of a particular type of product (programming language, database, library, etc.)
 - ArcGIS

- Kotlin
- Implementation was made from scratch
- Future plans for extending or enhancing the software
 - Implementation of a changing data based on a different zipcode
- User interface paradigms
 - A mobile device and internet connection is required to use the application.

4. System Architecture

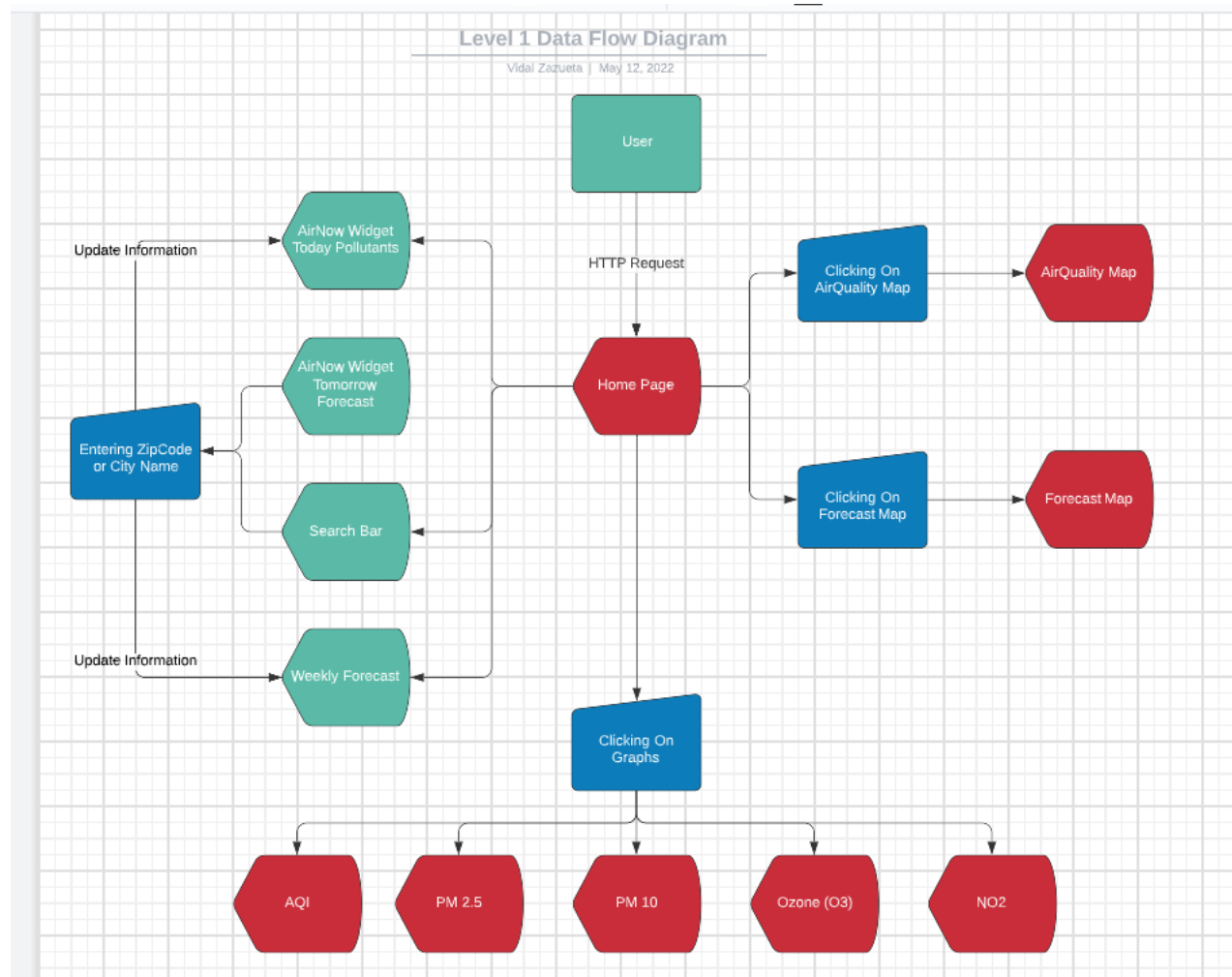
Level 0 Data Flow Diagram
Vidal Zazueta | December 9, 2021



Level 0 Data Flow Diagram (DFD)

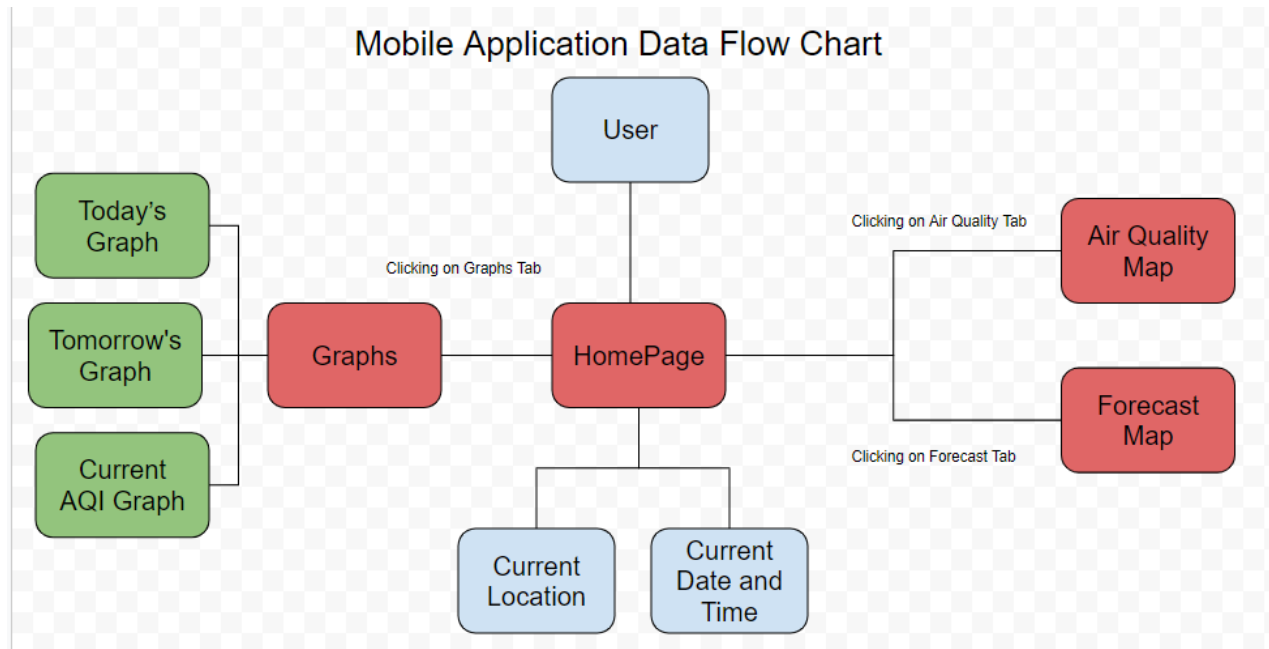
4.1

Website Architecture:



4.2

Mobile Application:



Level 1 Data Flow Diagram (DFD)

5. Policies and Tactics

5.1 Choice of which specific products used

- Programming languages used:
 - JavaScript
 - HTML
- ArcGIS

5.2 Plans for ensuring requirements traceability

The requirements of the project are traceable via GitHub and the base code versions. Documents will follow System Design Description.

5.3 Plans for testing the software

The software will be continuously tested as new components and features are added and modified.

5.4 Plans for maintaining the software

The plans to maintain software are to fix bugs as they arise, and to collect and live update data as it becomes available.

5.5 Engineering trade-offs

- Due to issues pertaining to parent child information sharing a temporary search bar had to be implemented.

5.6 The choice of a particular algorithm or programming idiom (or design pattern) to implement portions of the system's functionality

- A simple segmented system with individual components was chosen to make it easier to move components from page to page
 - This system was also chosen to make web-app development simpler

5.7 Plans for maintaining the software

- Routine updates will update data as it is received.
- Update product keys for weather APIs in order to maintain function.
- Renew licensing for ArcGIS to keep maps accessible.

5.8 Interfaces

- React
- Javascript
- Android Studio
- Kotlin for Android

5.9 System Deliverables

- For the Web App the use of Visual Studio and React were used to develop and build our website.
- For the Mobile app the use of Android Studio, Kotlin and ArcGIS dependencies were used to build and develop the app.

6. Detailed System Design

6.1 Data Visualization

6.1.1 Responsibilities

The primary responsibility of this module is to visualize data on a map and translate the data into UI elements such as symbols or polygons. This module should also ensure that all symbols are unique and that all polygons are colored based on intensity.

6.1.2 Constraints

Some datasets used for this module are not up to date or do not update in real-time which may lead to inaccurate representation. Datasets that are up to date may also have null fields which may cause certain data to not appear on the map.

6.1.3 Composition

The list below details the use and meaning of the subcomponents used in this module

- **Legend:** shows the different symbols and their meanings as well as the different colors for the polygons and their meanings
- **Toggle on/off:** allows for datasets to be toggled on/off and refreshes the map
- **Add dataset:** allows for custom datasets to be added to the map given they are in the right format
- **Switch map:** allows for multiple maps with different datasets and different usage to be shown in the same application

6.1.4 Uses/Interactions

This module will be used to visualize the common causes of air pollution, the measured levels of air pollutants, the current demographics of the populus, as well as statistics on the effects of air pollution surrounding Los Angeles county.

6.1.5 Resources

The resources this module uses are datasets of Feature Layers that are present within ArcGIS's Living Atlas as well as data gathered from various sensors surrounding Los Angeles county.

6.1.6 Interface/Exports

The visualized data will be displayed on the Air Pollution in Los Angeles County Data Visualization application via the use of the ArcGIS Online JavaScript API.

6.2 Navigation Bar

6.2.1 Responsibilities

Allows users to navigate between the 3 different options: Home, Graphs, Maps with a work in progress search bar

6.2.2 Constraints

Users must have an internet connection and an I/O device

6.2.3 Composition

Compositions consists Javascript for the syntax of the code, React for the functions, and CSS for the styling

6.2.4 Uses/Interaction

Consists of our logo, motto, and a search bar to search temperature and air quality by zipcode. It is a work in progress. Also contains 3 tabs: Home, Graphs, and Maps.

6.2.5 Interface/Exports

-Javascript, CSS, and React

6.3 Home

6.3.1 Responsibilities

Allows users to see the current air quality at the specific hour and location and 5 week weather forecast

6.3.2 Constraints

Users must have an internet connection as well as an I/O device.

6.3.3 Composition

The composition process consists of javascript, html, css, and react.

6.3.4 Uses/Interaction

A user-friendly menu which consists of a widget from AirNow and a 5 day weather forecast with temperature.

6.3.5 Interface/Exports

6.4 Search

6.4.1 Responsibilities

Allows users to search for the air quality and weather forecast based on the zipcode input

6.4.2 Constraints

Requires a user input of the locations zip code or city name

6.4.3 Composition

The composition of the process required React and JavaScript

6.4.4 Uses/Interaction

A search bar above the weekly forecast. Entering a valid zip code will display the air

quality through the gauge and the weekly forecast. The user can also input the city name which will also change the gauge and weekly forecast.

6.4.5 interface/Exports

-React

-JavaScript

6.5 Graphs

6.5.1 Responsibilities

Provides the user graphical data on different air pollutants on a certain location based on the zipcode

6.5.2 Constraints

Requires the user to navigate between the locations by zip code

6.5.3 Composition

The composition of the process used JavaScript, React , and CanvasJs.

6.5.4 Uses/Interaction

A user-friendly page that displays different gauges on different air pollutants. Including AQI, PM10, Ozone, and NO2.

6.5.5 interface/Exports

-JavaScript

-React

-CanvasJS

6.6 Air Quality Map

6.6.1 Responsibilities

Displays an interactive air quality map with various sites around the globe but mainly in ' the United States. Additionally, includes a forecast air quality map to show machine learning generated sensor values.

6.6.2 Constraints

Users must have an internet connection and an I/O device to interact with the map.

6.6.3 Composition

The composition uses React, JavaScript, and ArcGIS

6.6.4 Uses/Interaction

Displays an interactive map built with ArcGIS. Users can zoom in and out of the map and navigate around the map. Users can click on any of the sites, identified by a colored circle, for more information such as current air quality, location, site name, etc. There is a legend on the bottom left to show what each site's air quality is based on the color. Users can also use the search bar and input a location to be taken to that location.

6.6.5 interface/Exports

-React

-JavaScript

-ArcGIS

6.7 Forecast Map

6.7.1 Responsibilities

Users can see and interact with a map that is an air quality forecast respective to their location. Currently, the forecast is limited to Los Angeles County and can predict by showing different layers of how the air quality is going to be every hour.

6.7.2 Constraints

Users must have an internet connection, javascript enabled and an I/O device.

6.7.3 Composition

Composition is made up of ArcGIS, AWS, GeoTiff Files Layers, React, and JavaScript

6.7.4 Uses/Interaction

The user is able to zoom in and zoom out of the map. This map shows prediction layers and changes every hour for 24 hours. There is a forward and backwards button for the user to press to have the prediction layers change. An auto play button is also implemented for the user to

autoplay the prediction layers and see the layers change every hour.

6.7.5 interface/Exports

-ArcGIS

-JavaScript

-React

II. Air Pollution in Los Angeles County Data Visualization (Mobile App)

6.8 HomePage

6.8.1 Responsibilities

Users are able to see the Homepage when they launch the app. It contains a default location of Los Angeles as well as the current date and time. The Weather and the three boxes are still a work in progress, but they should display different AQI values.

6.8.2 Constraints

Users must have an internet connection, and Mobile Device

6.8.3 Composition

Composition is made up of Kotlin frameworks

6.8.4 Uses/Interaction

The user lands on the homepage whenever the app is launched. The user can see the current date and time. There is a bottom navigation bar for the user to move between tabs. There are 4 different tabs, Homepage, Graphs page, AirqualityMap, and ForecastMap.

6.8.5 interface/Exports

-ArcGIS

- Kotlin

6.9 Graphs

6.9.1 Responsibilities

Users will be able to access the different graph gauges that will let the user see the conditions of the air quality. Displaying if the air pollutants are good, moderate, or bad. There are three different graphs that display a Today's, Tomorrow, and Current AQI. Each graph tells the user whether the air pollutant for a certain location is good or not.

6.9.2 Constraints

Users must have an internet connection, and Mobile Device

6.9.3 Composition

Composition is made up of Kotlin frameworks

6.9.4 Uses/Interaction

The user lands on the graphs page by clicking on the graphs (second navigational tab). The user can see the current AQI, Today's and Tomorrow's Air pollutants. There is a bottom navigation bar for the user to move between tabs. The user can change tabs between Homepage, Graphs page, AirqualityMap, and ForecastMap.

6.9.5 interface/Exports

-ArcGIS

- Kotlin

6.10 Airquality Map

6.10.1 Responsibilities

The air quality map is an arcGIS map where the user is able to zoom in and out of the map to see a clearer view of the locations and the different AQI.

6.10.2 Constraints

Users must have an internet connection, and Mobile Device

6.10.3 Composition

Composition is made up of Kotlin frameworks

6.10.4 Uses/Interaction

The air quality map is helpful for the user to be able to see the different AQI values in each location. These AQI values show the major air pollutant for that certain location. It also states whether in that certain location the air pollutants are good or bad.

6.10.5 interface/Exports

- ArcGIS

- Kotlin

6.11 Forecast Map

6.11.1 Responsibilities

The user is able to access this map, it's the 4th tab of the navigational tab. Its a useful map where the user can see the predicted future air quality layers and determine if it would be good or bad.

6.11.2 Constraints

Users must have an internet connection, and Mobile Device

6.11.3 Composition

Composition is made up of Kotlin frameworks

6.11.4 Uses/Interaction

The user is able to zoom in and out of the arcgis map and the user is able to click on the forward and backward button to be able to change the different predicting layers of air quality for a certain hour for all of the 24 hour predictions.

6.11.5 interface/Exports

- ArcGIS

- Kotlin

7. Database Design

- Current Version 2.0 of PWWB's APLAC does not utilize a database on a server since it is mainly a visualization of live sensor readings and manually and locally generated machine learning forecasts. Future Versions will include a database to keep track, manage, and display such data and revisions to include these changes will be made as needed.

8. User Interface

8.1 Overview of User Interface

When a user enters our website's web address, they will be introduced to the home page. At the top of the website page is the Navigation Bar that holds different tabs; Home, Graphs, AirQualityMap, and ForecastMap. The Navigation Bar also holds our team logo and our project name, "Predict What We Breathe." There is also a search bar: the user can type in the zipcode and the data will change to the zip code entered by the user.

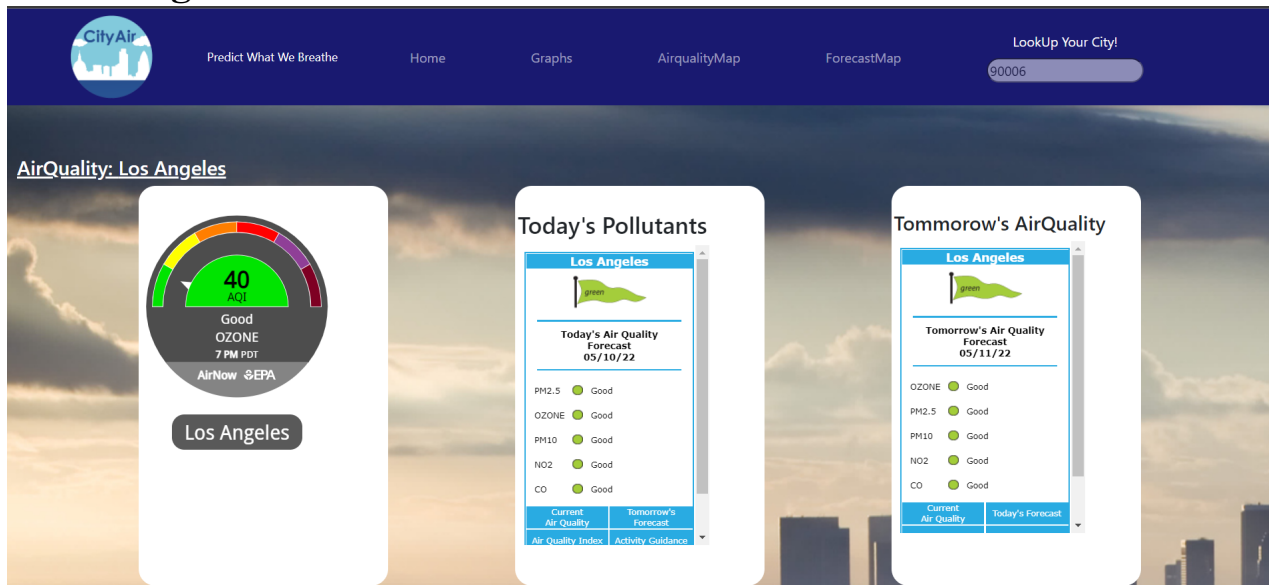
The home page will be the first tab any users will see when they visit our website, but can also be accessed when you are in a different page from the Navigation Bar. To the left of the page we have a widget from AirNow. The gauge displays the current air quality at the hour at the location it states, Los Angeles will be the default location. The gauge will also display what air pollutant it is reading and the gauge will move from left to right depending on the condition of the air quality. In the center we have another gauge graph that shows the Today's Air quality also from AirNow. This graph shows the different air pollutants for the certain location that the user wants it to show based on the zip code. The Third gauge graph is the Tomorrow's Air Quality graph that shows what tomorrow's air pollutants are going to be. Green = good, Yellow=moderate, and Red = bad. This graph also changes data when the user enters a new zip code. In the center below these graphs is another search bar and a weekly forecast. The weekly forecast will show the weather as well as the average, maximum, and minimum temperature for the following days. Inputting a city name or zip code in the second search bar will update the AirNow widget and the weekly forecast, displaying the information for the specified location. If the user goes to the Graphs Tab on the navigation bar, the user will see different gauges that display different air pollutants. Specifically, AQI, PM10, Ozone, and NO2. These gauges also change every time the user enters a new zip code. In the AirQualityMap tab, the user will see an interactive map built with ArcGIS. Users can do basic functions such as zooming in and out as well as moving the map around. Users can also click on any of the sites, identified by a colored circle, to view more information from that site. There is also a legend on the bottom left to identify the sites. The Forecast map is another interactive map built with ArcGIS. The map will display the air quality per hour to the users. There is a control scheme on the bottom left that includes a slider and a play, previous, and next button. Moving the slider will show the air quality at that hour. Clicking on play will show the change in air quality for each hour automatically. Clicking on next will go forward 1 hour while clicking on previous will go back 1 hour. Our mobile application implementation is very similar to how we implemented

our website, but in the mobile app we implemented the navigational tab at the bottom. We have the air quality map and the forecast map the same as our website. The homepage is a bit different where we have the current location, current date and time. The weather is still a work in progress as well as the three boxes at the bottom of the homepage.

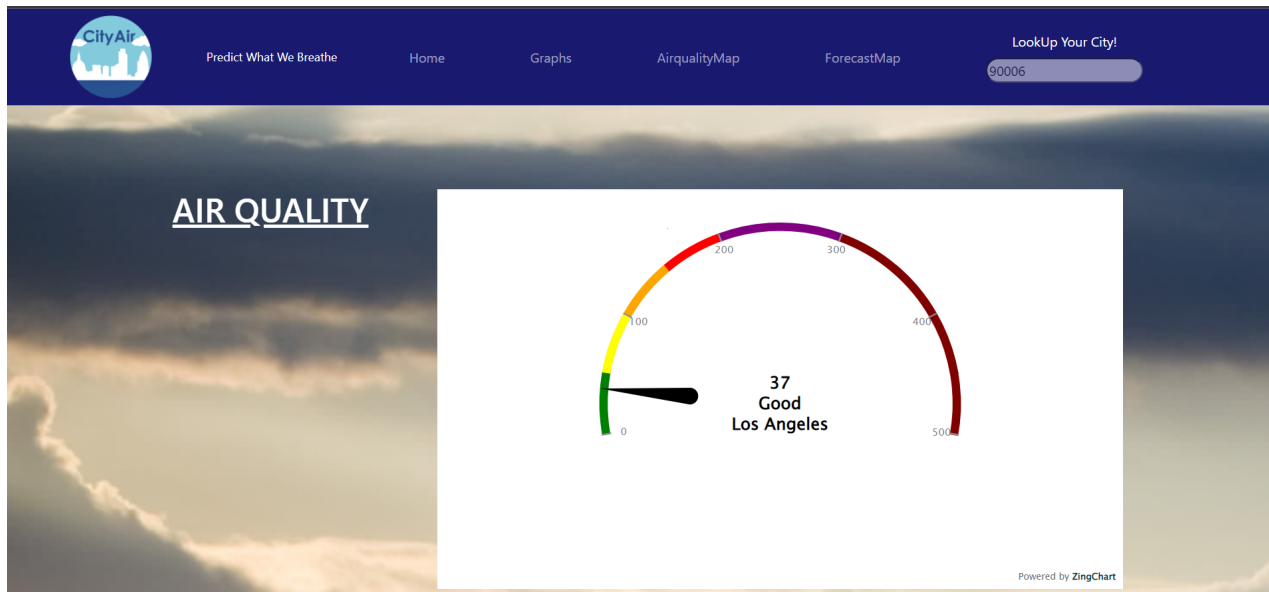
8.2 Screen Frameworks or Images

WebPage:

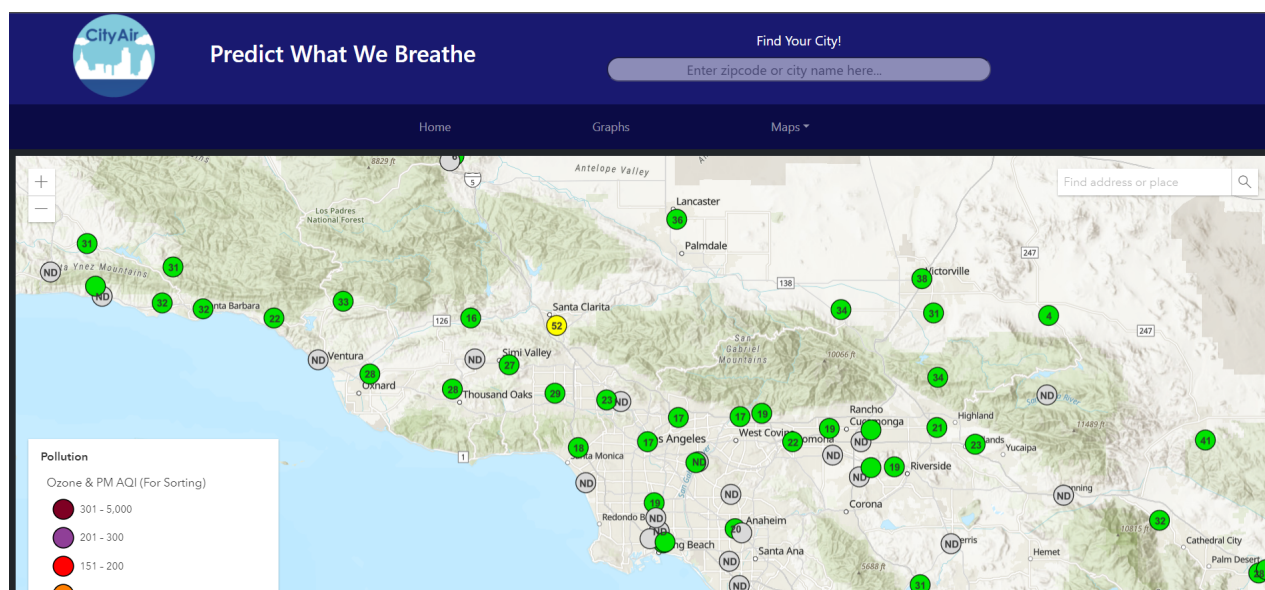
Home Page:



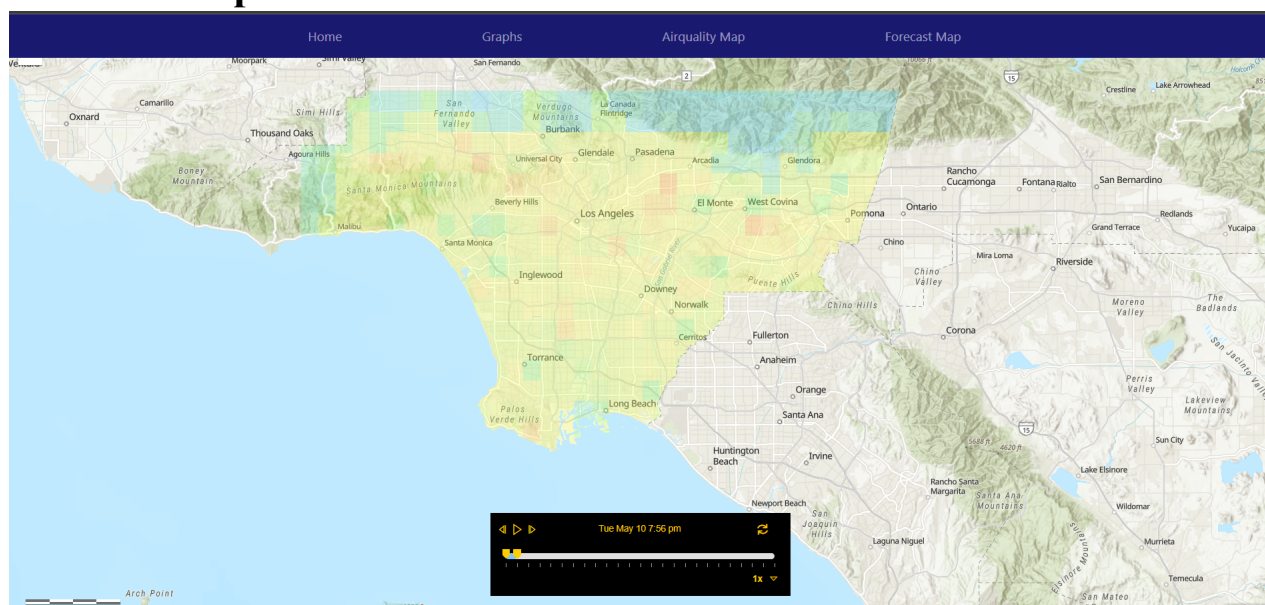
Graphs Page:



Air Quality Map:

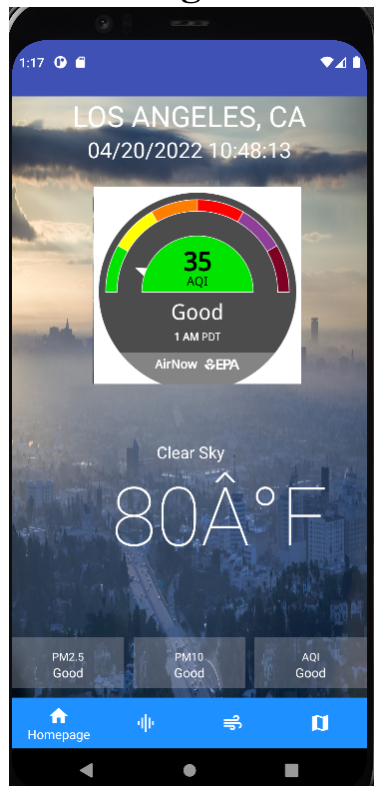


Forecast Map:

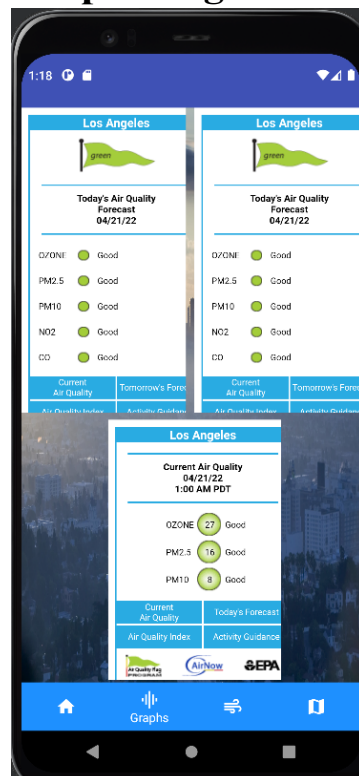


Mobile Application:

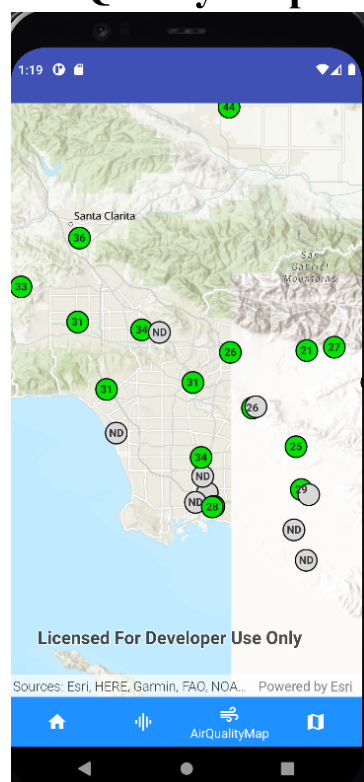
Home Page:



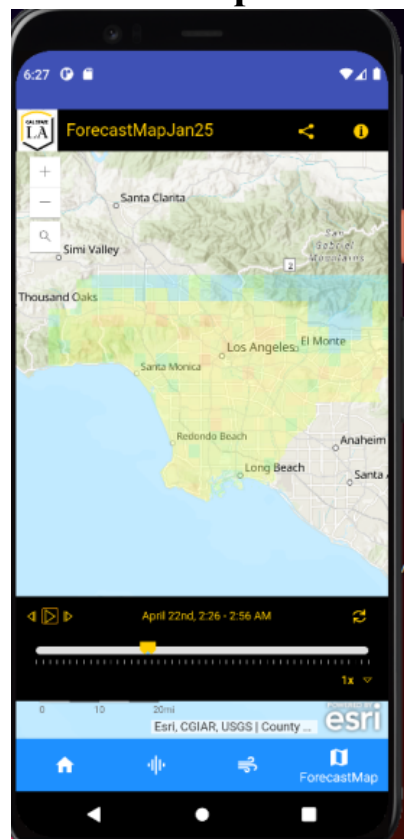
Graphs Page:



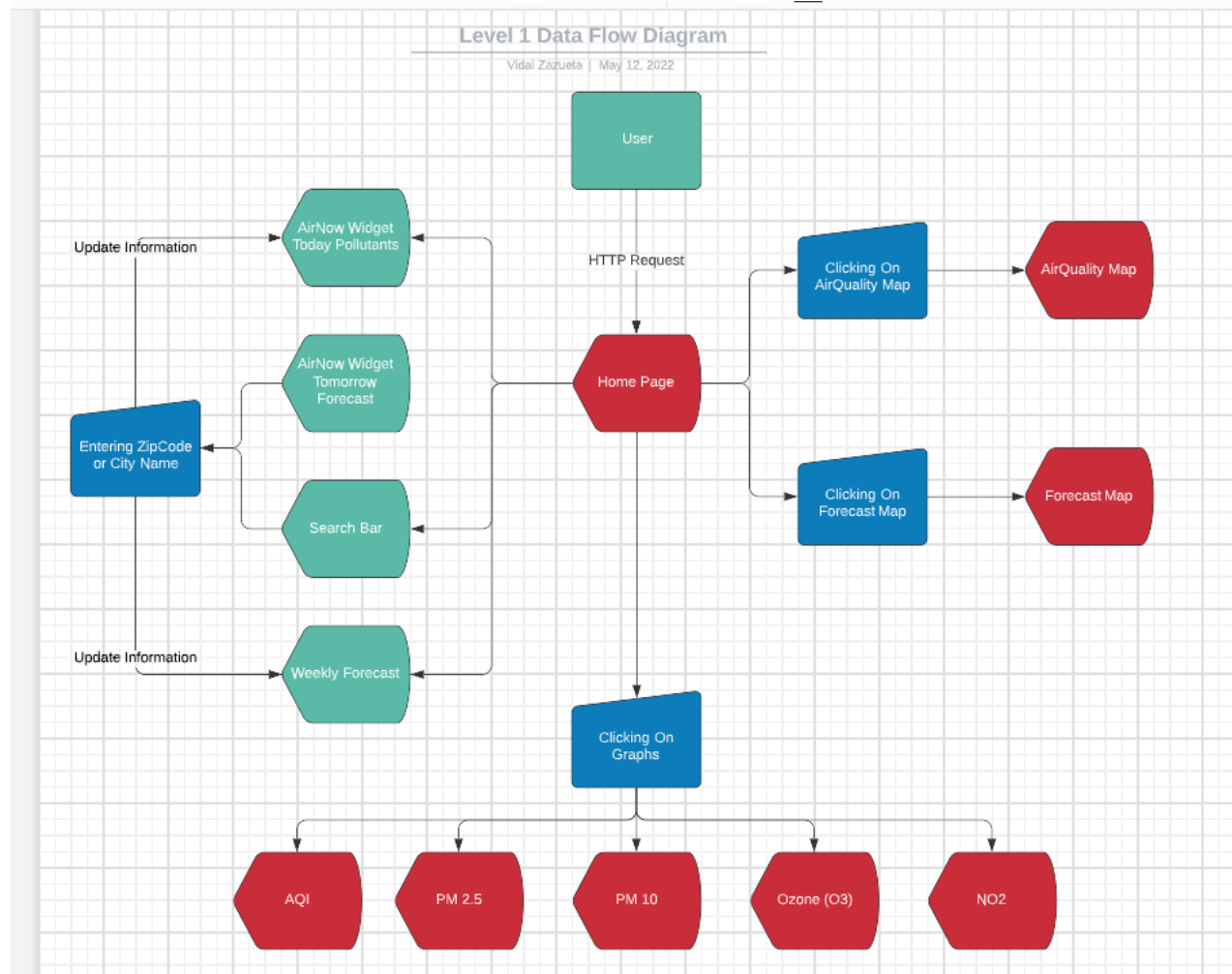
Air Quality Map:



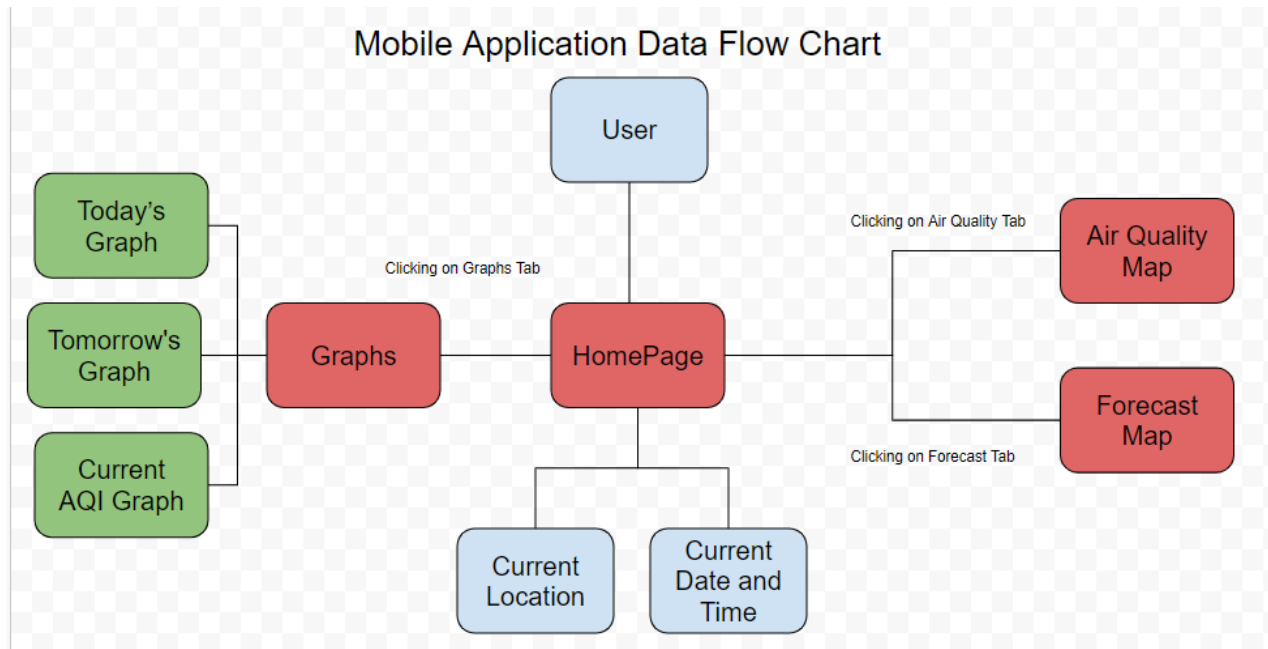
Forecast Map:



8.3 User Interface Flow Model (Website)



Mobile Application:



9. Requirements Validation and Verification:

I. Air Pollution in Los Angeles County Data Visualization Module

4.1.1	The system shall retrieve data Layers from ArcGIS's Live Atlas	Air Quality Map
4.1.2	The system should retrieve data for custom Feature Layers from air quality sensors and fill in data for census tracts	Air Quality Map
4.1.3	The system shall use the retrieved data to display symbols on the map	Air Quality Map
4.1.4	The system shall use the retrieved data to display polygons on the map	Air Quality Map
4.1.5	The system shall visualize measured levels of air pollution using colors based on air quality severity harm	Air Quality Map
4.1.6	The system shall visualize demographic statistics using colors based on air quality	Air Quality Map
4.1.7	The system shall display a popup window upon clicking on a symbol on the map	Air Quality Map
4.1.8	The system shall display a popup window upon clicking on a highlighted polygon on the map	Air Quality Map

4.1.9	The system shall remove the popup window upon clicking away from the info window	Air Quality Map
4.1.10	The system shall add Layers to the map, Forecast Map prediction on air quality	Air Quality Forecast Map
4.1.11	Forecast Map has slider to show predicting machine learning model layers that predict each hour	Air Quality Forecast Map
4.1.12	Forecast Map shall be easier to see air quality prediction data on a certain hour	Air Quality Forecast Map

10. Glossary

Appendix A: Glossary

AIDSAPPV	Artificial Intelligence and Data Science for Air Pollution Prediction and Visualization
Air Pollution	the presence of substances in the atmosphere that are harmful to the health of humans and other living beings or cause damage to the climate
APLAC	Air Pollution in Los Angeles County Data Visualization
API	a computer interface that defines interactions between software immediaries
ArcGIS	Esri's all-in-one solution to work with geographic information
Artificial Intelligence	intelligence demonstrated by machines
Data Science	an interdisciplinary field that uses scientific methods, processes, algorithms, and systems to extract knowledge from data
Feature Layer	a grouping of similar geographic features that are used for visualizing data
HTTPS	application layer protocol that is used for secure communication over a computer network

Machine Learning	an application of artificial intelligence that provides systems the ability to automatically learn and improve
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Appendix B: To Be Determined List

The following requirements are conditions are to be updated:

- Website: Personalized User Experience
 - Social Media Sharing
 - Text alerts for dangerous conditions
- Mobile
 - User location air quality readings
 - Air quality readings based on zip code searches

11. References

SRS document:

https://docs.google.com/document/d/1Nz4_klIBgWuZvKEjCWoi8G7RZJNRBggr5WM29zdvvAE/edit?usp=sharing