Requirement Specification Document

PowerView

CoastWorks

Arden Loewen, Elyas Alhaddad,
Konrad Jasman, Adin Nelson, Omar
Madhani, Harsh Patel

Nov 26, 2023

Contents

List of Tables

List of Figures

Revision History

Name	Date	Reason for Changes	Version
CoastWorks	12-10-2023	Requirement Document 1.0 base added	0.1.0
CoastWorks	14-10-2023	Revision with Steelhead Solutions' feedback on RD 1.0	0.1.1
CoastWorks	20-10-2023	Revision with second client-designer meeting report	0.1.2
CoastWorks	20-10-2023	Use cases UC-1-1 to UC-3-1 added	0.3
CoastWorks	21-10-2023	Use case UC-1-2	0.31
CoastWorks	23-10-2023	UML Diagram added	0.4
CoastWorks	23-10-2023	Use cases added, final edits of the document	1.0
Steelhead Solutions	25-10-2023	Provided feedback on the overall document	1.1
CoastWorks	1-11-2023	Implementation of feedback + general editing of use cases and Figure 1	1.2
CoastWorks	5-11-2023	Addition of sequence diagrams for all use cases	1.3
CoastWorks	6-11-2023	Addition of entity diagram, data dictionary, and unique and foreign key dictionaries	1.4
CoastWorks	6-11-2023	Final edits of RSD 2.0	2.0
CoastWorks	15-11-2023	Added requirement rationales, CFD, and level 0, 1, 2 DFDs	2.1
CoastWorks	15-11-2023	Mockups and Storyboards added	2.2
CoastWorks	16-11-2023	Final edits of RSD 3.0	3.0
Steelhead Solutions	19-11-2023	Provided feedback on RSD 3.0	3.1

CoastWorks	23-11-2023	Implemented RSD 3.1 feedback	3.2
CoastWorks	23-11-2023	Added traceability matrix and test cases	3.3
CoastWorks	26-11-2023	Overall document review	Final

1 Introduction

1.1 Purpose

The project specified in this requirement specification document (RSD), refers to PowerView [1], belonging to Steelhead Solutions. The words project, product, system, dashboard, and application occur synonymously throughout this document, and they all refer to PowerView. The system requested by Steelhead Solutions is intended to monitor and manage electricity usage for their port operations. The objectives of this system include lowering port carbon emissions, predicting and optimizing energy consumption, lowering energy costs, and minimizing outages. The overarching goal for PowerView is to assist Steelhead Solutions in lowering their port carbon emissions, following the International Maritime Organization plan to reach net zero by 2050 [2].

1.2 Project Scope

The scope of this document includes the entire system, PowerView. The system consists of two parts: software and hardware. The main part of the system is the software, which will be accessed through pre-existing tools owned by Steelhead Solutions. The only hardware to be implemented in this project consists of power meters, databases, and servers, along with a tool to be integrated with pre-existing Steelhead Solutions to make power measuring more efficient.

1.3 Glossary of Terms

Table 1: Glossary of Terms	
Term/Acronym/Abbreviation	**Definition**
CI/CD pipeline	Refers to the continuous integration, continuous delivery, and continuous deployment pipeline. It allows for the automation and monitoring of an application continuously, making it easier to integrate, test, and deploy software.
CSV	Comma-separated values
IT	Information Technology
kWh	Kilowatt-hours
MongoDB	A popular database used for scalable applications.
NoSQL	Non-tabular database.
JSON	A human-readable file format used to store data in value-attribute pairs.

1.4 References

[1] Steelhead Solutions. *PowerView: Request for Proposal, v1.0, Sep. 21, 2023*. Source: https://onlineacademiccommunity.uvic.ca/steelheadsolutions/rfp/.

[2] International Maritime Organization. *2023 IMO Strategy on Reduction of GHG Emissions from Ships, July 7, 2023.* Source: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/annex/MEPC%2080/Annex%2015.pdf.

[3] Steelhead Solutions. *In Class Activities*. Accessed Oct 12, 2023. Source: https://onlineacademiccommunity.uvic.ca/steelheadsolutions/in-class-activities/.

[4] Government of Canada. *Privacy Act, Sep 19, 2023.* Source: https://laws-lois.justice.gc.ca/eng/acts/P-21/page-1.html.

[5] Maddox, I. (2021) *Account authentication and password management best practices | google cloud blog*, *Google*. Accessed Oct 14, 2023. Source: https://cloud.google.com/blog/products/identity-security/account-authentication-and-password-management-best-practices/

[6] Gülen, K. (2023) *Cracking the code: How database encryption keeps your data safe?*, *Dataconomy*. Accessed Oct 14, 2023. Source: https://dataconomy.com/2023/04/11/what-is-database-encryption-types-methods/

1.5 Overview

Within this document, there is an in-depth description of the project including its origin, features, identified users, operating environment, constraints, and assumptions made while creating the Requirements Specification Document. This section underlines the core understanding of PowerView between Steelhead Solutions and us, CoastWorks. The requirements for the system features are discussed. They are accessibility options, user authentication, distinct user interfaces, and forecasting time frames. The external interface requirements are listed, consisting of user, hardware, software, and communications interfaces. These requirements explain how the components of the system interact to create PowerView. Non-functional requirements are listed that don't fit in the previously mentioned topics and are followed by other requirements that also don't fit in the rest of the document, but are no less important to the project.

2 Overall Description

2.1 Product Perspective

PowerView is developed as a self-contained solution to the absence of predictive energy modeling infrastructure available to Steelhead Solutions. The software solutions provided must integrate with power meters we install on critical infrastructure, primarily buildings and heavy machinery in such a way that data can be collected wirelessly from these devices.

2.2 Product Features

The system will:

- Allow users to see real-time energy consumption for various buildings and machines under the Port system
- Allow access to data analytics to view historical data for energy consumption
- Be accessible from any phone, tablet, laptop, and desktop
- Create a predictive model for energy consumption a year in advance
- Maintain two user groups.

2.3 User Classes and Characteristics

The various users are summarized in the table below, along with their relevant characteristics:

Table 2: User Classes and Characteristics	
User	**Characteristics**
Port Managers	Primary user, non-technical. Prefers intuitive delivery, making use of visual aids: graphs, etc.
Engineers	Secondary user, technical. Prefers raw data interface for technical analysis.

2.4 Operating Environment

The software will operate on servers stored at Steelhead regional offices, and interface with the power meters we will implement across the Vancouver Port infrastructure. It will be delivered through a web-based interface to ensure cross-platform functionality and minimize end-user hardware requirements. There do not exist additional software components with which our product must interact.

2.5 Design and Implementation Constraints

We must purchase and install BC Smart Meters across the Steelhead network; on larger machinery and buildings. This cost is reflected in the budget.

2.6 Assumptions and Dependencies

We assume that users will be computer literate and have access to a stable internet connection.

3 System Features

3.1 User Authentication

3.1.1 Description and Priority

User registration feature enables users of different categories (port managers and engineers) to register to the Steelhead Solutions dashboard to visualize energy consumption and its relative cost. This is a high-priority task since users cannot make informed decisions about energy consumption without an authorized user account. In addition, the data analysis on the user dashboard contains both sensitive and proprietary information.

3.1.2 Functional Requirements

REQ-1: Upon entering valid credentials and passing multi factor authentication, users must be able to log in to their associated accounts.

Rationale: This requirement ensures the security of the confidential property by checking that the user has entered valid login credentials and passed the multi-factor authentication.

REQ-2: Upon entering a valid username and password, users will go to the multi-factor authentication screen where they must authenticate themselves using the authenticator application integrated with their account.

Rationale: This requirement expands upon REQ-1 by indicating how multi-factor authentication will be integrated within the system.

REQ-3: Upon failing multi-factor authentication 3 times, users must be locked out from their associated account and must contact the IT department to retrieve their account.

Rationale: This requirement ensures that an unauthorized person cannot access confidential data by locking them out upon failing multi-factor authentication 3 times but it also ensures that an authorized person does not get locked out by allowing them to enter valid login credentials numerous times. In addition, if the user is locked out, the IT department will help them to retrieve their accounts.

3.1.3 Use Cases

The use cases and the requirements they satisfy are as so:

- **UC-1-1:** REQ-1, REQ-2, REQ-3.

UC-1-1: Login
ID: UC-1-1
Description: A user can log in to the PowerView dashboard.
Actors: Port Managers, Engineers.
Secondary Actors: Authenticator Application, IT Department.
Secondary Use Cases: N/A
Precondition: User has an active account, which has verified credentials.
Postcondition: User is logged in to their account, can view the dashboard, and can change account settings.
Main Flow: 1. User navigates to the PowerView login screen. 2. User enters a valid username and password. 3. PowerView requests the user to complete multi-factor authentication. 4. User receives an authentication request from the authentication application. 5. Users authenticate themself with the system. 6. PowerView forwards the user to the dashboard homepage. 7. User has successfully logged in and now has access to the dashboard and their account details.
Alternative Flow: A1. If username and password are not valid: a. Error message is returned to the user. b. User is prompted for valid credentials and continues from step 2 in Main Flow. A2. If username and password are valid, but MFA is failed 3 times: a. PowerView locks the user out of their account. b. PowerView displays pop-up informing the user to contact Steelhead Solutions' IT department to bypass and reset the MFA.

3.2 Energy Forecast Dashboard

3.2.1 Description and Priority

This feature enables the engineer and port manager users to visualize the energy consumption and prices data for their selected timeframe. The data visualized will be historical, present, and AI predicted data. The forecasted energy consumption and cost allows Steelhead Solutions to prepare in advance for immediate spikes in demand of energy. Forecasted data will be utilized up until midnight for the date of prediction, but once the current data is collected for that date, then the forecasted data will be deleted since present information has been collected. This is a high-priority task since managing their port's energy efficiency is one of Steelhead Solutions' primary goals and the dashboard assists this through the numerical data and its appropriate visualization of energy consumption predictions.

3.2.2 Functional Requirements

REQ-4: Dashboard should enable users to visualize real-time, historical, and predicted energy consumption data for their selected dates. Energy consumption must be predicted a year in advance, with detailed explanation about how the prediction was made. The predictions must have an accuracy within 1% of reality at least 98% of the time.

Rationale: This requirement allows the authorized user to view real-time, historical and predicted energy data based on date selection to help them make a data-driven decision about energy consumption for a specific timeframe. In addition, the requirement also indicates that the data predictions must be provided 1 year in advance with detailed explanation to help the user understand how the prediction was made. Furthermore, the predictions are required to be accurate within 1% of reality at least 98% of the time to ensure that the user always makes a decision that is in their favor.

REQ-5: Dashboard should allow users to visualize real-time, historical and predicted cost of energy for selected dates. Cost of energy must be predicted, a year in advance, with detailed explanation about how the prediction was made.

Rationale: This requirement allows the authorized user to view real-time, historical and predicted energy cost data based on date selection to help them make a data-driven decision about energy cost for a specific timeframe. In addition, the requirement also indicates that the data predictions must be provided 1 year in advance with detailed explanation to help the user understand how the prediction was made.

REQ-6: Dashboard should have heatmaps for Vancouver port to visualize forecasted energy consumption.

Rationale: This requirement ensures that the user can see heatmaps for all ports in Vancouver and visualize its corresponding forecasted energy consumption charts. This requirement helps the user to make the decision on how the energy consumption can be reduced by analyzing what level of the port is consuming the most energy and how they can make it more efficient.

REQ-7: Heatmaps and data visualization charts with detailed information should have size adjustment and read aloud technology implemented to enable visually impaired users to understand the data.

Rationale: This requirement allows the authorized user to access heatmaps and data visualization charts with detailed information as well as size adjustments and read aloud technology for all data visualization. This requirement helps the visually impaired users to understand the data in a better way. In addition, the size adjustments can help the user visualize the data charts in a focused way. Furthermore, the detailed information in the charts allows the user to understand what the chart represents.

REQ-8: User dashboard should provide AI generated suggestions about reducing energy consumption.

Rationale: This requirement ensures that the user is suggested different techniques to reduce energy consumption through AI algorithms.

3.2.3 Use Cases

The **UC-2-1** use case is for REQ-4, REQ-5, REQ-6, REQ-7, and REQ-8.

UC-2-1: View Dashboard
ID: UC-2-1
Description: The dashboard will show all ports located in Vancouver and each port will have their specific data charts, heatmaps, and AI recommendations.
Actors: Port Managers, Engineers.
Secondary Actors: Database, Machine Learning Algorithm.
Secondary Use Cases: UC-1-1 Login.
Precondition: The user must be logged in to the web dashboard.
Postcondition: The user will be shown data charts and heatmaps with embedded AI recommendations for a particular port selected by the user.
Main Flow: 1. On the homepage of the dashboard, the user will see various ports to visualize its data further. 2. The user selects a particular port to see its data including data charts and heatmaps with embedded AI recommendations.
Alternative Flow: N/A

The **UC-2-2** use case is for REQ-4, REQ-5, REQ-6, and REQ-7.

UC-2-2: Data Visualization
ID: UC-2-2
Description: The user can access heatmaps and data charts for ports in Vancouver with predictions to make data driven decisions about energy consumption and cost.
Actors: Port Managers, Engineers.
Secondary Actors: Database.
Secondary Use Cases: UC-1-1 Login, UC-2-1 View Dashboard.
Precondition: 1. The user must be logged in to the web dashboard. 2. On the homepage of the dashboard, the user has selected a particular port to visualize its data.
Postcondition: 1. The user can visualize heat maps and charts for Vancouver port to understand the energy consumption and distribution on each level of the port. 2. The user can visualize appropriate data visualization charts including the cost of energy used in real-time, historical, and provide predictions for expected future cost. 3. Similarly, the user can visualize charts about energy consumption and energy cost, with real-time and future prediction. 4. The user can visualize charts and heatmaps for specific dates with at most 12 months of range. 5. Based on user role, port managers or engineers, they will be provided detailed information about how the predictions were made for energy consumption and its cost. 6. In addition, the application will help visually impaired users by having a clickable read aloud feature.
Main Flow: 1. Once selecting a specific port, the user can either select heatmaps or data charts with numerical data such as energy consumption in Joules. 2. If the user selects heatmaps, the heatmaps for each level of a particular port will appear, demonstrating how much energy each level of the port is consuming. 3. Furthermore, each heatmap will have a prediction for energy consumption for each level of the port. These predictions can help the user to make data-driven changes to their current plans. 4. In addition, the user will have an edit button on the right hand corner of the heatmap to specify the timeframe within a 12 month range to visualize a specific range of data. 5. The heatmaps will have a detailed description to help users understand the presented data such as which level of the port the user should focus on to reduce energy consumption. 6. The written description will have a clickable read aloud feature, located on the right side of the edit button.

Alternative Flow:

A1. If the user selects data charts

a. Energy consumption and energy cost charts will appear for the selected port.
b. The charts will contain data such as how much energy is consumed and its relative cost for specific port activities such as shipping, loading, etc.
c. Furthermore, each data chart including energy consumption and energy cost charts will have a prediction for energy consumption and energy cost respectively to help the user in adjusting their current plans.
d. In addition, the user will have an edit button on the right hand corner of each chart to specify the time frame within a 12 month range to visualize a specific range of data.
e. The charts will have a detailed description to help users understand the presented data such as which port activity consumes most energy and increases the energy cost.
f. The written description will have a clickable read aloud feature, located on the right side of the edit button.

The **UC-2-3** use case is for REQ-8.

UC-2-3: AI Recommendations
ID: UC-2-3
Description: The user can access AI recommendations based on data charts and heatmaps to make changes to their current plans using the provided insights.
Actors: Port Managers, Engineers.
Secondary Actors: Database, Machine Learning Algorithm.
Secondary Use Cases: UC-1-1 Login, UC-2-1 View Dashboard, UC-2-2 Data Visualization.
Precondition: 1. The user must be logged in to the web dashboard. 2. On the homepage of the dashboard, the user has selected a particular port to visualize its data. 3. The user is inside the data charts or heat maps section for the particular port.
Postcondition: Whenever the user is visualizing a specific data chart or heatmap, AI generated predictions will appear to guide the user to make decisions for improving energy consumption.
Main Flow: 1. The user will see the AI recommendations inside each data chart and heatmap. 2. If the user is visualizing energy consumption data charts then the AI recommendations will be related to how to reduce energy consumption such as modify current technique of shipping. 3. For each AI recommendation, the details about how the prediction was made will be available.
Alternative Flow: A1. If the user is visualizing energy consumption cost charts then the AI recommendations will be related to how to stop excessive cost by changing the current operations technique. A2. If the user is visualizing heatmaps then the AI recommendations will be related to which level of the port is consuming most energy and how to make it efficient.

3.3 Distinct User Interfaces

3.3.1 Description and Priority

The application should have two distinct user interfaces to serve both port managers and engineers. The port manager interface should be intuitive, interactive, and navigable. In addition, the interface should avoid technical jargon and provide appropriate data visualization graphs. The engineer interface should include detailed technical information about data visualization graphs. This is a high priority task since it would disturb the workflow of users if implemented poorly.

3.3.2 Functional Requirements

REQ-9: Port manager interface should provide appropriate data visualization graphs with concise information about energy consumption, prices, and future usage.

Rationale: This requirement allows the port manager to view all data charts and heatmaps about energy consumption, prices, and future usage with non-technical details, such as units of energy, to make the experience more intuitive.

REQ-10: Engineer interface should include detailed technical information that explains the energy consumption graphs including its trough, peak, and steady behaviors so users can find the root cause of the issue whenever required.

Rationale: This requirement allows the engineer to view all data charts and heatmaps about energy consumption, prices, and future usage with technical details, such as explanation of trough, peak, and steady behaviors of graphs, so that the engineers can find the root cause of the issue whenever required.

REQ-11: Engineers should be able to generate energy consumption and prediction reports, in csv format, that contains various types of data for different ports: energy usage, energy production, and cost of energy consumption.

Rationale: This requirement allows the engineer to generate energy consumption and prediction reports, in CSV format, so that they can visualize the data in their own way and apply different data visualization techniques to make a better decision.

REQ-12: Engineers should have access to an interface supporting the generation of recommendation reports, while port managers should have access to an interface supporting the generation of ship arrival schedules.

Rationale:

This requirement emphasizes role-specific access to distinct interfaces, ensuring engineers can generate recommendation reports, while port managers can utilize interfaces tailored for generating ship arrival schedules.

3.3.3 Use Cases

The use case and the requirements they satisfy are as so:

- **UC-3-1:** REQ-10, REQ-11, and REQ-12.
- **UC-3-2:** REQ-9. REQ-12

UC-3-1: Engineer Recommendation Report
ID: UC-3-1
Description: An engineer creates a recommendation report suggesting methods of reducing energy consumption within the port.
Actors: Engineers.
Secondary Actors: N/A
Secondary Use Cases: UC-1-1 Login, UC-2-1 View Dashboard.
Precondition: Engineer is logged in and authenticated.
Postcondition: The engineer formed a recommendation report suggesting technical changes to better optimize the system.
Main Flow: 1. The engineer views the interface which dynamically changes based on the logged-in user. 2. The engineer views the graphs and predictions. 3. The engineer requests a recommendation report from the PowerView Dashboard, specifying what data they want in the report. 4. If the data is unavailable/invalid, display an error message to the engineer. Otherwise, the PowerView Dashboard will pull requested data from the database and formulate the report, sending it to the engineer. 5. The engineer exports some energy prediction-related data to CSV format.
Alternative Flow: A1. If the PowerView Dashboard cannot provide the report because of a non user issue, then the PowerView should display an appropriate error message.

UC-3-2: Port Manager Creates a Ship Arrival Schedule
ID: UC-3-2
Description: A Port Manager wants to generate a schedule for ship arrival.
Actors: Port Manager.
Secondary Actors: N/A
Secondary Use Cases: UC-1-1 Login, UC-2-1 View Dashboard.
Precondition: Port Manager is logged in and authenticated.
Postcondition: The Port Manager successfully generates a distributed schedule such that the power grid has minimal spike in strain.
Main Flow: 1. The Port Manager has logged in and views the PowerView Dashboard. 2. The Port Manager accesses the energy consumption reports. 3. The Port Manager views historical and predictive data for ship traffic and related energy consumption. 4. The Port Manager requests an optimized ship schedule, by providing two dates that will count as a range. 5. If both selected dates are within a year of the present day, then the PowerView Dashboard will request the appropriate data from the database to create and provide the schedule to the Port Manager. If not, then the PowerView Dashboard will ask for the dates to be inputted again.
Alternative Flow: A1. If the PowerView Dashboard cannot provide the schedule because of a non user issue, then the PowerView should display an appropriate error message.

3.4 UML Use Case Diagram

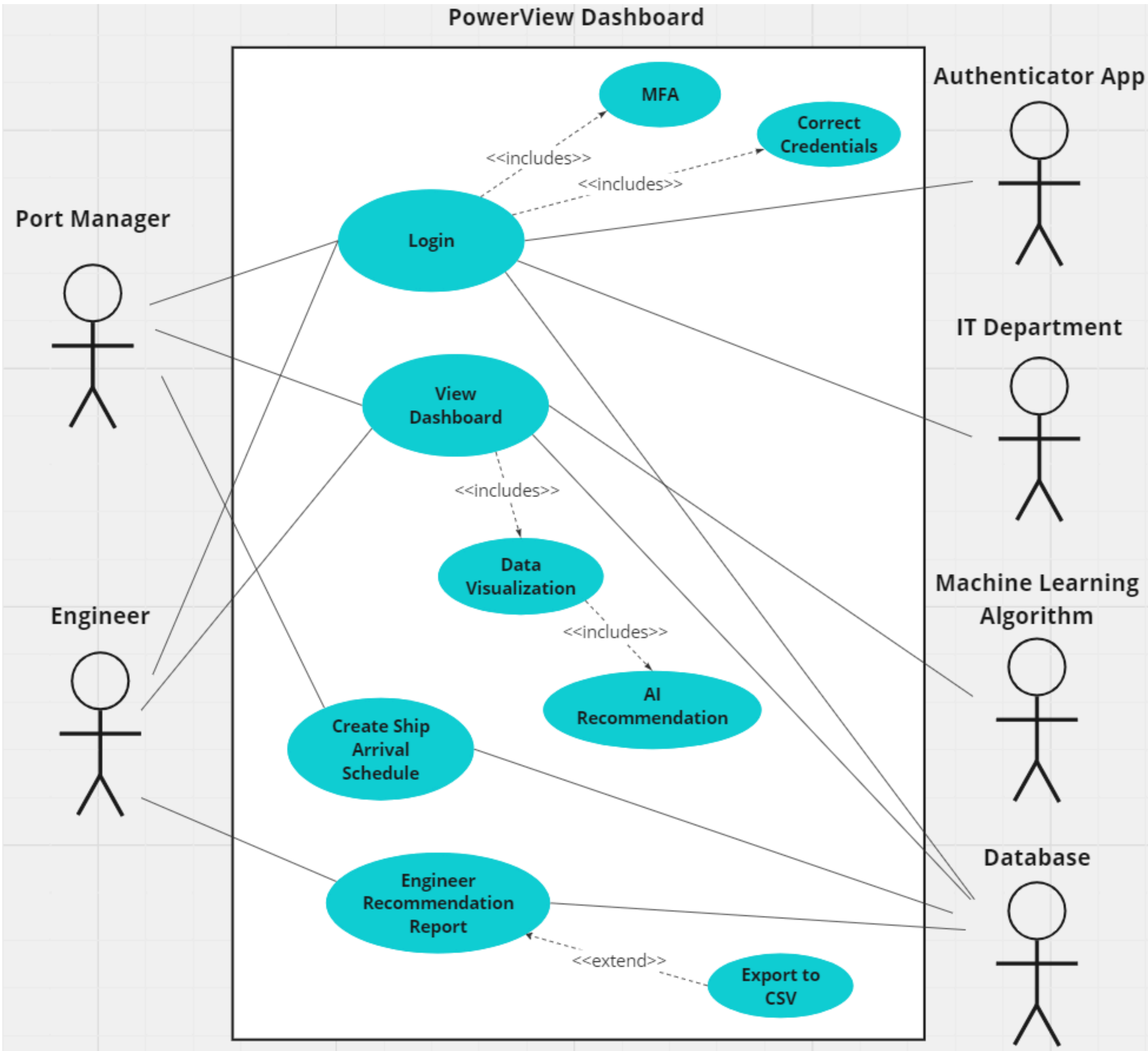


Figure 1: UML use case diagram for PowerView dashboard

3.5 Sequence Diagrams

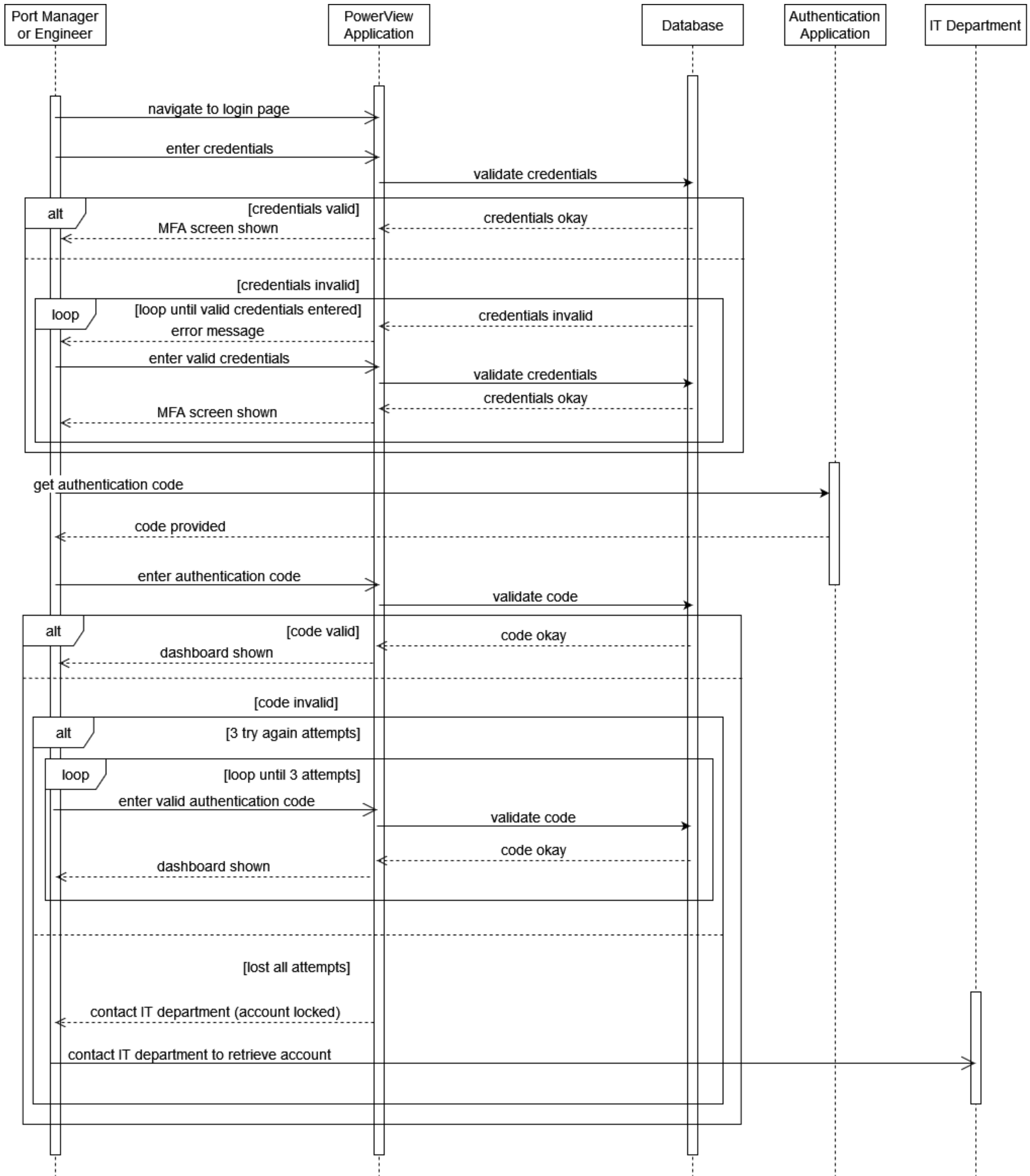


Figure 2: Sequence diagram for UC-1-1: Login

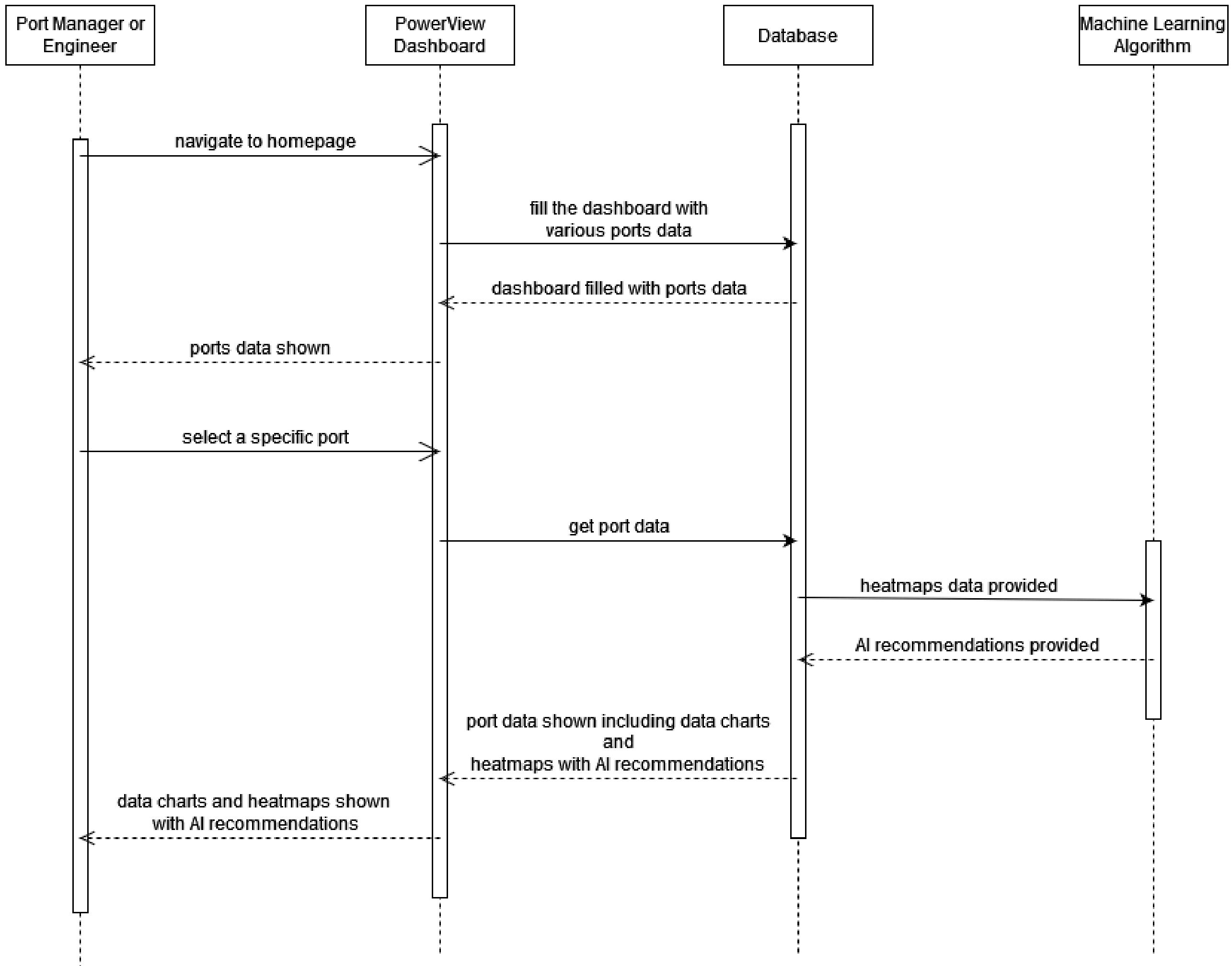


Figure 3: Sequence diagram for UC-2-1: View Dashboard.

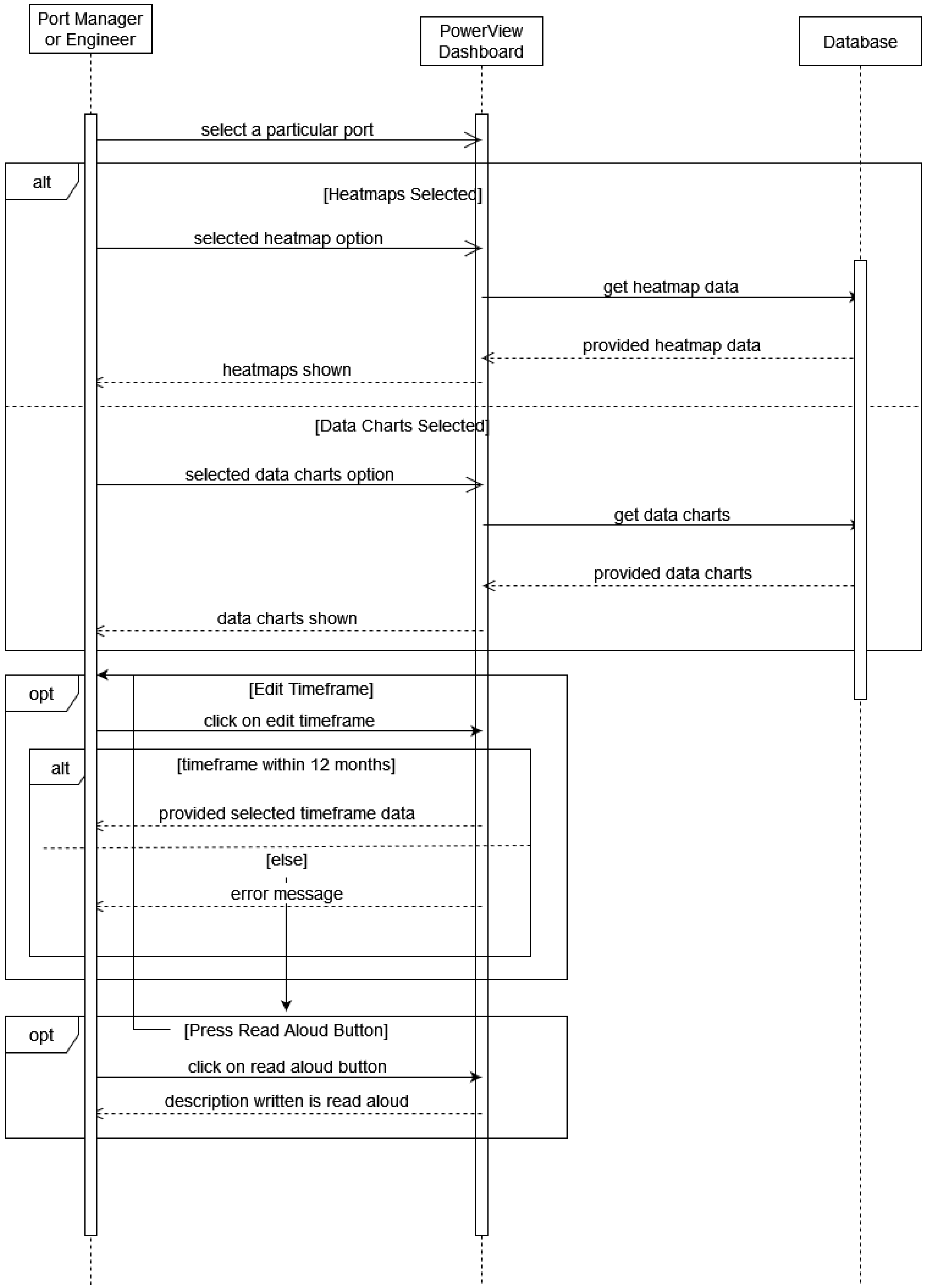


Figure 4: Sequence diagram for UC-2-2: Data Visualization.

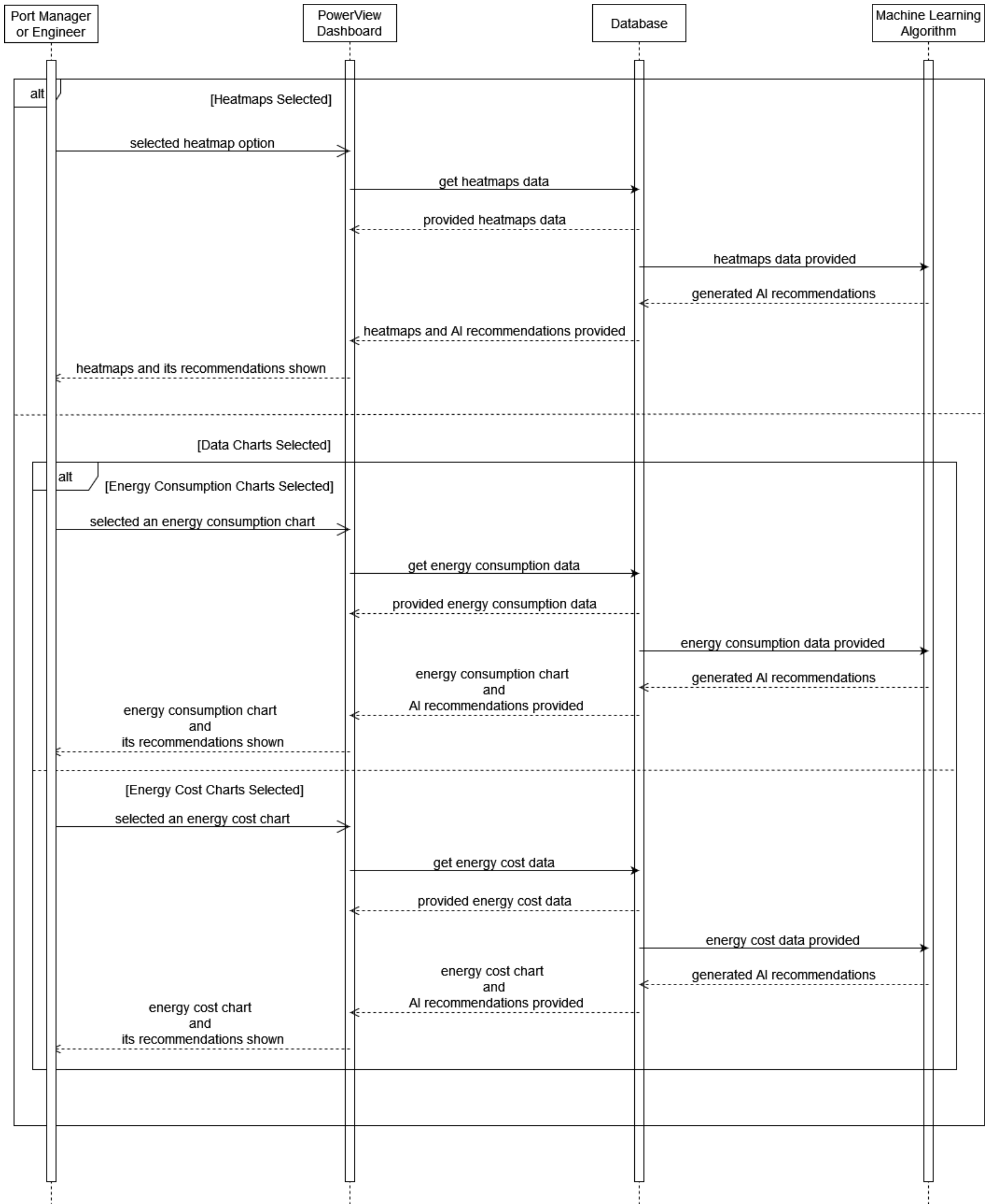


Figure 5: Sequence diagram for UC-2-3: AI Recommendations.

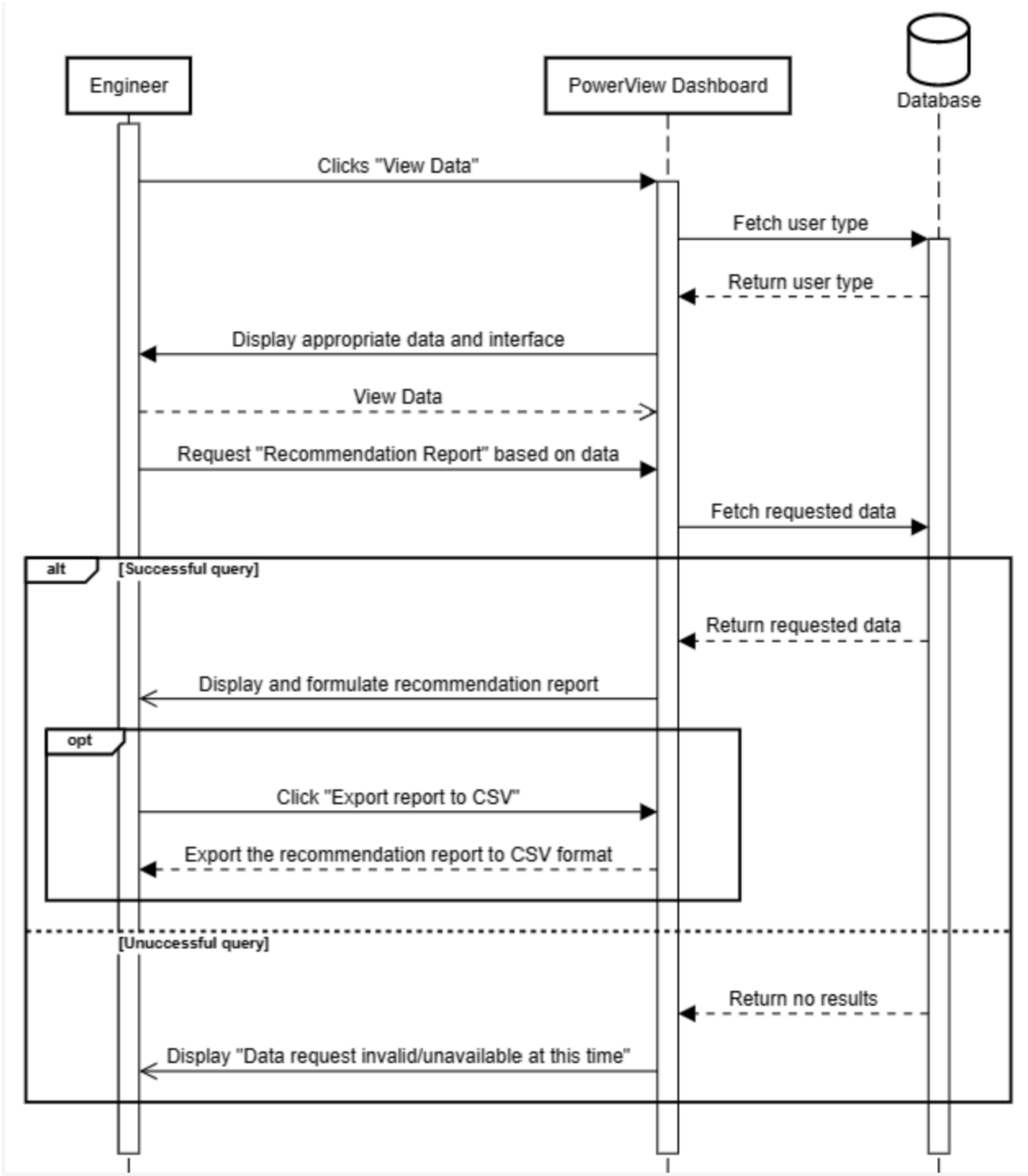


Figure 6: Sequence diagram for UC-3-1: Engineer Recommendation Report.

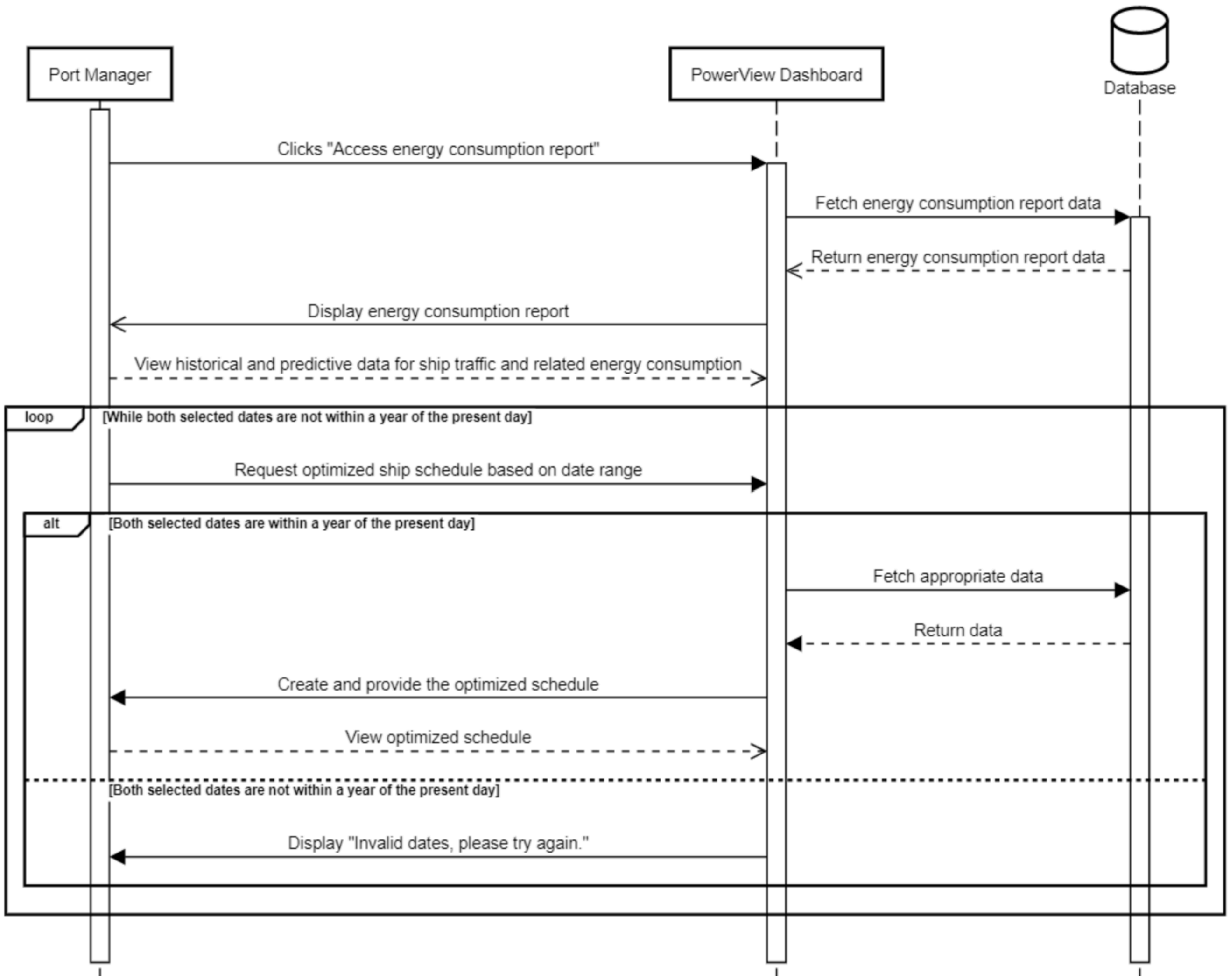


Figure 7: Sequence diagram for UC-3-2: Create Ship Arrival Schedule.

4 Entity Relationship Diagram

This describes the relationship between various entities in PowerView.

4.1 Entity Relationship Diagram

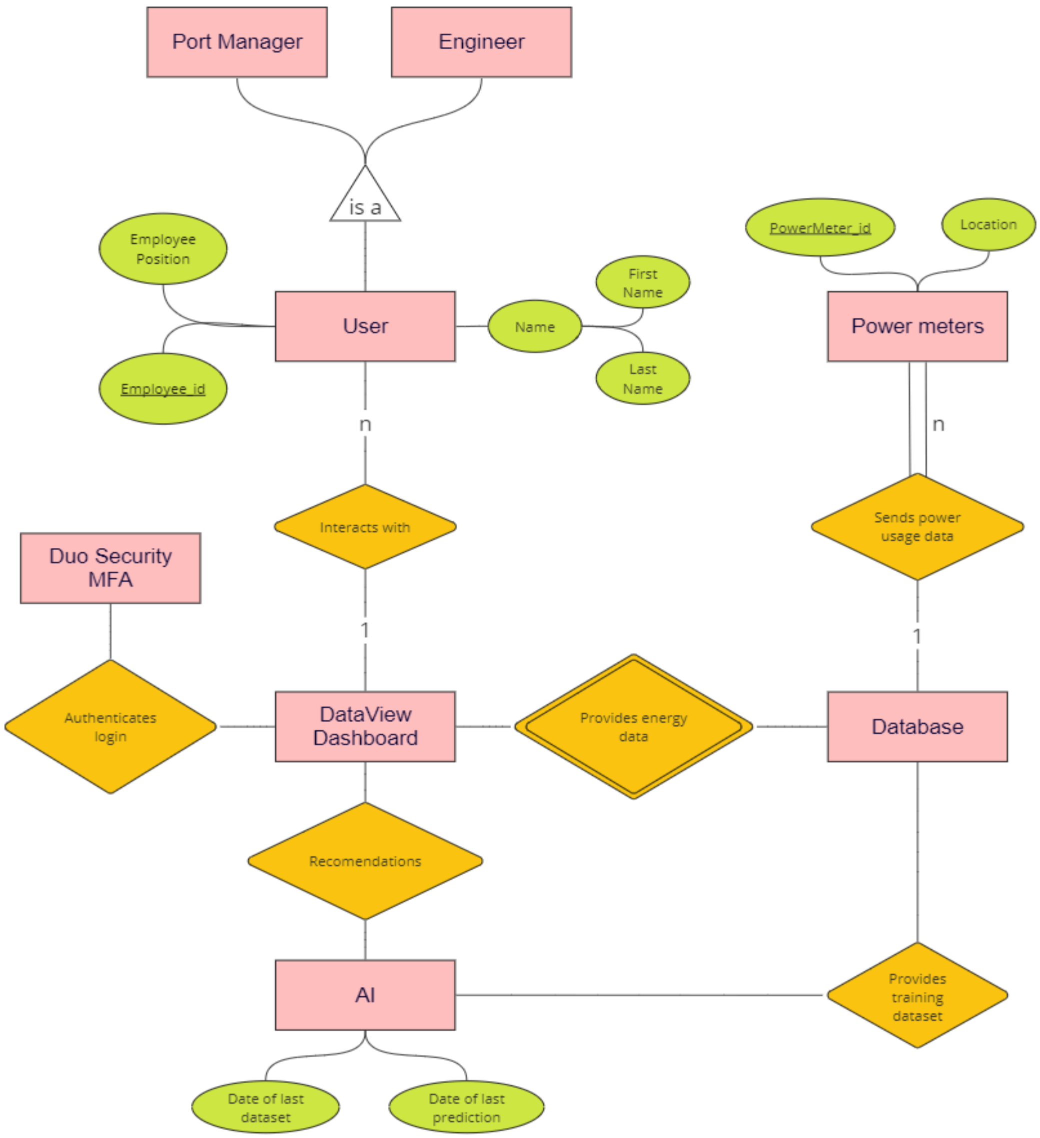


Figure 8: Entity Relationship Diagram

4.2 Data Dictionary

Table 3: Data Dictionary	
Object Class	**Attributes**
User	Employee Id (*int*) Employee Position (*varchar*) First Name (*varchar*) Last Name (*varchar*)
Power Meters	Power Meters Id (*int*) Location (*varchar*)
AI	Date of Last Dataset Received (*date*) Date of Last Prediction (*date*)
Duo Security MFA	Authentication Code (*int*)
DataView Dashboard	Admin Id (*int*)
Database	Name (*varchar*) Size (*int*) Date of Last Updation (*date*) Owner Id (*int*)

Table 4: Unique Keys		
Type	**Table**	**Columns**
Primary	User	Employee Id
Primary	Power Meters	Power Meter Id

Table 5: Foreign Keys			
Table	**Column**	**Reference Table**	**Reference Column**
DataView Dashboard	Admin Id	User	Employee Id
Database	Owner Id	User	Employee Id

5 External Interface Requirements

5.1 User Interfaces

The two types of users of our project will be port managers and engineers. The interface presented to the Port Managers assumes that they are non-technical users and will be designed such that the average nontechnical user who is immediately presented with the dashboard will understand the purpose of the page and the actions they may perform in no more than a minute of interaction. The technical interface will be feature-rich to ensure the engineers have access to all the tools to view and analyze the energy consumption of the port.

The port managers are not responsible for analyzing the data and should be provided with a macro overview of the energy consumption to make informed decisions. Our graphs in the dashboard will be dynamic and change the information being displayed based on which type of user is using the interface. Furthermore, as the primary users of the interface, the port managers will have access to data such as arrival/departure times among other data required to accomplish their tasks.

The engineers responsible for analyzing the data for energy consumption will have more complicated and specific graphs in their interface. They will be able to view the macro overviews just like the port managers but have added functionality to tinker with the data. They will also receive the suggestions from the AI. The engineers can then form their conclusions with the help of the AI to inform the port managers.

5.2 Hardware Interfaces

Upgraded power meters will be deployed in the port to track the live energy consumption at the port in kWh. The data the meters track will be sent to data servers on-site at the port to be stored. Our application will then retrieve the data from the data servers and the dashboard will be updated periodically. This information is displayed to the user in the form of numbers, graphs, and heatmaps.

5.3 Software Interfaces

Being that there are no software systems in place, our application doesn't need to worry about compatibility with current systems at the port. It does however increase the amount of work it will have to do. The current use of spreadsheets to store port operation data is not scalable. The application will need to interface with MongoDB as it will be used to store data on the servers. MongoDB is a NoSQL database that uses JSON-like documents. It is great for scalability, and real-time data processing. Furthermore, it offers the option for documents to contain sub-documents, making it great for complex hierarchies of data.

5.4 Communications Interfaces

This project has 5 devices that will require communication among each other to operate:

- Energy meters
- Database Servers
- Application
- Energy providers
- User device.

To ensure security, every device should only be able to communicate with the devices or entities listed above. As the devices that will access the interface are provided by Steelhead Solutions to their employees, a Steelhead Solutions IT specialist should be present to set up and maintain the devices for the company. Authorization keys generated by the application will be assigned to each device by the IT specialist such that only those devices can access the interface to ensure security.

6 Other Non-Functional Requirements

6.1 Performance Requirements

6.1.1 Scalability

Steelhead Solutions will eventually expand out of British Columbia, so the solution must be scalable to support energy consumption forecasting for additional ports. In other words, the solution must not experience performance impacts when we deploy it in additional ports. The solution should also be configurable with different port layouts.

6.1.2 Execution Time

REQ-13: Energy meters and graphs must be updated within 0.1 seconds [1].

Rationale: This requirement ensures that the updation process for the energy meters or graphs is quick to make better predictions about reducing energy consumption at all times. This requirement allows the user to work efficiently.

REQ-14: Energy forecasts/predictions for any given time frame must take at most 3 minutes.

Rationale: This requirement ensures that the data visualization is fast so that it can provide energy predictions for selected dates within 3 minutes. This requirement allows the user to work efficiently.

CoastWorks will research methods to minimize data retrieval and insertion speed to accomplish REQ-14.

6.1.3 Storage capacity

REQ-15: Abundant historical and real-time data must be available at all times to ensure the accuracy of energy cost and consumption forecasts; therefore, high storage capacity is vital.

Rationale: This requirement ensures that abundant historical and real-time data is available at all times to create accurate machine learning algorithms to provide data-driven predictions about energy consumption and its cost. However, high storage capacity must be utilized to ensure that this requirement is met.

REQ-16: The solution must ensure data redundancy (by saving multiple instances of the data) to maintain availability [3].

Rationale: This requirement ensures the availability of the data by implementing data redundancy that saves multiple instances of the data. This requirement ensures that if an instance fails then another instance can be utilized to keep the application available.

6.1.4 Speed of response

REQ-17: To increase productivity and minimize user frustration, the page load time should be at a maximum of 3 seconds [1].

Rationale: This requirement ensures that the user is productive at all times by having the page load time to be within 3 seconds.

6.1.5 Throughput

REQ-18: The solution’s AI algorithm will process a plethora of data to generate cost and energy consumption forecasts; thus, the solution must be optimized for high data processing throughput.

Rationale: This requirement ensures that many data points are used in AI algorithms to predict energy consumption and its cost to make it as accurate as possible.

REQ-19: Specifically, up to 1TB of energy data must be able to be processed by the AI algorithm within execution time requirements.

Rationale: This requirement ensures that AI algorithms can process as much as 1 TB of data points while predicting the energy consumption and its cost to meet the requirement of having accuracy within 1% at least 98% of the time.

6.2 Safety Requirements

6.2.1 Anomalies

Steelhead Solutions expects that the following risks of the solution are minimized:

REQ-20: Displaying power consumption levels via a heatmap of the port will highlight areas with high energy supply. If users with unauthorized access and malicious intent obtain this information, our energy supply may be threatened.

Rationale: This requirement ensures that the authorized user can view heatmaps for the ports that highlight the level of the port that utilizes the most energy so that the user can modify their plans to make them efficient.

REQ-21: Inaccurate and unreliable energy cost predictions will result in unoptimized energy consumption, leading to potential power outages from unaccommodated demand.

Rationale: This requirement needs to be met because if the AI algorithm predicts inaccurate and unreliable energy consumption and its cost, it can lead to potential power outages due to a higher demand for energy than predicted.

The client initially stated that the AI algorithm must predict port energy cost and consumption with 100% accuracy within 1 year after initial deployment [1]. However, 100% accuracy, especially within only a 1 year timeframe isn’t necessarily feasible. A modification to 98% confidence was recommended and agreed upon.

6.3 Security Requirements

6.3.1 Data Security

REQ-22: All databases must ensure data-level encryption and be closely monitored.

Rationale: This requirement is crucial because if the unauthorized user accesses confidential data then the data can be leaked and compromised. Therefore, it is necessary to have all databases to be encrypted with best encryption techniques and closely monitored.

REQ-23: Energy data must be stored onsite at Steelhead Solutions monitored ports [3].

Rationale: This requirement ensures that energy data is stored onsite at Steelhead Solutions monitored ports to make it more accessible.

6.3.2 Privacy

REQ-24: The solution must adhere to the privacy laws of Canada [4].

Rationale: This requirement ensures that all privacy laws of Canada are obeyed for the entire development of the application to prevent it from being penalized.

REQ-25: The solution must not ask for or collect personal information from users as it is only intended for energy monitoring purposes.

Rationale: This requirement ensures that no user data is utilized or stored to develop any aspect of the application so that the user data is always safe and secure.

REQ-26: Users will be notified by email when a device with an unverified IP address successfully logs in to the dashboard interface using their credentials.

Rationale: This requirement ensures the security of the application by catching users if they break into the application and log in with an unverified IP address.

6.4 Software Quality Attributes

The dashboard solution must adhere to the TRUE usability factors to ensure a user-friendly interface. TRUE is short for “Task Efficiency,” “Ease of Remembering,” “Understandability,” and

“Ease of Learning.” The dashboard UI must be accessible to user groups with varying levels of ability. Though all of the listed TRUE factors are expected for the solution, ensuring task efficiency must be the highest priority as users will consistently want to retrieve and analyze historical, real-time, and predicted energy consumption data.

The front-end of the dashboard solution must have an availability or uptime of 3 9’s (99.9%). In other words, the solution must only allow up to 8.76 hours of downtime per year. The backend of the solution must have an uptime of 6 9’s (99.9999%) or 31 seconds of downtime per year [3]. It is important to mention that these metrics must include scheduled maintenance times. CI/CD pipeline should be utilized to avoid downtime during feature deployment [3]. Steelhead Solutions relies on real-time and forecasted data to optimize energy consumption, and predictions can change at a moment’s notice. Therefore, developers should prioritize ensuring the availability of the solution for users.

The dashboard software must be thoroughly documented to ensure code readability and efficient testing. The QA team should be able to spend 80%+ of their time developing tests and assessing software functionality. They should only require up to 20% of their time to understand how the code works. If changes are made to the software, developers must adjust the documentation accordingly. In addition, both technical and non-technical stakeholders of the project within Steelhead Solutions must be able to understand a high-level purpose of the code to ensure software quality.

7 Other Requirements

The following requirements must also be considered:

7.1 Databases

Databases are required for storing a variety of information necessary for different functions of the dashboard.

REQ-27: Databases must

- Use appropriate data encryption services
    - Weekly server updates to patch data encryption and related security issues
    - Use up to date hashing methods to store sensitive account information such as

    - passwords [5]
    - Use encryption methods to slow down hackers, such as transparent database encryption and symmetric database encryption [6]
- Have an uptime of 99.9999%
- Have daily backups for database systems

Rationale: This requirement ensures availability and security of the database by implementing best data encryption techniques with uptime of 99.9999% so that the application is also available at all time while being safe and secure.

7.2 Localization

REQ-28: The dashboard is used primarily by employees of Steelhead solutions. To cater to the culture of Steelhead solutions employees, we have the following requirements:

- The dashboard will support the primary languages used by Steelhead Solutions; English and French.
- The dashboard will use an intuitive UI design with universal symbols to be more inclusive.
- The backend code must support unicode characters to make multi-language support easier.
- The backend code will be modular.
    - Modification of the aforementioned symbols must be easy.
    - Reorganization of existing UI elements must be simple.

Rationale: This requirement ensures localization of the application by having support for primary languages used by Steelhead Solutions and universal symbols to help users better understand content regardless of where they come from.

8 Data Flow Diagrams

8.1 CFD

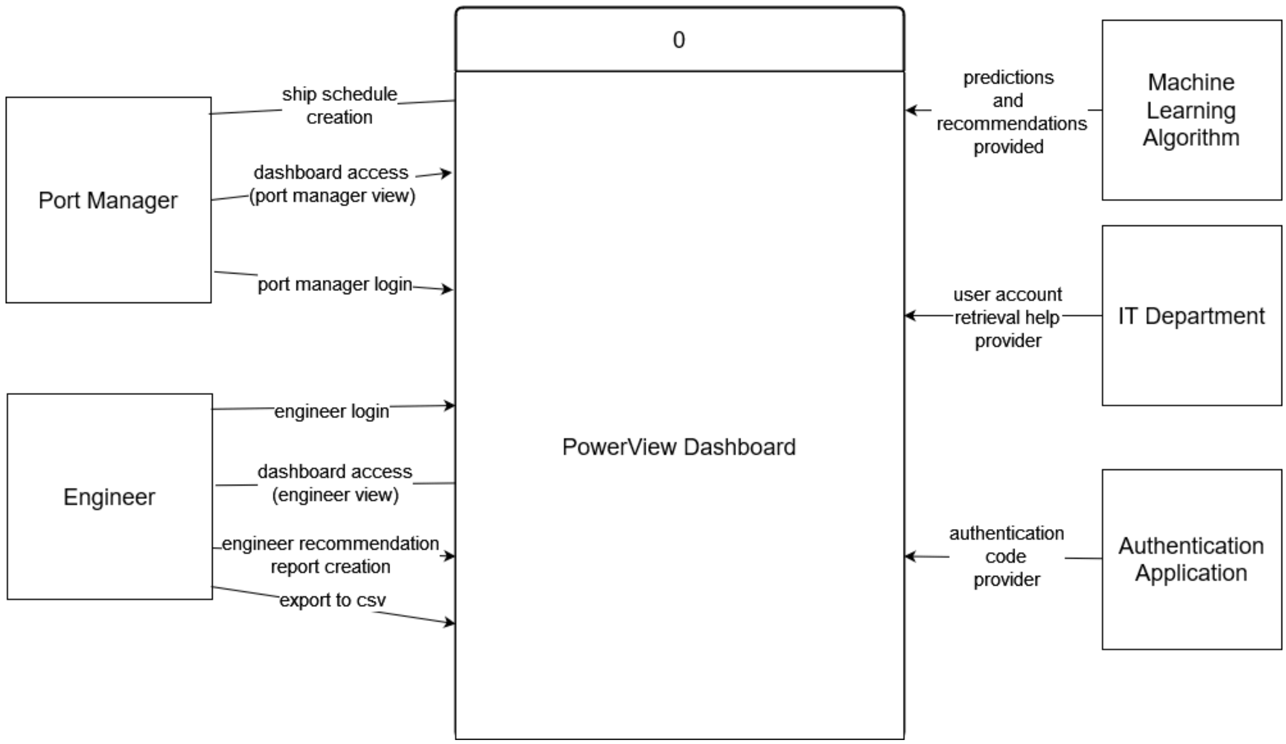


Figure 9: Context Flow Diagram

The CFD represents the main PowerView Dashboard process that communicates with 5 unique entities including port manager, engineer, machine learning algorithm, IT department, and authentication application.

8.2 DFD Level 0

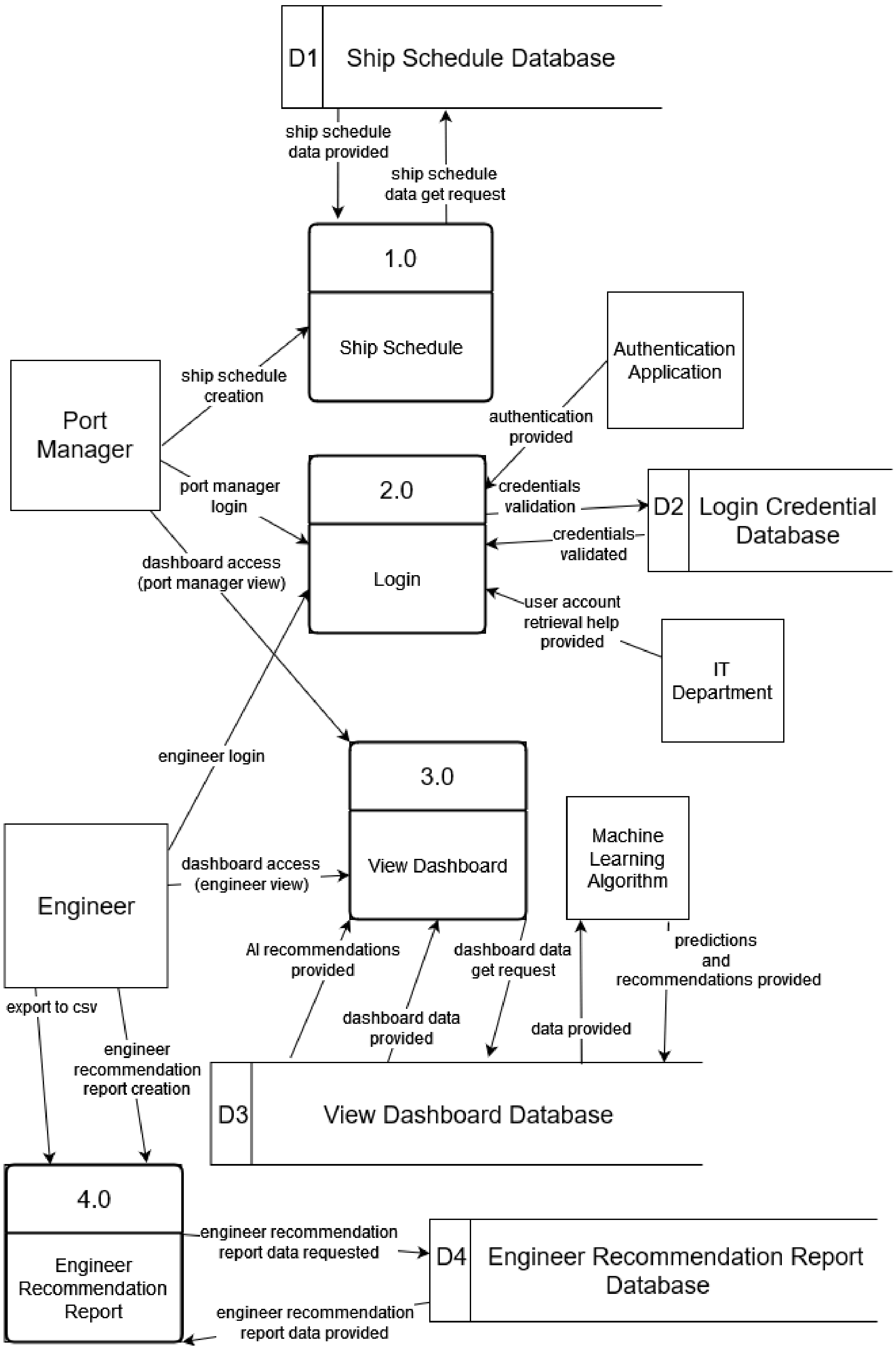


Figure 10: Data Flow Diagram Level 0.

The DFD Level 0 represents the 4 unique processes of the main PowerView Dashboard process including ship schedule, login, view dashboard, and engineer recommendation report. There exists 4 different databases, one for each process.

8.3 DFD Level 1

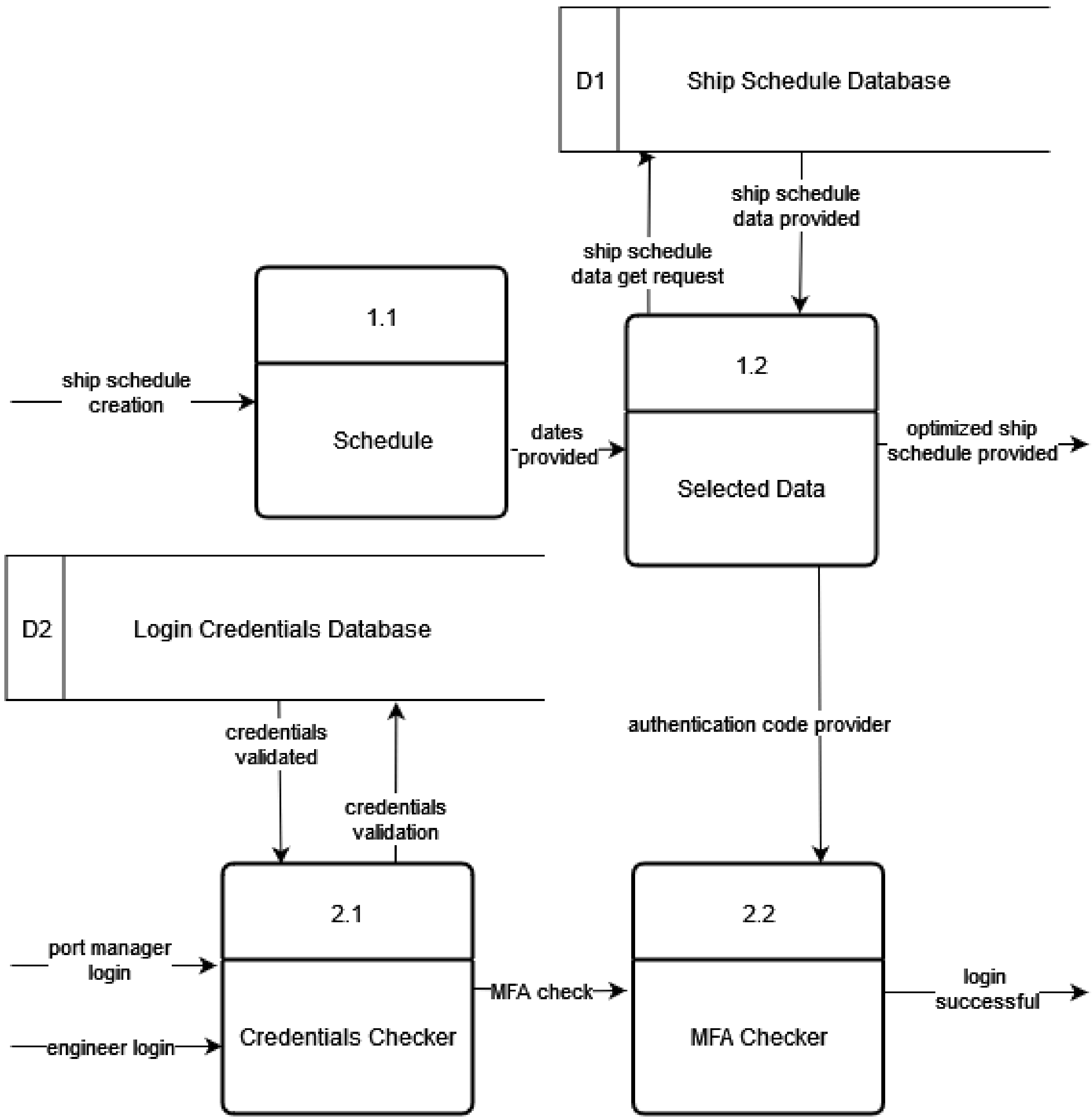


Figure 11: Data Flow Diagram Level 1 part 1.

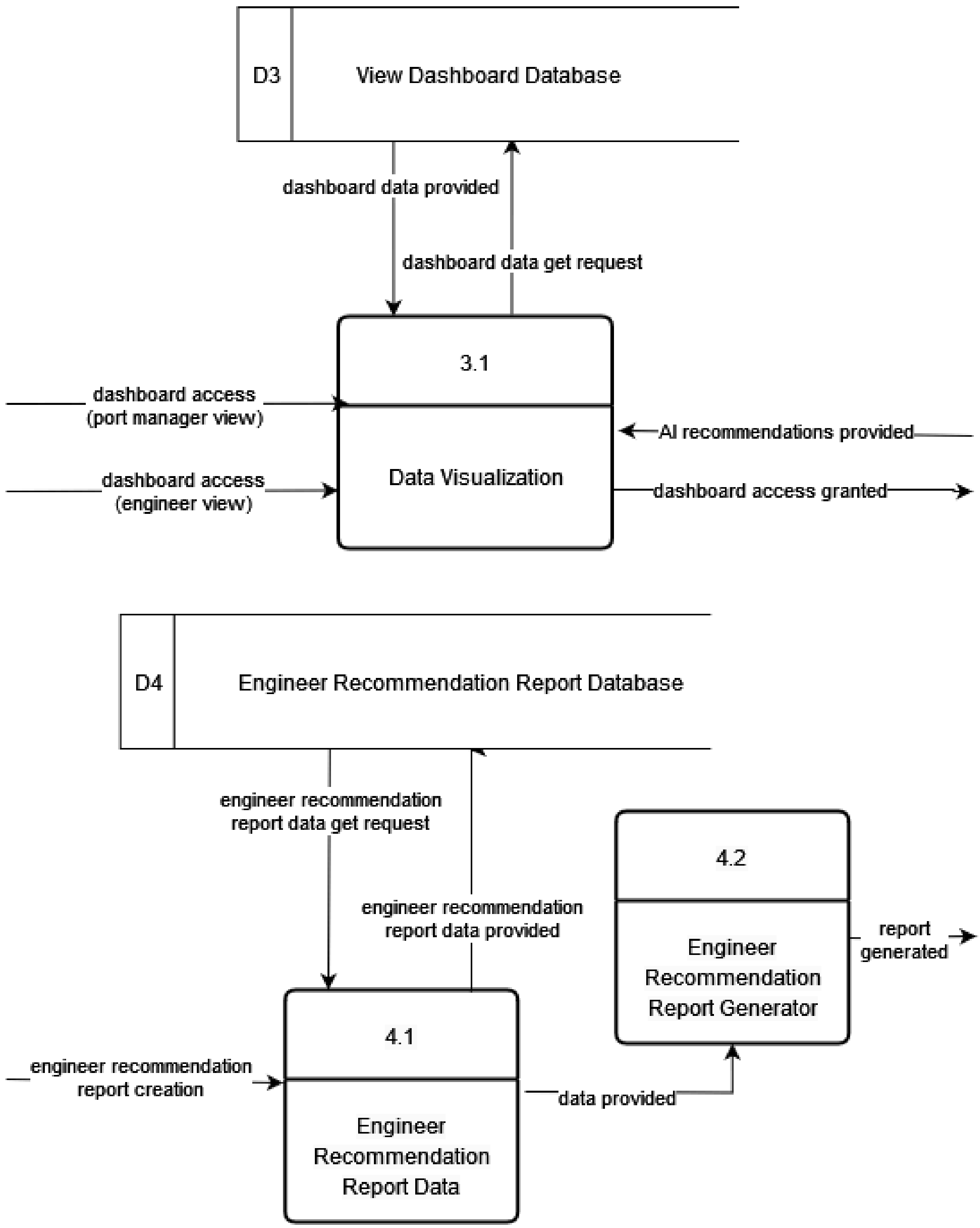


Figure 12: Data Flow Diagram Level 1 part 2.

The DFD Level 1 represents the 2 unique processes of the ship schedule process including schedule and selected data. Similarly, the login process has 2 different processes including credentials checker and MFA checker. Moreover, the view dashboard process has a unique process called data visualization. Furthermore, the engineer recommendation report process has 2 different processes including engineer recommendation report data and engineer recommendation report generator.

8.4 DFD Level 2

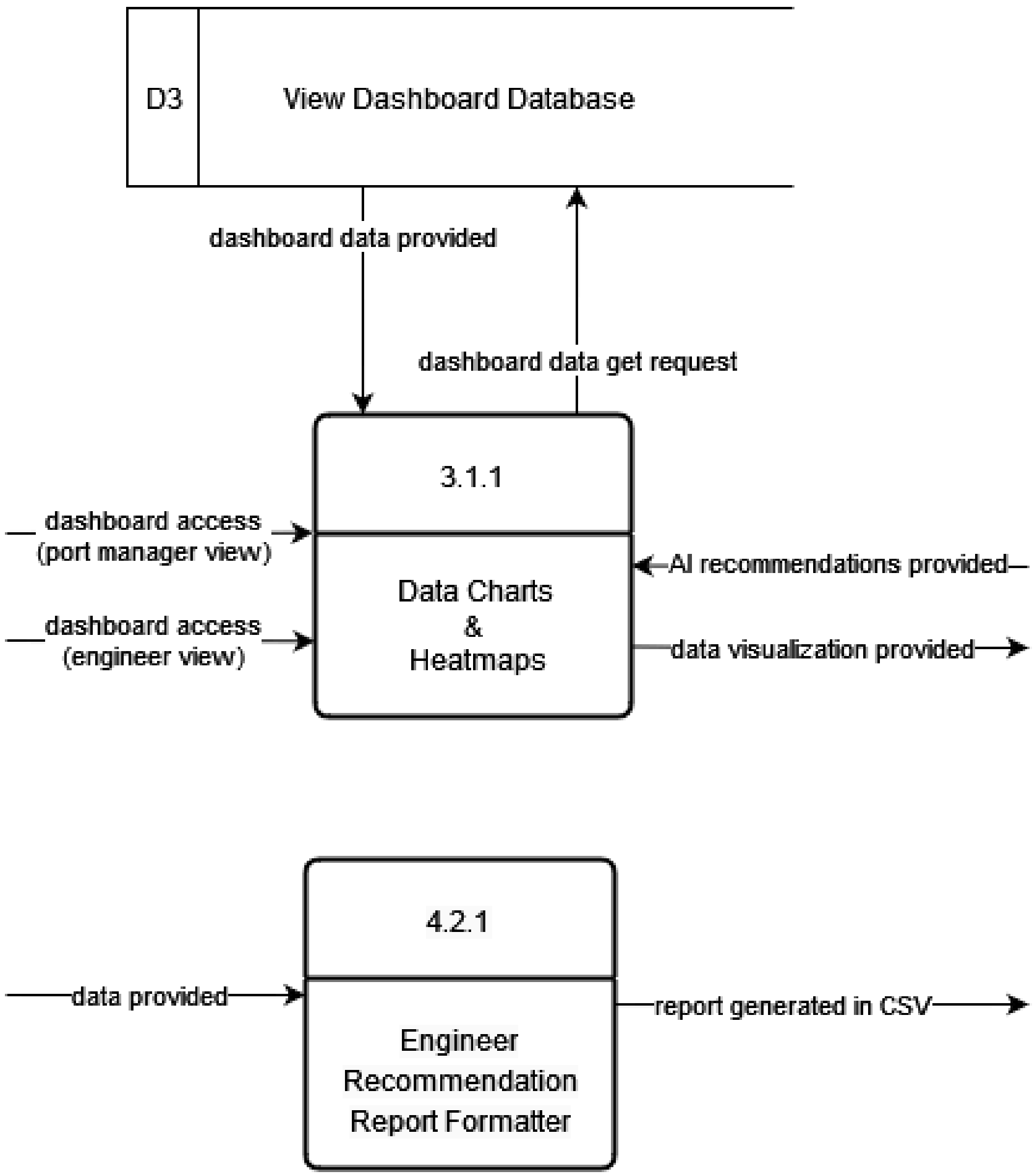


Figure 13: Data Flow Diagram Level 2.

The DFD Level 2 represents a unique process for data visualization called data charts and heatmaps. In addition, the engineer recommendation report generator process has a unique process called engineer recommendation report formatter.

9 Test Scenarios

Within this section are test scenarios that will be used to test PowerView requirements.

9.1 Logging In

TC-1: This scenario begins when the user attempts to input their username and password to get access to the PowerView dashboard and then press the login button. If done correctly, the user is requested to complete the MFA process. If done incorrectly, the user is prompted to input their credentials again.

REQ-1.

9.2 MFA

TC-2: This scenario begins when the user credentials are correct but need to multi-authenticate the user identity. The Duo Mobile notification will be sent to the user and once the user accepts the request, the user will be logged in to the PowerView dashboard. If the user rejects the request, the user will be prompted to send the Duo Mobile notification again for up to 3 times. If the user fails to validate their identity within 3 attempts of multi-factor authentication, the user will be locked out from their account and the user will need to contact the IT department to retrieve their account.

REQ-1, REQ-2, REQ-3.

9.3 Data Visualization

TC-3: This scenario begins when the user has logged in to the PowerView dashboard. The user will be able to see different ports located in Vancouver. Then, the user can click on a specific port and can see the heatmaps and data charts associated with that port. Now, the user can visualize either the data charts or/and the heatmaps for that selected port for two specific dates within a 1 year period. The data that can be visualized by the user includes real-time, historical, and predicted energy consumption data and cost of energy consumed. Moreover, the data charts and heatmaps shall have detailed information about the data being visualized as well as have a size adjustment and read-aloud technology implemented to enable visually impaired users to understand the data.

REQ-4, REQ-5, REQ-6, REQ-7.

9.4 AI Recommendations

TC-4: This scenario begins when the user is viewing some data charts or/and heatmaps for a specific port. Once the user clicks on a specific data chart or heatmap for a particular port, the user will be shown AI recommendations about reducing energy consumption.

REQ-8.

9.5 Port Manager

TC-5: This scenario begins when the user is logged in as the port manager. In addition, the user shall pick a specific port to view its data. Once the port is selected, the user can select two dates within a 1 year period and then click on the create ship schedule button that will generate an optimized ship schedule for that particular port based on the ship traffic data for that specific range of dates. Moreover, the port manager shall be provided appropriate data visualization graphs with concise information about energy consumption, prices, and future usage.

REQ-9, REQ-12.

9.6 Engineer

TC-6: This scenario begins when the user is logged in as the engineer. In addition, the user can select specific attributes from the data set of data charts or heatmaps and can generate a report by clicking the generate recommendation report button. For example, the user might select energy consumption in Joules for a specific port as well as its associated cost. Moreover, the engineer shall be provided detailed technical information about the data charts and heatmaps including the explanation of trough, peak, and steady behaviors of the graphs to allow engineers to find the root cause of the issue whenever required.

REQ-10, REQ-12.

9.7 Export Report

TC-7: This scenario begins when the user is logged in as the engineer. Once the user clicks on the generate recommendation report button, the user will be asked to export the report as CSV. Once the report is exported as CSV, the user can visualize the data by themselves to get more clarity so the user can make better decisions.

REQ-11, REQ-12.

9.8 System Throughput and Execution Time

TC-8: The system's energy meters and graphs must update within 0.1 seconds. The system's energy predictions must update in less than 3 minutes. The AI algorithm must be able to process up to 1 TB of data within the 3-minute execution time.

REQ-13, REQ-14, REQ-18, REQ-19.

9.9 System Storage Capacity

TC-9: The database storage capacity shall be high enough since the historical data are required to be available at all times.

REQ-15, REQ-16.

9.10 System Response Time

TC-10: The PowerView dashboard should not surpass 3 seconds when loading its web pages.

REQ-17.

9.11 AI Algorithm Accuracy

TC-11: The AI algorithm must make predictions with 98% confidence and above every time. The AI algorithm shall be able to process up to 1 TB of data points to make the AI algorithm accurate.

REQ-20, REQ-21.

9.12 Database Maintenance and Security

TC-12: The energy databases at Steelhead Solutions' port must be under surveillance 24/7. Weekly server updates must be completed to patch data encryption and related security issues. There will be daily backups for the databases used by PowerView and the databases will have an uptime of 99.9999%

REQ-22, REQ-23, REQ-27.

9.13 Privacy

TC-13: The PowerView dashboard will not collect personal information from its users. Users must be notified when a device with an unverified IP address logs into the dashboard using their credentials.

REQ-24, REQ-25, REQ-26.

9.14 Localization

TC-14: The PowerView dashboard shall support English and French languages by implementing unicode characters in the backend. In addition, the dashboard shall be implemented while considering TRUE usability factors: task efficiency, ease of remembering, understandability, and ease of learning.

REQ-28.

9.15 Traceability Matrix

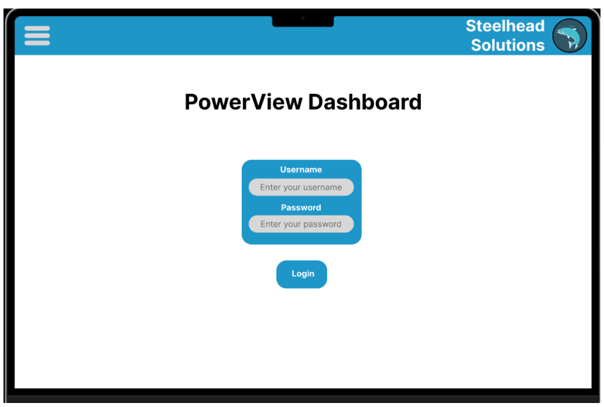
Table 6: Traceability Matrix			
Requirement		**Use Case**	**Test Case**
Requirement ID	**Priority**	**Use Case ID**	**Test Case ID**
REQ-1	High	UC-1-1	TC-1, TC-2
REQ-2	High	UC-1-1	TC-2
REQ-3	High	UC-1-1	TC-2
REQ-4	High	UC-2-1, UC-2-2	TC-3
REQ-5	High	UC-2-1, UC-2-2	TC-3
REQ-6	High	UC-2-1, UC-2-2	TC-3
REQ-7	High	UC-2-1, UC-2-2	TC-3
REQ-8	High	UC-2-1, UC-2-3	TC-4
REQ-9	High	UC-3-2	TC-5
REQ-10	High	UC-3-1	TC-6
REQ-11	High	UC-3-1	TC-7
REQ-12	High	UC-3-1, UC-3-2	TC-6, TC-7
REQ-13	Low	N/A	TC-8
REQ-14	Low	N/A	TC-8
REQ-15	High	N/A	TC-9
REQ-16	High	N/A	TC-9
REQ-17	Low	N/A	TC-10
REQ-18	High	N/A	TC-8
REQ-19	High	N/A	TC-8
REQ-20	High	N/A	TC-11
REQ-21	High	N/A	TC-11
REQ-22	High	N/A	TC-12
REQ-23	Low	N/A	TC-12
REQ-24	High	N/A	TC-13

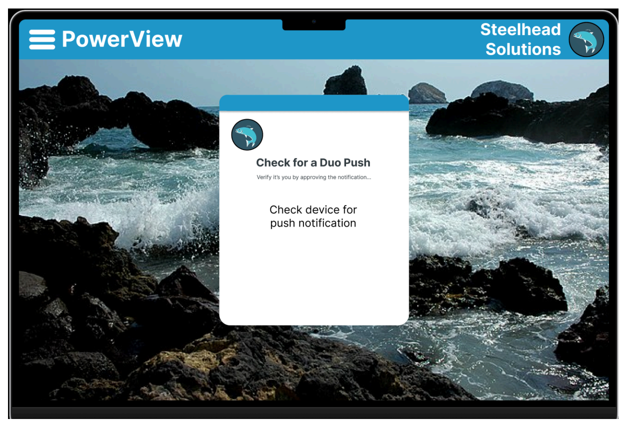
REQ-25	High	N/A	TC-13
REQ-26	High	N/A	TC-13
REQ-27	High	N/A	TC-12
REQ-28	Medium	N/A	TC-14

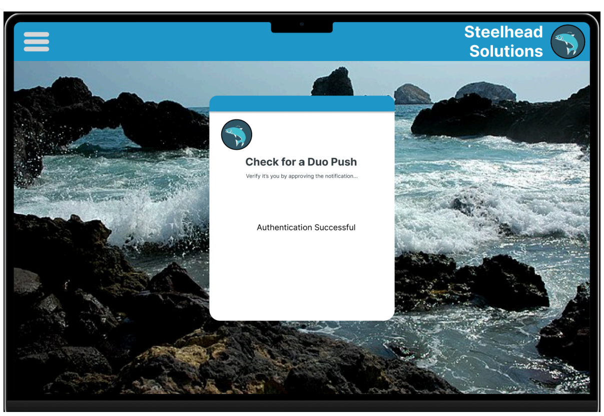
10 Mockups and Storyboards

Within this section are storyboards that are composed of the PowerView mockups. The mockups are taken from our functional prototype, which can be viewed on Figma here.

10.1 Login Storyboard







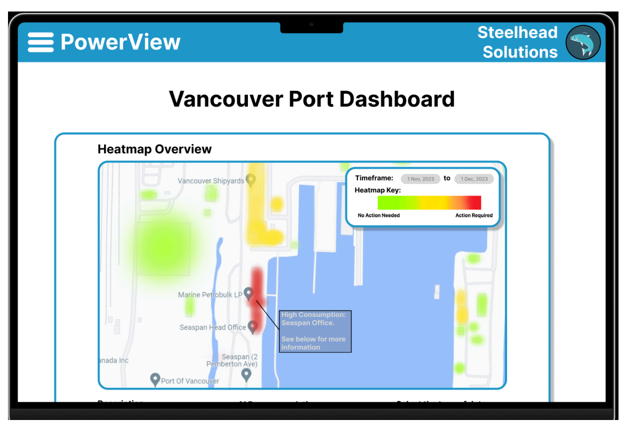


Figure 14: Login Storyboard.

Storyboard Description (Login): The user is first prompted to input the credentials associated with their Steelhead Solutions account. After correct credentials are inputted, the user must approve the login attempt via multi factor authentication (Duo). After the user authenticates the login request, they are taken to the PowerView Dashboard.

10.2 Heatmap Overview Storyboard

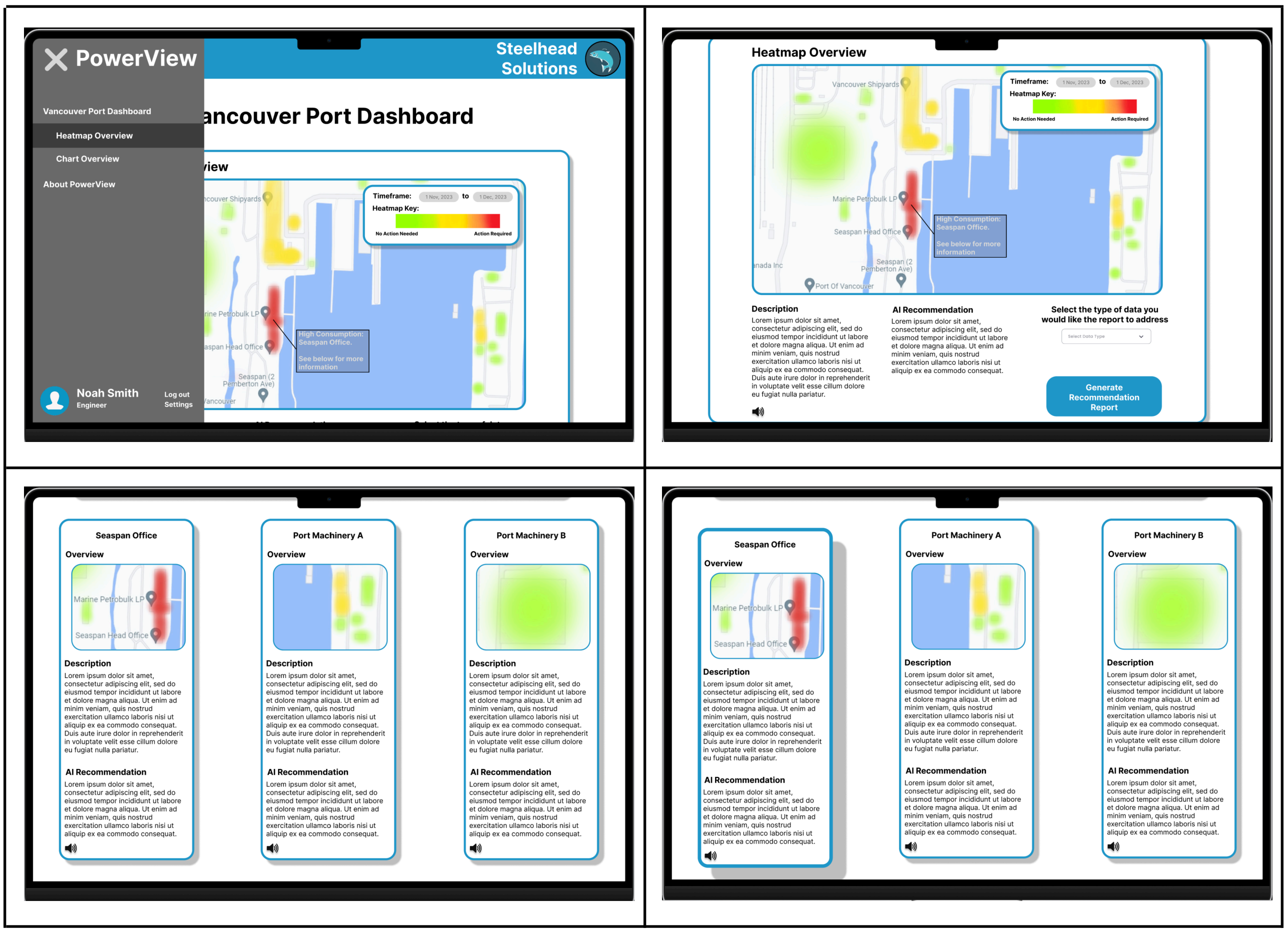


Figure 15: Heatmap Storyboard.

Storyboard Description (View Heatmap): The user can visualize levels of energy consumption throughout the port as a whole or in sections. The user can also enter in a valid time frame to display historical, real-time, or forecasted data. Accessibility is ensured through the read-aloud icon; when pressed, the text displayed underneath the heatmap will be read aloud.

10.3 Chart Overview Storyboard

Figure 16: Chart Overview Storyboard.

Storyboard Description (View Charts): This is similar to the flow described in the previous storyboard. However, the user can visualize predicted energy consumption data through the use of charts.

10.4 Recommendation Report Storyboard

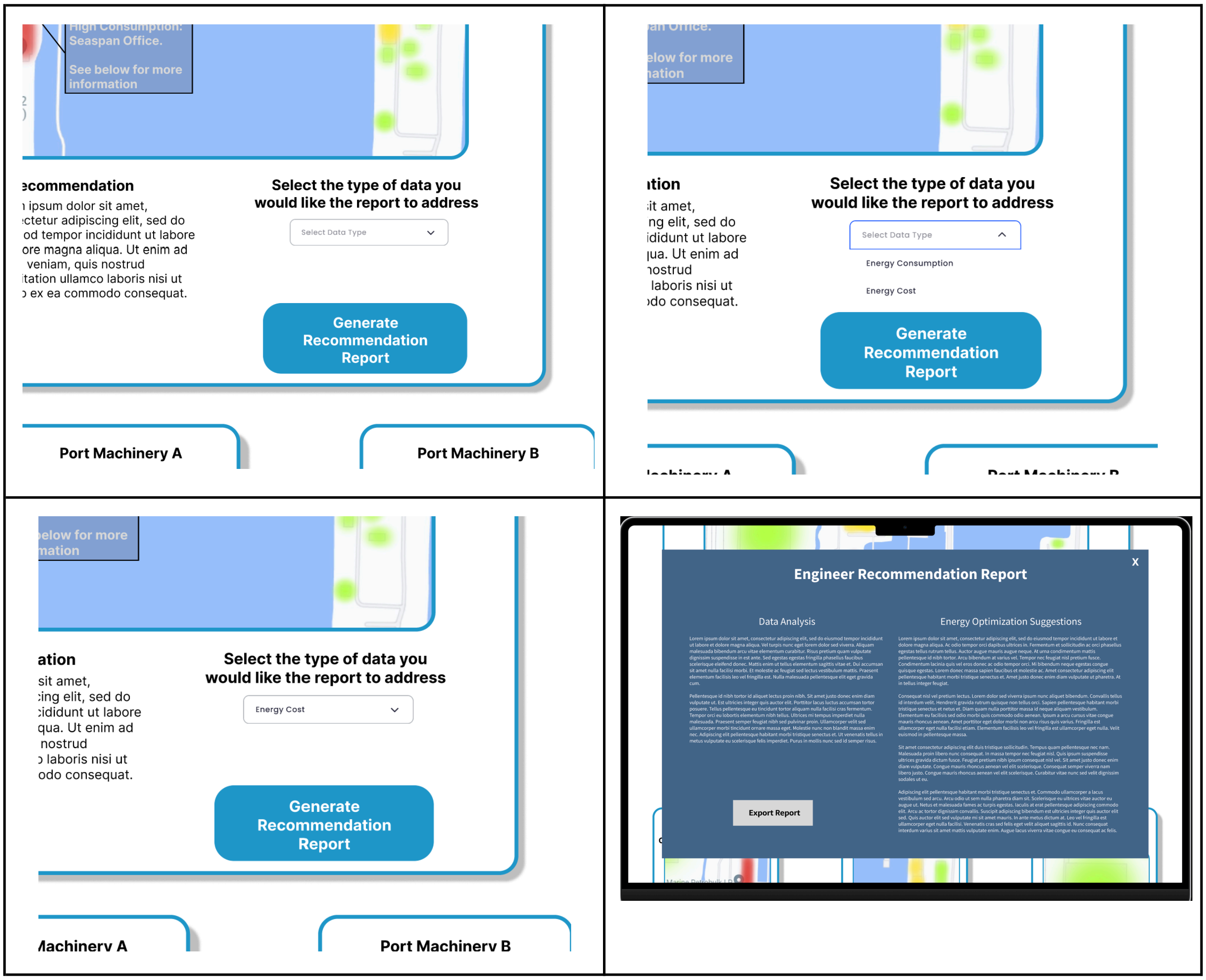


Figure 17: Recommendation Report Storyboard.

Storyboard Description (Engineer Recommendation Report): The user is on the main PowerView Dashboard screen (or Chart Overview screen) and scrolls down midway through the page. The user selects the type of data they want the report to address, either ‘Energy Consumption’ or ‘Energy Cost’. They click ‘Generate Recommendation Report’ and a pop-up window containing the report appears. Sections titled “Data Analysis” and “Energy Optimization Suggestions” are displayed, offering more sophisticated data interpretation and technical solutions. The user has the option to export this report.

Appendix: Issues List

There are no known issues at this time.