PERSONAL RAPID TRANSPORT SYSTEM (PRTS)

Team 1:
Jillian Deaver
Maxey Duncan
Matt Dykes
Megan Hewison
Dominic Hoefer
Hareish Raghupathy

EMIS 7311 – Systems Engineering Design

Approved By:
Long S. Dong, Ph.D.

Table of Contents

1.0 Introduction 4
1.1 Purpose 4
1.2 Product Development Factors 4
1.3 Development Risks 4
1.4 Roles and Responsibilities 5
2.0 Problem Analysis 5
2.1 Problem Definition 5
2.2 Stakeholders 6
2.3 System Boundary 7
2.4 Constraints 8
3.0 Operational View, OV-1 8
4.0 Defined Set of Possible Operational Scenarios 9
4.1 Operational Scenario Analysis 9
4.2 Defined Operational Scenarios 10
5.0 Developed Objectives Hierarchy 12
6.0 Multi-Level Functional Architectures Development 13
7.0 Operational Architecture Development 17
8.0 Interface Design 20
9.0 Physical Architectures Development 20
9.1 Morphological Analysis 21
9.2 Feasibility Analysis 21
9.3 Physical Architecture 22
10.0 Context Diagram, OV-5 23
11.0 Data Model 24
11.1 Entity Relationship Diagram (ERD) 24
12.0 Operational Scenarios 25
12.1 Normal Scenario 1 – User Authentication - Validate User Identity 25
12.2 Normal Scenario 2a - Request a Ride - Verify User's Eligibility to Request a Ride 26
12.3 Normal Scenario 2b - Request a Ride - Display Ride Information (type, location, and capacity status) 27
12.4 Normal Scenario 3 – User Adds Stop to Ride 27
12.5 Normal Scenario 4 - User Cancels Ride 28
12.6 Normal Scenario 5 - Perform User Account Maintenance 30
12.7 Normal Scenario 6 - Validate User Pickup 30
12.8 Abnormal Scenario 1 - The TOS Does Not Recognize Location That the User Submits 31
12.9 Abnormal Scenario 2 – User Enters Wrong ID and/or Password 33
12.10 Misuse Scenario 1 - Hacker Tries to Log In 33
13.0 Activity Diagrams 35
13.1 Normal Scenario 1 – User Authentication 35
13.2 Normal Scenario 2 – Request a Ride 35
13.3 Normal Scenario 3 – Add Stop 36
13.4 Normal Scenario 4 – Cancel Ride 36
13.5 Normal Scenario 5 – User Account Management 37
13.6 Normal Scenario 6 – Validate Ride Pickup 37
13.7 Abnormal Scenario 2 – User provides Invalid Username and/or Password 38
14.0 Sequence Diagrams 39
14.1 Normal Scenario 1 – User Authentication (No Timeline) 39
14.2 Normal Scenario 2 – Request a Ride 39
14.3 Abnormal Scenario 2 – User Provides Invalid User ID and/or Password 44
14.4 Abnormal Scenario 3– User Account Has Constraint 45

15.0 Data Flow Diagram 46
16.0 Sequence Enumeration 47
16.1 Assumptions 47
16.2 System Boundary 48
17.0 Functional Requirements 49
18.0 Non-Functional Requirements 51
19.0 Traceability Tables 53
19.1 Functional Requirements to Use Case Trace 53
19.2 Non-Functional Requirements to Use Case Trace 54
20.0 System Level Test Plan 55
21.0 Glossary 58
22.0 Works Cited 58

1.0 Introduction

1.1 Purpose

The purpose of the PRT system on the Line is to provide a high-speed and efficient transportation solution for passengers and cargo between designated locations. This system aims to optimize the use of resources, including energy and time, while ensuring safe and comfortable travel for passengers. The system will use advanced technology, including a central control system and hyperloop pods, to achieve the desired outcomes and provide a competitive alternative to traditional transportation systems.

1.2 Product Development Factors

Several factors are likely to influence product development, such as the reliability of the system, speed of the system, security of the system, and safety of the system.

The system will use advanced technology to achieve the speeds necessary to meet NEOM's transportation goals. Therefore, it is essential to stay up to date with the latest advancements in technology to ensure that the system remains efficient, competitive, and able to meet transportation needs. This is addressed in the evolutionary lifecycle model for the personal rapid transportation system (PRTS).

The security of the system is critical due to risks that could be posed by hackers of the system and due to the sensitive passenger information to which the system has access.

Safety is a crucial factor in the system. It is essential to design the system with safety in mind, including measures such as emergency braking systems and backup power supplies.

Reliability is a critical factor in developing the PRT system on The Line, and it must sustain this reliability for over nine million predicted residents of NEOM.

These factors will be considered while calculating the cost of the system, and the cost is to be handled by the Saudi Arabian government and other benefactors.

1.3 Development Risks

There are several risk areas that should be addressed for the PRT system. The first identified risk is the overwhelming population that will be using the PRT on The Line, especially during rush hour on weekdays. This poses a threat to the system's capacity limits, as well as network capability. To alleviate the risk of capacity limits, the system has been developed to offer a number of pods that can service up to 2/3 of NEOM's population at any given time. The extensive number of pods will also operate with a quick turnaround time so that passengers can be served efficiently with their transportation. In order to address the issue of network capability, a study will be conducted with a technology consulting company of the Saudi Arabian government's choosing; a partnership with this consulting firm will provide an optimal solution for network uncertainties.

The next risk identified is the lengthy timeframe of The Line's development project. The current solution in place for citizens of NEOM's The Line is a rapid transportation system, but due to the drawn-out schedule that will last decades, the PRT may be outdated by the time The Line is populated. An analysis using forecasting and predictive modeling will be utilized to determine the patterns of future citizens and their preferred method of travel.

The last risk identified is the level of security of the system. Passengers are to trust the PRT with their personal information, such as financial details, home locations, and login information, so this is a priority to be kept secure. An analysis of threats and hacker techniques is to be completed and has been briefly touched on in this report regarding use cases. The primary analysis will be undergone after the development of the system when the information technology is in place.

1.4 Roles and Responsibilities

The Saudi Arabian government and founding members of NEOM are responsible for the creation of The Line and have requested service from Dr. Dong's Systems Engineering Design project team for the design of the personal rapid transportation system. The Systems Engineering Design team shall draft requirements and ideas for the PRTS that will later be implemented into NEOM's The Line.

Contractors appointed by the Saudi Arabian government shall be responsible for developing The Line's PRT system. Systems Engineers appointed by the Saudi Arabian government are responsible for testing the PRT system and will follow the guidelines established in the Systems Engineering Design project team's system-level test plan.

The Line's system administrators will be responsible for day-to-day activities upon activation of the PRT and will be supported by system maintenance personnel and system operators. Emergency services will be available to the PRT system and will be provided by Saudi Arabian first responders.

A web designer shall develop the user interface application and website for use by citizens of NEOM's The Line.

2.0 Problem Analysis

2.1 Problem Definition

The following table describes the problem that the PRTS (Personal Rapid Transport System) aims to solve.

Element	Description
The Problem	Citizens and visitors to The Line require quick and reliable personal transportation throughout the city.
Affects	- Citizens and visitors of The Line. - The Line administration.

	- Saudi Government. - Existing government internal systems/databases. - Businesses operating within The Line
Results	- Citizens and visitors arrive promptly and safely at their desired destination. - Cargo arrives promptly and safely at its intended destination. - Emission-free transportation throughout The Line
Benefits	- Reduced travel time compared to traditional transportation systems - Smoother ride compared to traditional transportation systems - Completely powered by renewable energy sources. - Pods are more spacious and comfortable than traditional transportation systems. - Reservable pods. - Maintain pod availability, travel time, account information, and travel information in the database to provide users with the most current and accurate information.

2.2 Stakeholders

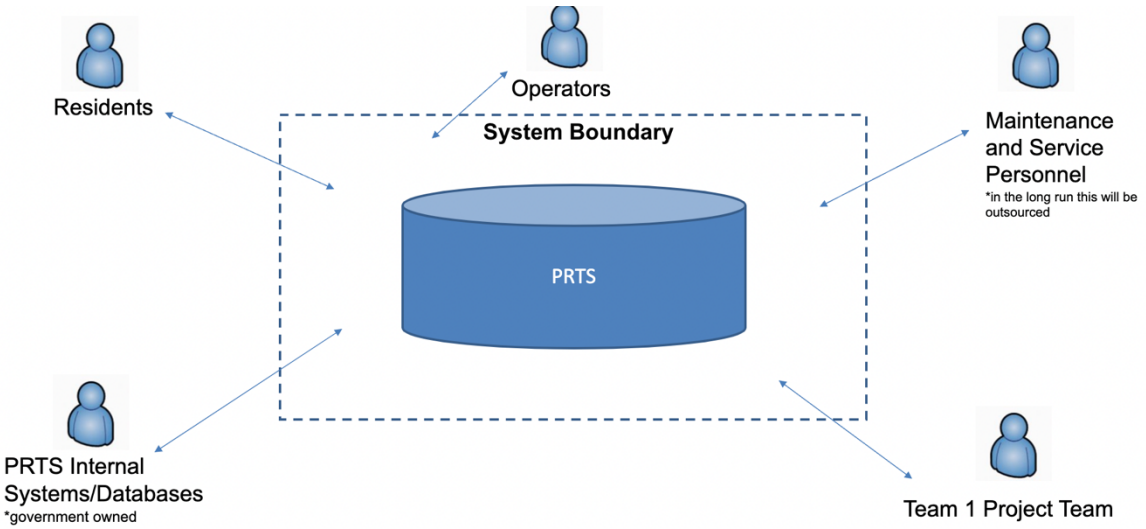
The following table describes the stakeholders for the PRTS.

Direct Users	Other Stakeholders
Residents: The residents of The Line will be the primary users of the PRT System.	**Team 1 Engineering Team: This** challenging project will need to be developed by Team 1.
Cargo Senders/Receivers: Cargo senders and receivers will also be primary users of PRTS transportation.	**The Line Upper Management:** The upper management team of The Line is comprised of various vice presidents, CTO, CIO, CFO, CEO, etc.
PRTS Operators: The employees of The Line that operate the transportation system.	**The Line Marketing Department:** The marketing team of The Line knows that this transportation system is a high selling point for potential residents.
PRTS Maintenance & Service Personnel: The employees of The Line that maintain	**The Line Stockholders:** If this transportation system is selected and successful, the stock price will increase.

the pods and other components of the PRTS.	

2.3 System Boundary

The following is the System Boundary Diagram for the PRTS.

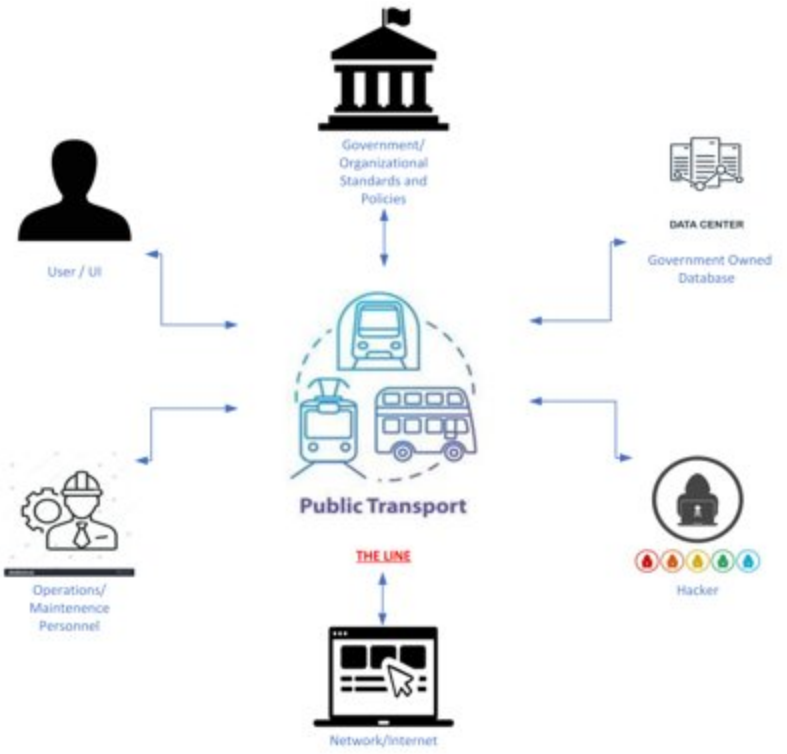


2.4 Constraints

The following constraints of the PRTS have been identified and must be considered to prepare for their impact on the system development.

Constraint Category	Particular Constraint Descriptions
Schedule and Resources	- The PRTS must be developed, prototyped, and integrated alongside The Line's own construction. - High-quality materials and equipment designed to meet all safety and performance requirements must be used. - The PRTS must be completely functional before The Line becomes inhabited.
Financial	- Budget for design, development, testing, and integration of the PRTS is controlled by the Saudi Arabian government's Public Investment Fund approximately $500 billion USD.
Political	- Safety regulations mandated by Saudi Arabian Government. - Legal regulations mandated by Saudi Arabian Government.
Technical	- Technology used in the PRTS must currently exist. - All technology used in the PRTS must be exclusively powered by electricity. - All user data and control systems must be heavily encrypted and protected.
System	- The PRTS must be capable of servicing 2/3 of The Line's population at any given time. - Users of the PRTS must be citizens or possess a visitor pass.
Environmental	- All power provided to the PRTS must come from renewable energy sources. - The PRTS must not physically block or inconvenience citizens who are not currently using it.

3.0 Operational View, OV-1



4.0 Defined Set of Possible Operational Scenarios

4.1 Operational Scenario Analysis

User	Scenario	Input to PRTS	PRTS Output	Measure Of Effectiveness
Active Users	Authentication	User ID & Password	Grant Access Confirmation	-only authorized users get through the authentication
Active Rider	Book Transportation	-authorized login id & password -commands to book transportation (pick up/ drop off locations, time)	Confirmation of desired transportation	- authorized rider navigates & selects a desired ride within 5 minutes -rider can call, edit, and cancel rides without an additional tutorial -ride confirmation is displayed in less than 5 sec

Maintenance & Service Personnel	Maintain the PRT System and all components	-preventative maintenance of components -inspections on components -corrective maintenance on components	Working pods and other system components	- System and components stay operable 24 hours a day -Rider wait time stays within 5 minutes
Control Center	Control the PRT System's operations	Authorized pod transportation	Pod transportation	Pod movement after authorization within 3 sec
Operators	Operate the PRT System	commands for pod transportation	Pod transportation	Pod movement after command within 10 sec
Hacker	Attempt to steal personal identification	-unauthorized logon id/password -cracked authorized id/password	-display PRTS access denial	-deny unauthorized access 100% -block user after 4 attempts of login -identify & block" back-door" accesses within 3 sec
User Database	Keep accounts and history of all users	-user authentication data (usernames & passwords) -past rides	display user ride eligibility	display user ride eligibility (allow or denial message) within 5 sec
Pod Database	Keep accounts of and history of all pods	Pod authentication data (pod number and reports)	Pod available for ride	display pod available for a requested ride within 5 sec
Cargo Transporters	Transport cargo on the PRT system from point A to point B	-Cargo -Destination -Departure time	-Transported Cargo -Successful delivery message	-delivered cargo to correct destination -no damage to the cargo from transportation

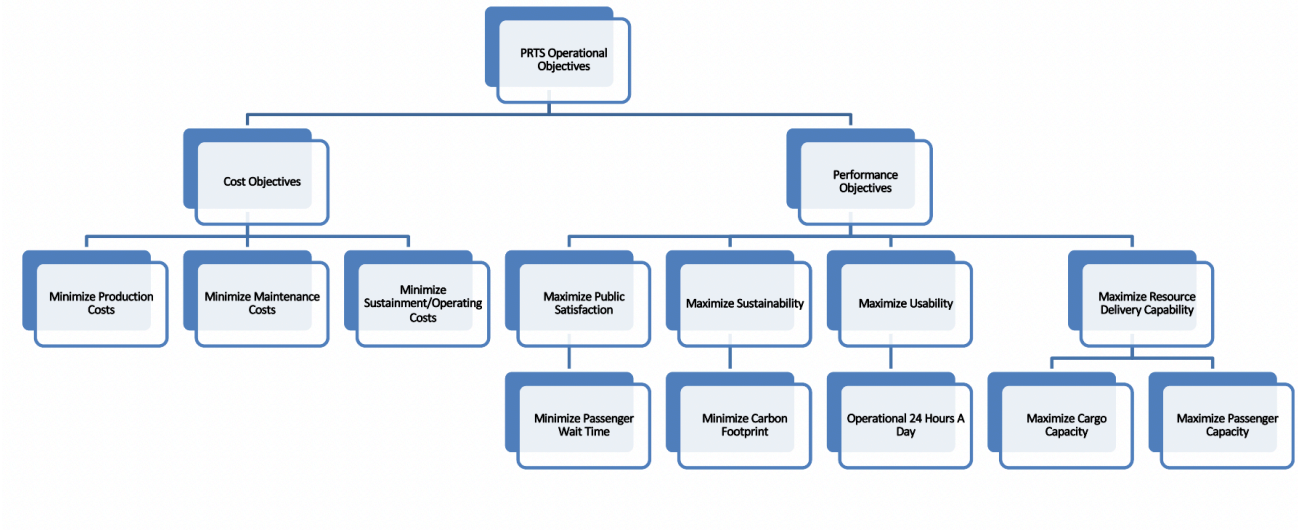
4.2 Defined Operational Scenarios

Use Cases	*Actor*	*Precondition*	*Post Condition*	*Description*
Authenticate User	Smartphone/Device Operator	Security feature is functioning	Accept/deny valid/invalid user	PRTS web or mobile application grants access for valid users to be able to book rides/use the application/service and

				blocks invalid users from being able to book rides/use the application/service
Request a Ride	Passenger	Passenger has downloaded the PRT app and has an account	System sends confirmation and trip details to the passenger's account and email	Passenger opens the PRT app and logs in, and selects "Request a Ride" option Passenger enters their origin and destination points, as well as preferred departure time System displays available pods and travel options Passenger selects desired pod and confirms booking
Add stop	Passenger	Web-based / application system has validated user id/password, and user has successfully logged in. User has already requested a ride.	The TOS is ready for the next input item from user.	Passenger selects “Add stop” function on PRT platform. Passenger browses available stop locations on route and selects one to add. System updates route information and adds a stop to the passenger's ride.
Cancel ride	Passenger	Web-based / application system has validated user id/password, and user has successfully logged in. User has already requested a ride.	The TOS is ready for the next input item from user.	Passenger selects “Cancel ride” function on PRT platform. System outputs a warning on cancel. Passenger confirms the cancellation, and the ride request is canceled through the database. System returns confirmation message.
Validate Ride Pickup	Passenger	Passenger has booked a PRT trip and arrived at the pickup station	The Passenger has left the station	Passenger enters the pod and scans the QR code to validate ride pickup Passenger loads their luggage, if applicable Passenger sits and proceeds to their destination
Manage User Account	Passenger	Passenger has an account on the PRT system and wants to manage their account	Passenger is able to manage their account	Passenger logs in to their account on the PRT app or website Passenger navigates to the "Profile" or "Preferences" section of their account

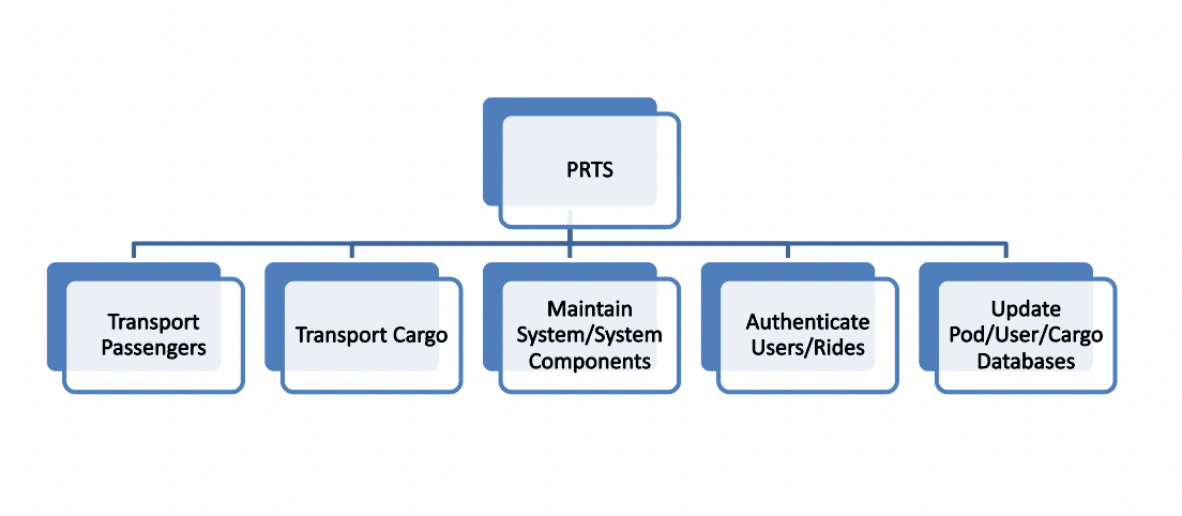
				Passenger updates their personal information, payment method, or other relevant details System confirms the changes and updates the passenger's account information
Request Emergency Service	Passenger	Passenger is on a PRT pod and experiences a medical emergency or other urgent situation	The passenger emergency is resolved with minimal interruption	Passenger activates the emergency button inside the pod or uses the PRT app to request emergency assistance Central control system receives the emergency request and assesses the situation System contacts emergency services and sends information about the passenger's location and situation System directs the pod to the nearest available station with medical facilities or other necessary resources System informs other pods on the network about the emergency and takes appropriate action to minimize disruptions
Maintain & Repair	Maintenance crew	PRT system requires routine maintenance or repair work	PRT is operational	Maintenance crew receives a request for maintenance or repair work on a specific pod, station, or section of the network Crew accesses the necessary tools and equipment and travels to the location of the work Crew performs the maintenance or repair work, including cleaning, inspection, replacement of parts, or other tasks as necessary Crew updates the central control system on the status of the work and any issues or concerns that arise System confirms that the work is complete and updates relevant records and maintenance schedules.

5.0 Developed Objectives Hierarchy

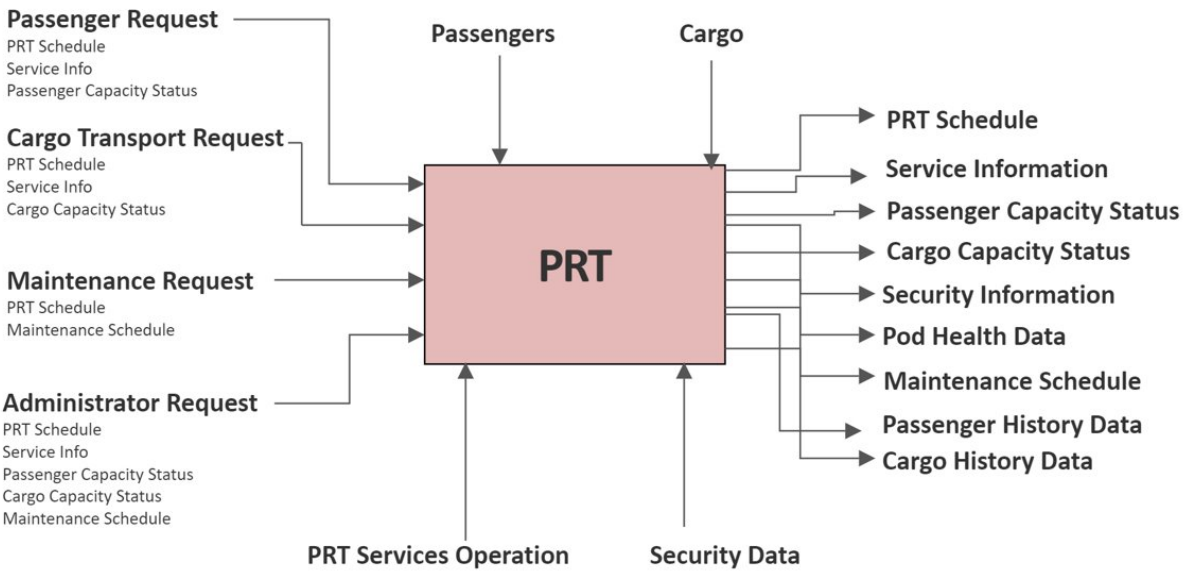


6.0 Multi-Level Functional Architectures Development

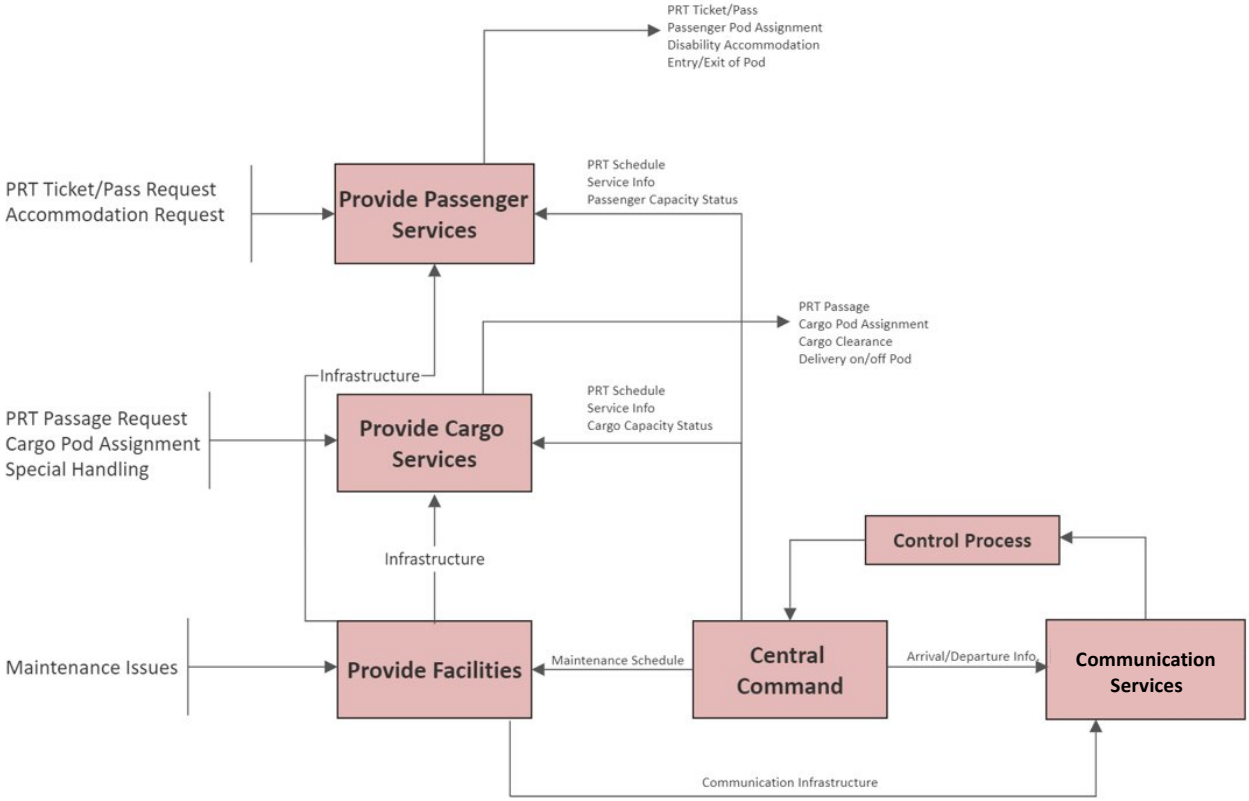
Functional Decomposition:



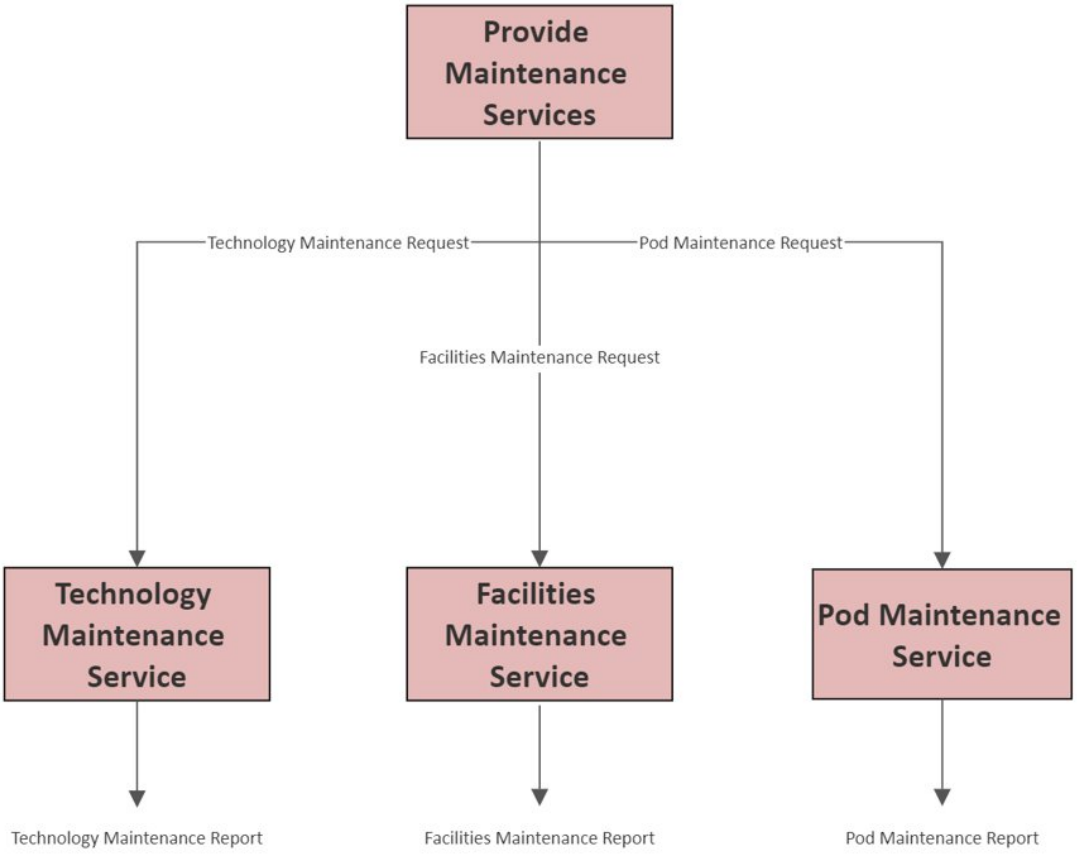
Functional Architecture – A.0:



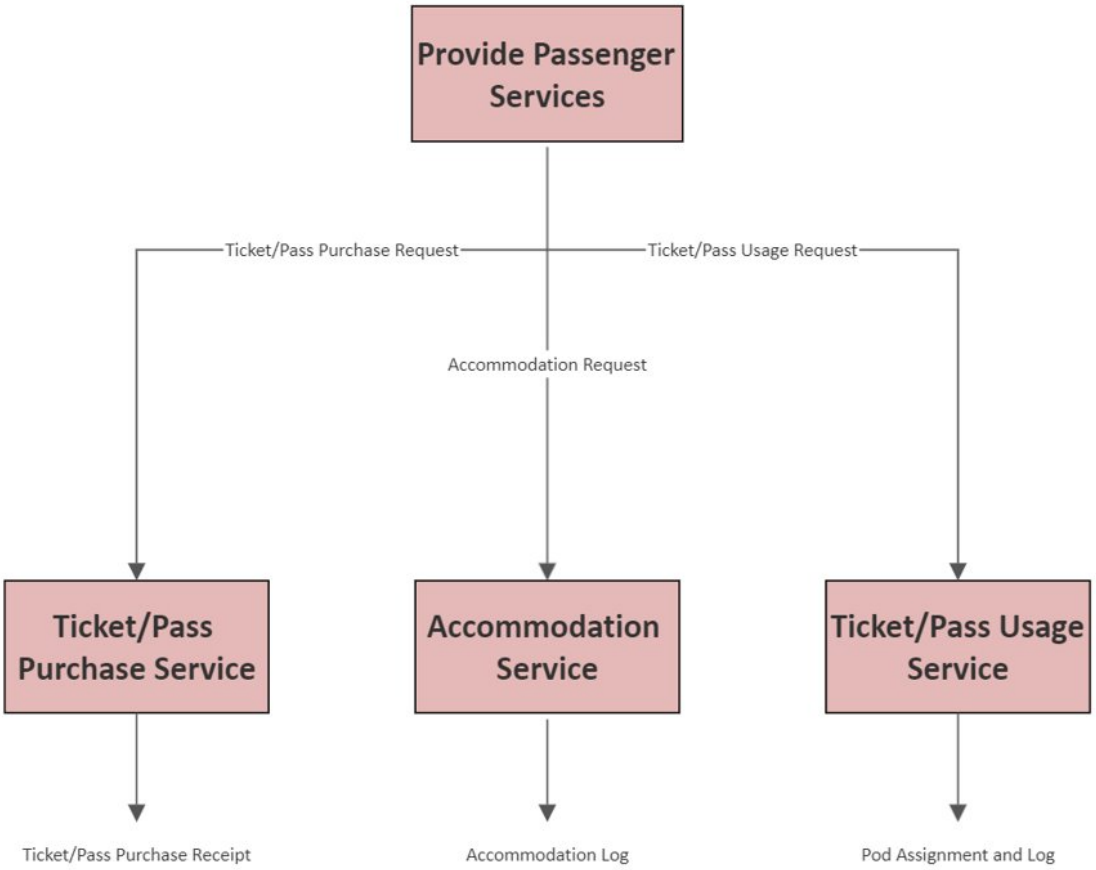
Functional Architecture – A.1:



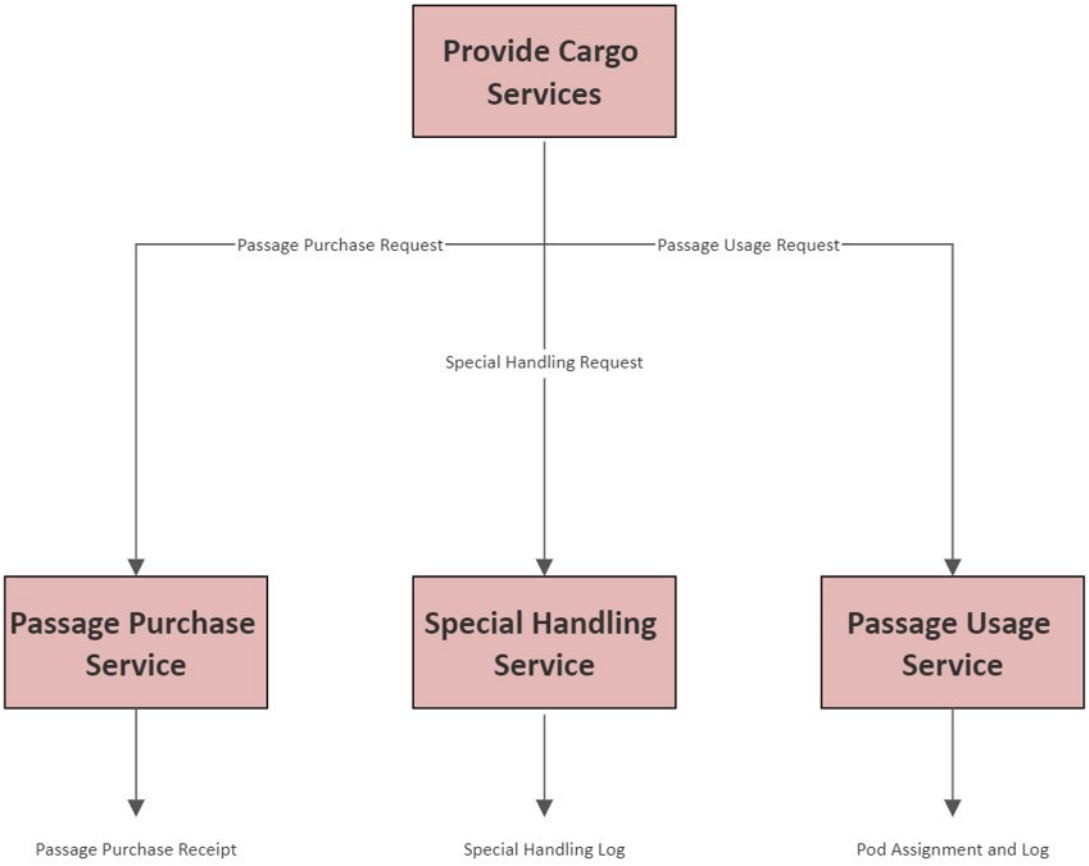
Functional Architecture – A.2.1:



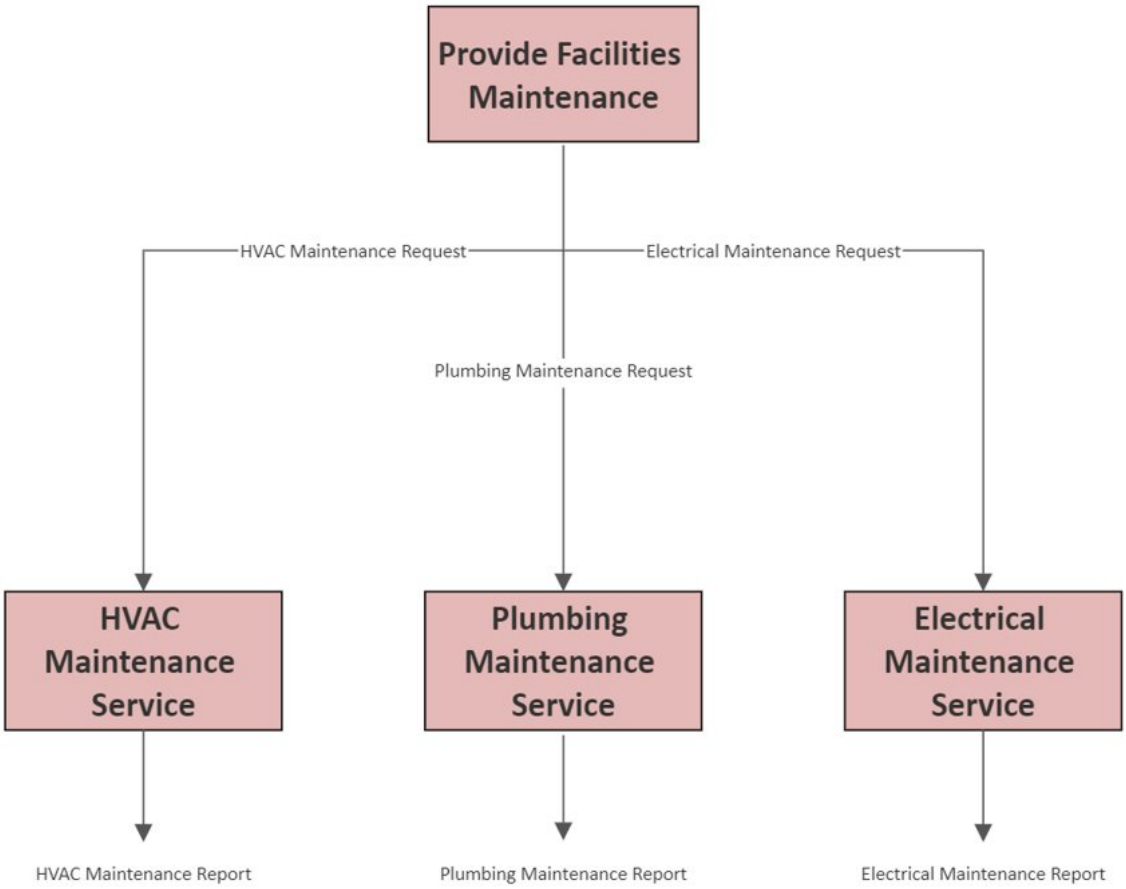
Functional Architecture – A.2.2:



Functional Architecture – A.2.3:

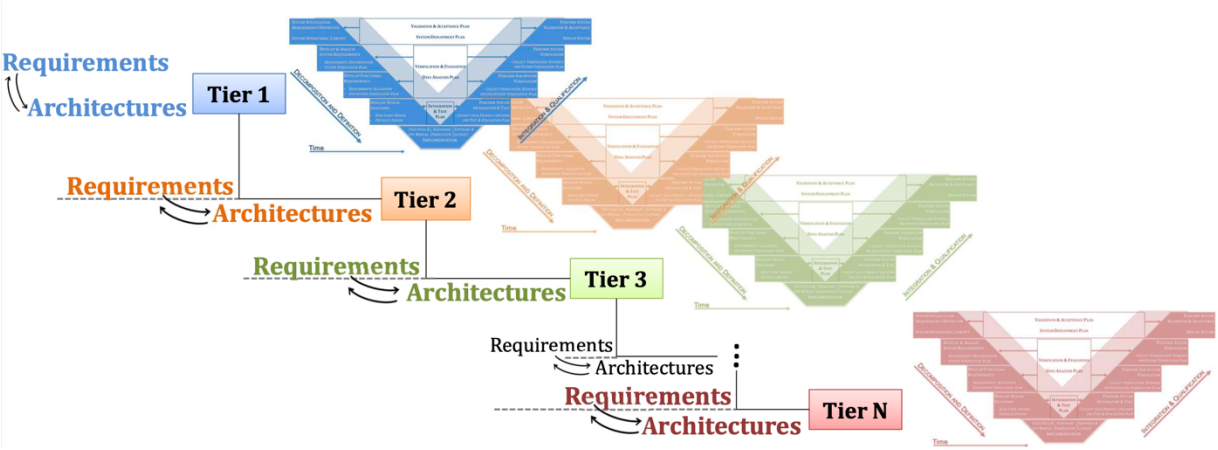


Functional Architecture – A.3.1:



7.0 Operational Architecture Development

Operational Architecture Development Approach:



In the operational architecture development approach shown in the image above, each of the design process activities will be completed to an abstract high level. Sequentially, the entire process is repeated in the Vee model and continued as needed for the design process.

The operational architecture development provides the complete description of the system design, including:

- The functional architecture allocated to the physical architecture (outlined in sections 6.0 Multi-Level Functional Architectures Development & 10.0 Physical Architectures Development – of this report)
- Derived input/output, technology, and system-wide qualification requirements for each component (all requirements outlined in the Specification Document)
- An interface architecture that has been integrated as one of the components (outlined in section 9.0 Interface Design – of this report)
- Complete documentation of the design and major design decisions (the detail of this is out of the scope of this student project)

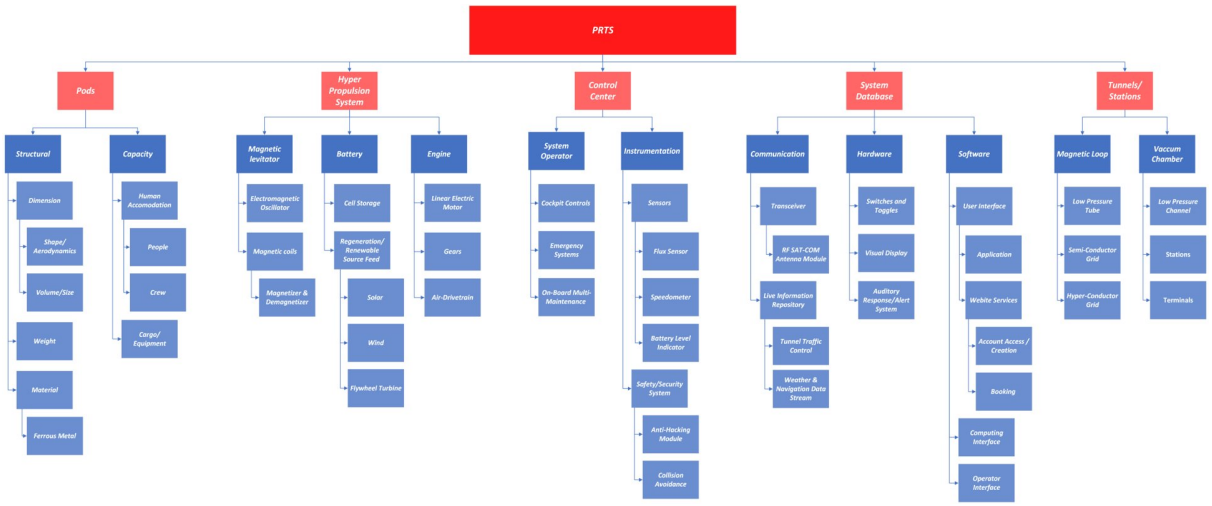
The operational architecture development consists of the following five major activities:

1. Allocate functions and system-wide requirements to physical subsystems
2. Define and analyze functional activation and control structure
3. Conduct performance and risk analysis
4. Document architectures and obtain approval
5. Document subsystem specifications

These five activities are further outlined in the following subsections:

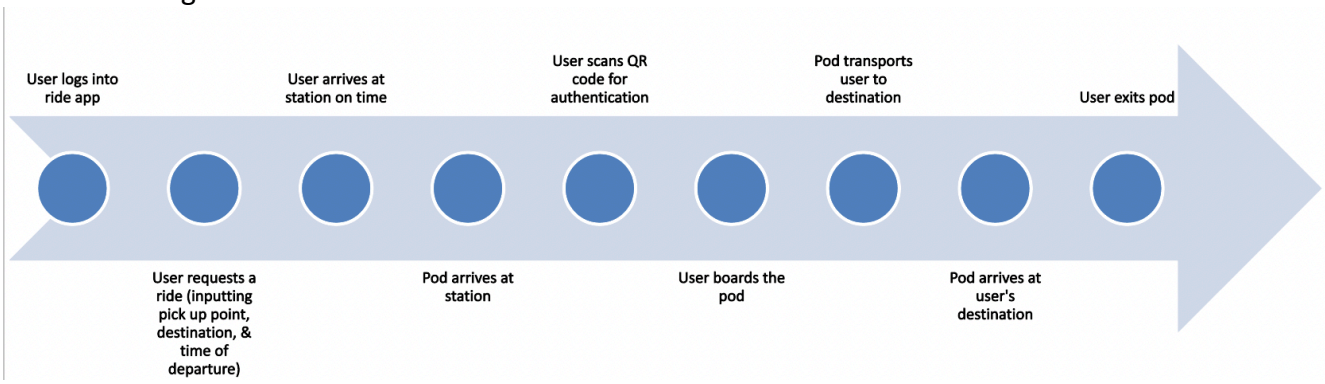
Allocate Functions and System-Wide Requirements to Physical Subsystems:

The following chart is a requirements hierarchy that shows the requirements derived into physical subsystems. The boxes represent the requirements pertaining to the components. For example: "Dimension" in Level 3 means: The "Dimension" of the "Pods" shall be capable of accommodating 20 people comfortably during the travel. Therefore, referring to the dimension requirements. The system requirements are included in the specification document.



Define and Analyze Functional Activation and Control Structure:

The following chart is a high-level flow chart depicting the order of activation for a resident reserving/taking a ride on the PRTS from the user's point of view. Note that each node requires the previous node's completion before starting.

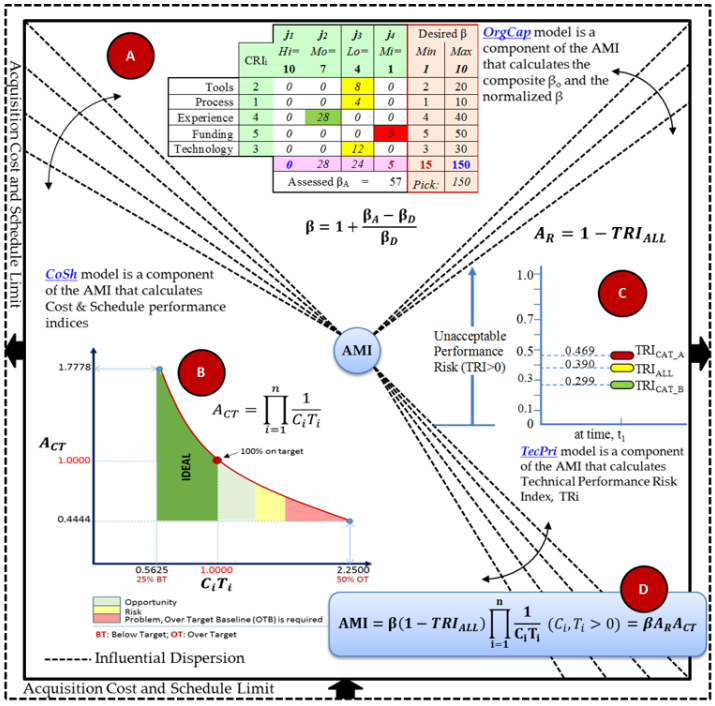


This process/method can be replicated for other functions of the PRT system.

Performance and Risk Analysis:

A full performance and risk analysis is beyond the scope of this student project, but the images below outline the methods to be used for performance and risk analysis.

- Cost Performance Index (CPI)
- Schedule Performance Index (SPI)
- Prioritised Risk List
- Ensure system scalability



CRI:		j_1 Hi= 10	j_2 Mo= 7	j_3 Lo= 4	j_4 Mi= 1	Desired β Min 1	Desired β Max 10
Tools	2	0	0	8	0	2	20
Process	1	0	0	4	0	1	10
Experience	4	0	28	0	0	4	40
Funding	5	0	0	0	5	5	50
Technology	3	0	0	12	0	3	30
		0	28	24	5	15	150
		Assessed β_A =		57		Pick:	150

FMEA- Threat Identification and Recommendations

Process Function	Failure Modes	Potential Effects	Sev	Class	Potential Cause	Occur	Current Control Process	Detect	RPN	Recommended Actions	Responsibility	Action Results				
												Action Taken	Sev	Occ	Det	RPN
Maintaining Magnetic flux density	- Pod Destabilizing - Departs from set trajectory - Increase or decrease in speed continuously	- Pod does not levitate - Pod rapidly accelerates/decelerates causing loss of control - Pod Crash in the tunnel	10	C	- Introduction of external Magnetism - Improper supply of electricity	3	Magnetic material detection before entry into the pod	5	150	- To eliminate small flux that escapes detection - Safety mechanism against change in flux	Mr. Fy	Coupled a flux stabilizing unit into the system to eliminate small interference Fail Safe Mechanism where the Pod stops operating when there is a difference in flux and gets ejected out of the loop	5	1	2	10

*Sev- Severity of the mode of failure[1-low, 10-high]
*Occ- Occurrence frequency of the mode of failure[1-low, 10-high]
*Detection- Detection capability of the failure mode[1- Easy detection, 10- Hard to detect]

RPN(Risk Priority Number(1-1000) = Sev x Occ x Det

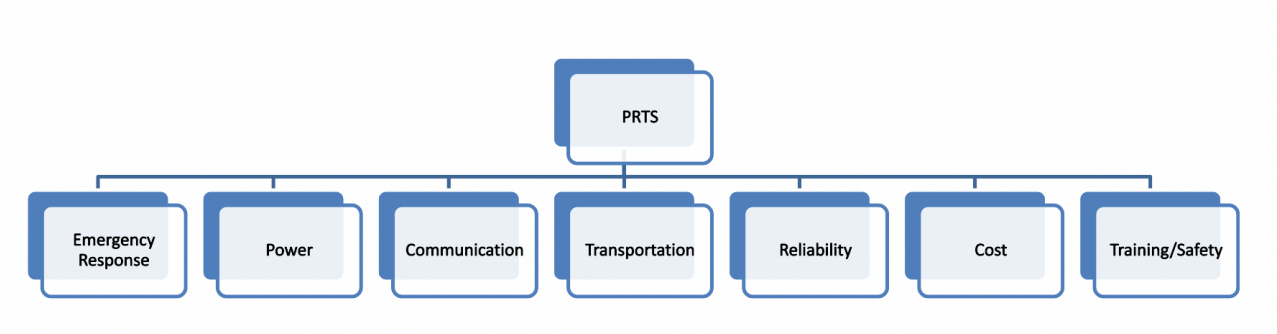
Document Architectures and Obtain Approval:

The functional, operational, and physical architectures of the PRT system are included in this report (sections 6.0, 8.0, and 10.0, respectively) at a high level. These architectures, along with the report, are to be submitted as a student project to Professor Dong on 5/3/2023.

Document Subsystem Specifications:

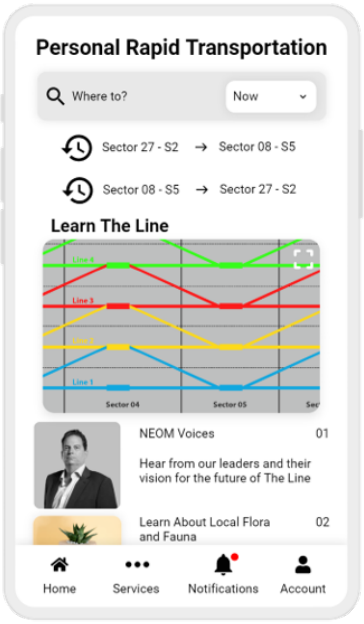
All system specifications are listed in the specification document. From this document, a specification document for each subsystem shall be produced (out of scope for this student project).

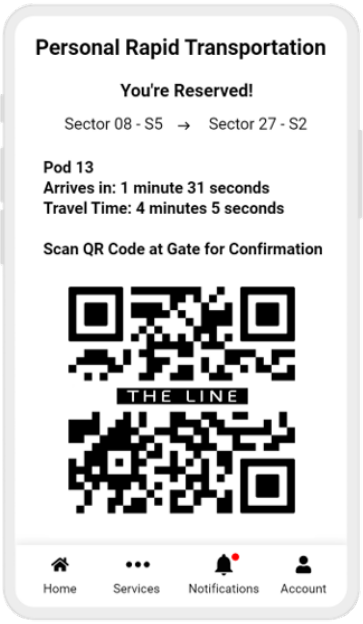
Operational Decomposition:

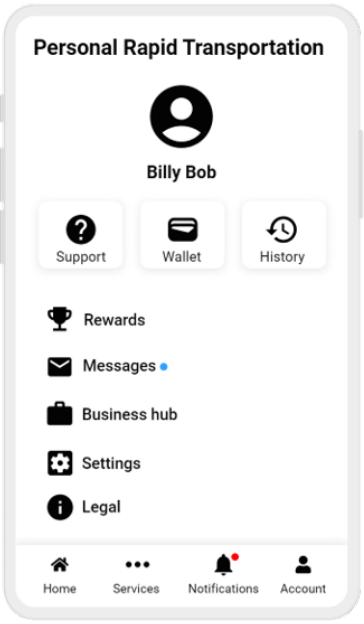


8.0 Interface Design

The design of the smartphone application is shown below. This, along with the website, is how users will reserve a ride on the PRT. It features destination selection, time selection, ride history, account information, ride confirmation, a map of the PRT, and more. This interface will allow users to have a streamlined experience when traveling throughout The Line.

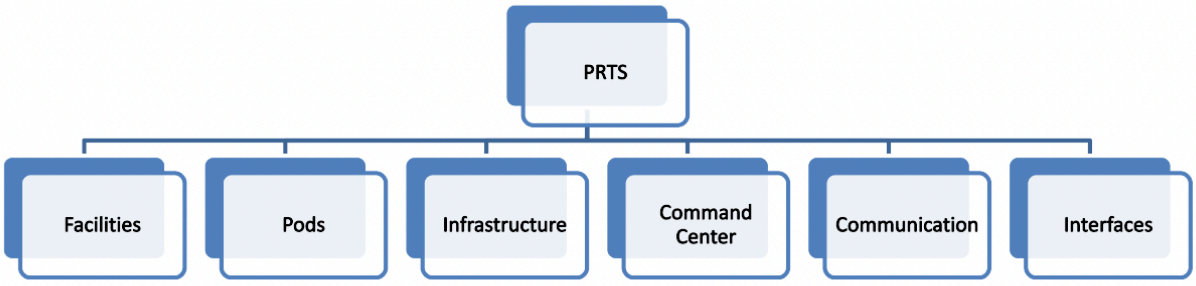






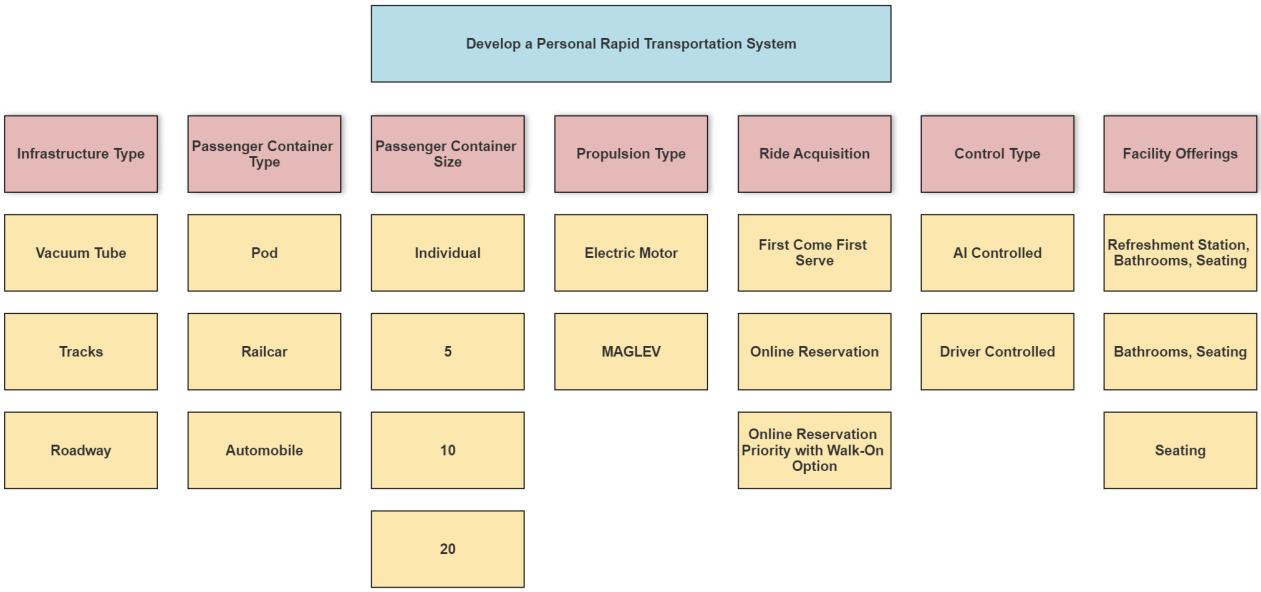
9.0 Physical Architectures Development

Physical Decomposition:



9.1 Morphological Analysis

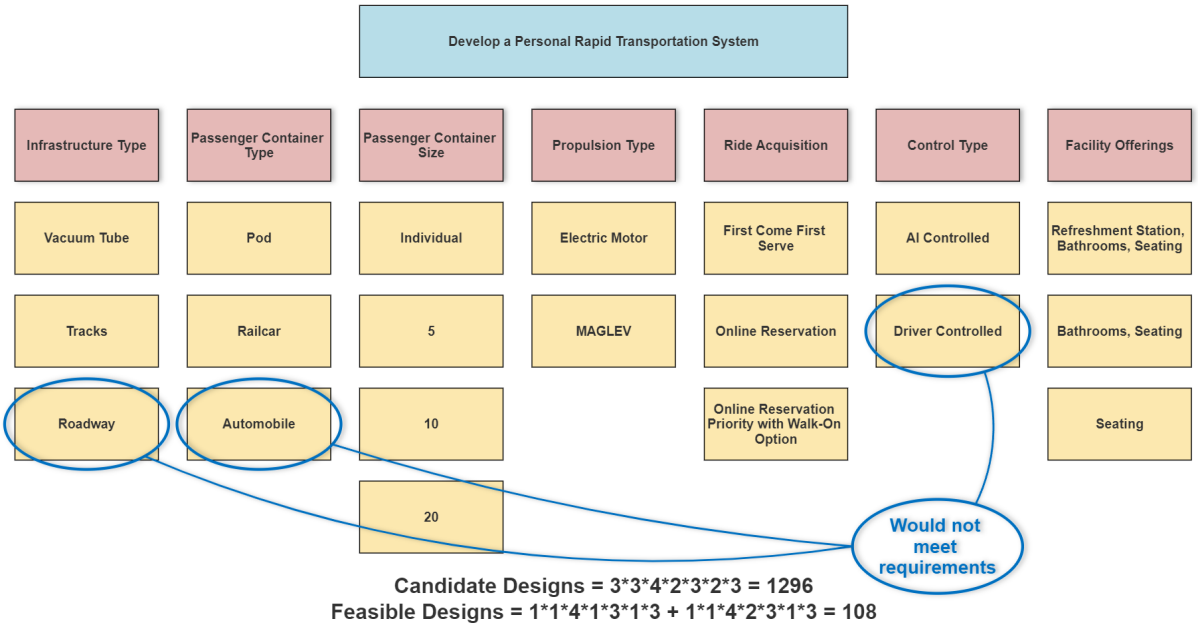
Below, the Morphological Analysis (or Morphological Box) is shown. This details each design choice considered before ultimately deciding. This type of analysis was used to investigate the complexities of the PRT that cannot be analyzed by formal mathematical methods.



Candidate Designs = 1296

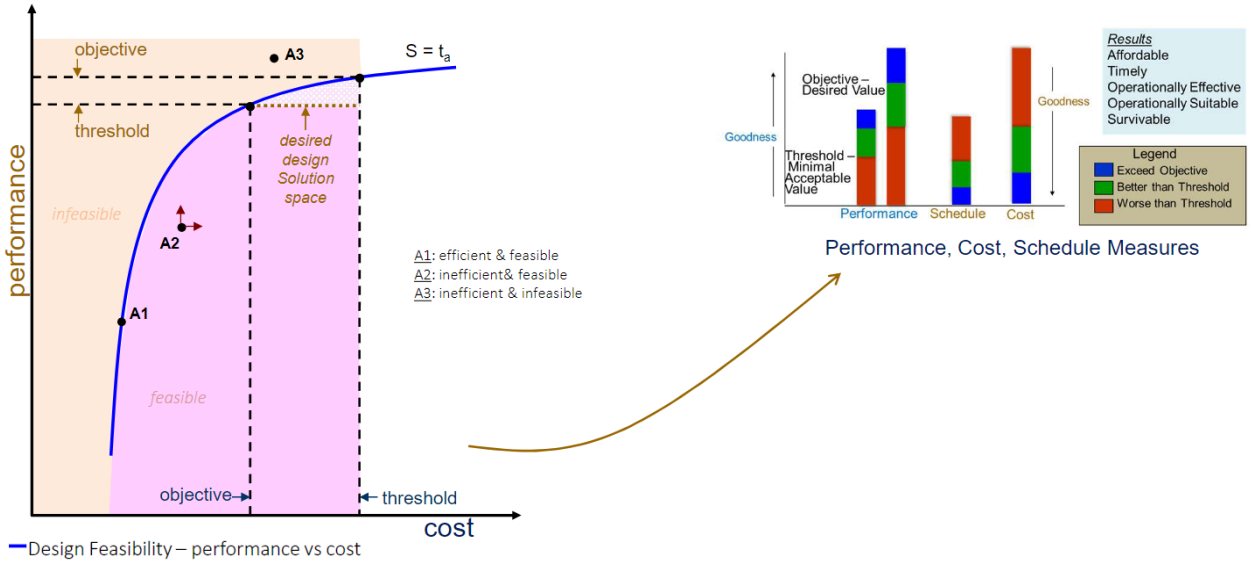
9.2 Feasibility Analysis

The Feasibility Analysis is conducted by investigating every candidate combination presented in the morphological box and deducing which configurations are most realistic with the highest probability of success. The expanded morphological box featuring feasible designs can be seen below.



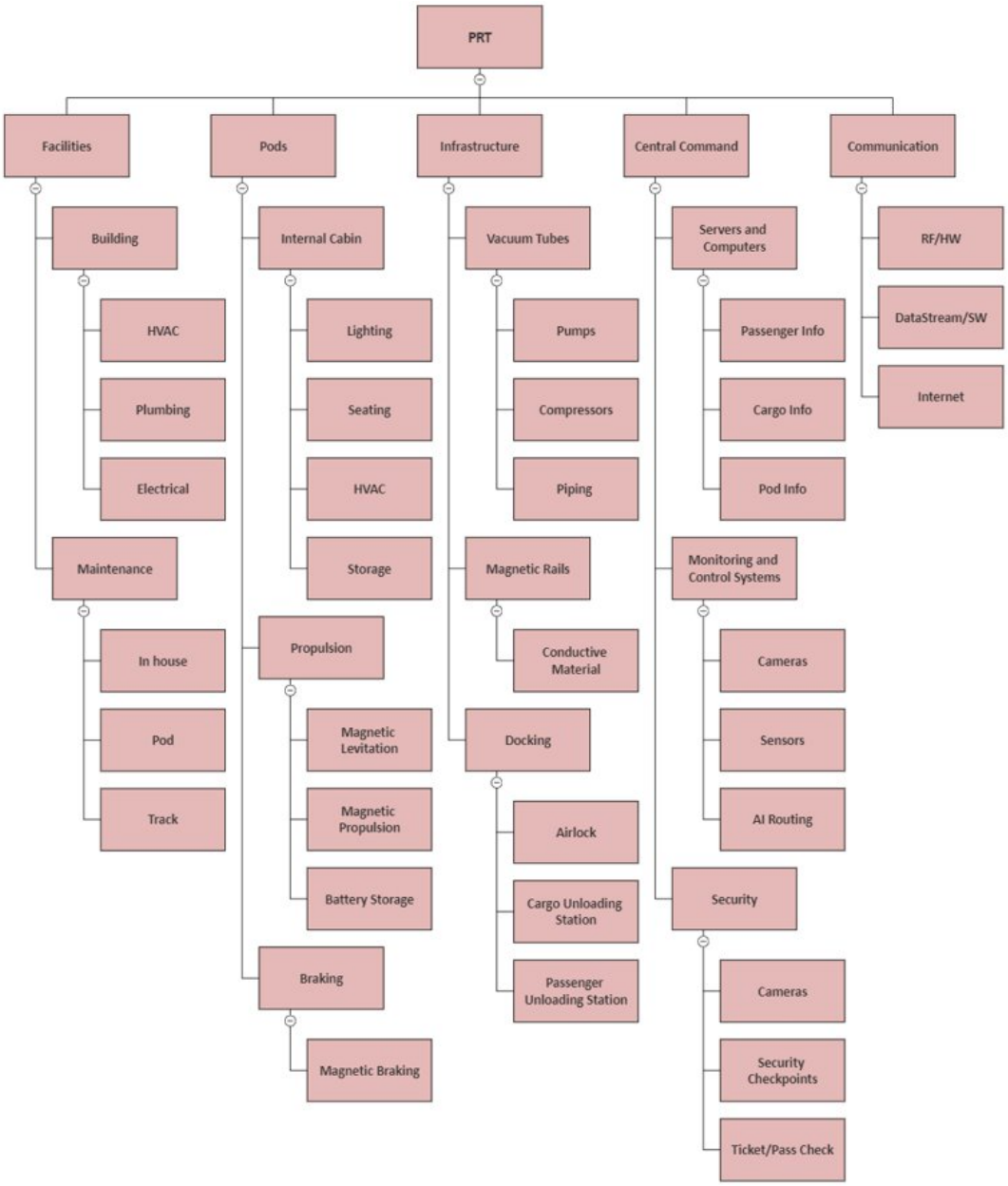
It should be noted that the design considerations circled in blue would not be able to travel fast enough and safe enough to meet the travel time, speed, and safety requirements. Thus, they must be removed from design consideration. It must also be noted that not every design consideration is compatible with one another. Considering this, the PRT is left with 108 feasible design options.

Once each design consideration's performance is measured and cost calculated, they can be analyzed in the plot below to determine the most desirable design.

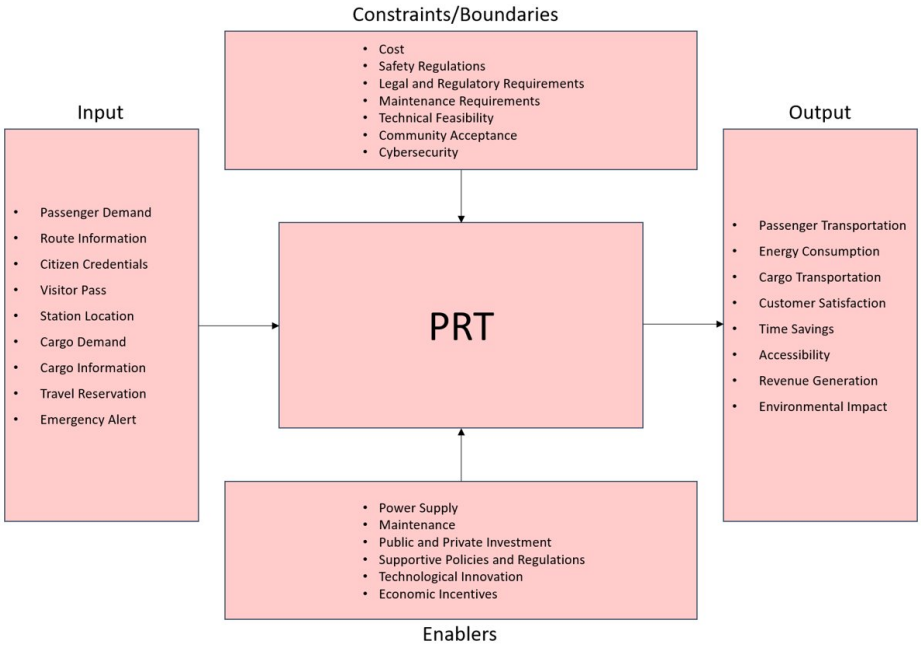


9.3 Physical Architecture

The physical architecture of the PRTS is the organization and arrangement of its physical components. It can be broken down into five main components: Facilities, Pods, Infrastructure, Central Command, and Communication. These components can then be broken down into more components, and so on. Below is a breakdown of the third level of the PRTS's physical architecture.



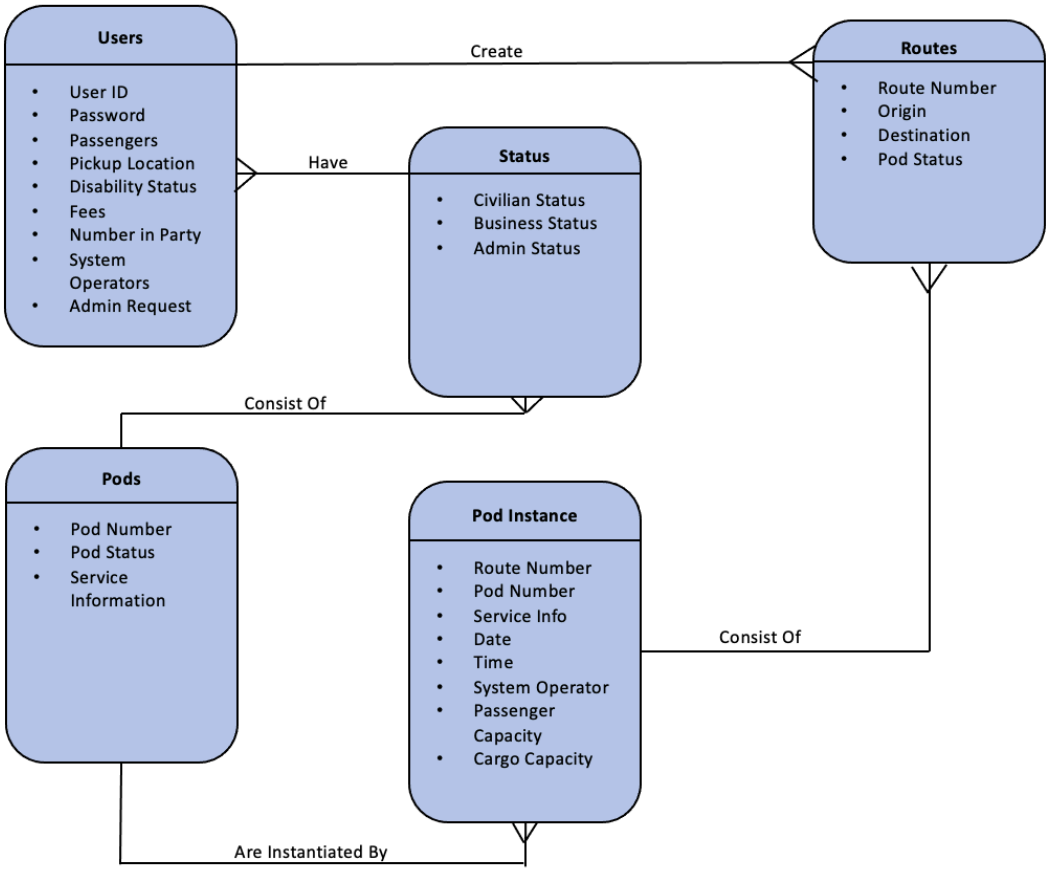
10.0 Context Diagram, OV-5



11.0 Data Model

11.1 Entity Relationship Diagram (ERD)

The entity relationship diagram depicts relationships between people, things, and events within a system. For the PRT system, we observe how users have different standings/titles and are able to utilize the PRT in different ways. The diagram also depicts how routes consist of individual pod units, and these pods are represented by their instances.



12.0 Operational Scenarios

For the detailed scenarios, we will be focusing on use cases targeted toward the front end of the system. This will include specific cases involving the users of the pods and the web-based / application system. This will be consistent with the activity diagrams and the sequence diagrams as well in sections 13 and 14 of this document.

12.1 Normal Scenario 1 – User Authentication - Validate User Identity

Use Case: Validate user identity	
ID: UC1	
Actors: 1. User 2. User database	
Preconditions: Web-based / application system is online and available for use.	
Flow of Events:	
Actor Action	**System Action**

1. The use case starts when user enters their user ID and password	
	2. The TOS accepts user input.
	3. The TOS connects to the user database to verify the password is correct, and the user has an account.
	4. The TOS authenticates information and takes the user to their home page.
5. The user acknowledges they have been logged in and clicks on function of interest.	
Secondary Scenarios: • User enters wrong ID and/or password	
Post conditions: The TOS is ready for the next input item from user.	

12.2 Normal Scenario 2a - Request a Ride - Verify User's Eligibility to Request a Ride

Use Case: Verify user's eligibility to request a ride	
ID: UC1b	
Actors: 1. User 2. User database	
Preconditions: Web-based / application system has validated user id/password, and user has successfully logged in.	
Flow of Events:	
Actor Action	**System Action**
1. The use case starts when the user selects "Request a Ride."	
	2. The TOS acknowledges input.
	3. The TOS connects to User database and checks the financial status of the user to verify that all fees have been paid.
	4. The TOS also verifies that the payment method is entered and secure.
	5. The TOS displays message about user's ability to request a ride
6. The user logs off when he/she is finished.	
Secondary Scenarios: • The TOS application is undergoing maintenance and is unavailable • The TOS web-based platform is undergoing maintenance and is unavailable • The TOS is unable to connect to the User database • The User database is undergoing maintenance and is unavailable	
Post conditions:	

The TOS is ready for the next user to log in (or same user may log in again).

12.3 Normal Scenario 2b - Request a Ride - Display Ride Information (type, location, and capacity status)

Use Case: Display ride information (type, location, and capacity status)	
ID: UC2	
Actors: 1. User 2. Pod database	
Preconditions: Web-based / application system has validated user id/password, and user has successfully logged in.	
Flow of Events:	
Actor Action	**System Action**
1. The use case starts when the user requests a ride and inputs preferred pickup and drop-off location.	
	2. The TOS acknowledges user input.
	3. The TOS connects to Pod database and displays pod types.
4. The user selects the pod of interest.	
	5. The TOS displays estimated arrival time, duration time, and cost for selected pod.
6. The user clicks on ride information	
	7. The TOS shows how many seats are taken for the selected pod.
	8. The TOS also shows the anticipated number of stops for the pod.
9. The user deselects the pod and browses other alternatives.	
10. The user logs off when he/she is finished.	
Secondary Scenarios: • User sees data while pod is not at capacity but selects pod after it reaches capacity, sending user back to previous page. • The TOS does not recognize the location that the user enters.	
Post conditions: The TOS is ready for the next user to log in (or same user may log in again).	

12.4 Normal Scenario 3 – User Adds Stop to Ride

Use Case: User adds stop to their ride
ID: UC3

Actors: 1. User 2. Pod database	
Preconditions: Web-based / application system has validated user id/password, and user has successfully logged in. User has already requested a ride.	
Flow of Events:	
Actor Action	**System Action**
1. The use case starts when a user selects “Add Stop” option.	
	2. The TOS accepts user input.
	3. The TOS connects to Pod database and displays ride information, including potential stop locations.
4. User selects location to add to ride.	
	5. The TOS ensures the stop is on route and compatible with the original ride request.
	6. The TOS validates that the stop is not a duplicate for the pod. The TOS returns a confirmation check with the user.
7. The user acknowledges the question and selects “Yes” to add stop.	
	8. The TOS acknowledges user input and adds the stop to the pod’s route.
	9. The TOS displays the user’s new route information with the added stop.
10. User proceeds with next input.	
Secondary Scenarios: • Stop is already part of the route of the pod, so the stop does not need to be added. • User is handling ride requests for a group that needs to make additional stops.	
Post conditions: The TOS is ready for the next input item from user.	

12.5 Normal Scenario 4 - User Cancels Ride

Use Case: User cancels their ride	
ID: UC4	
Actors: 1. User 2. Pod database	
Preconditions: Web-based / application system has validated user id/password, and user has successfully logged in. User has already requested a ride.	
Flow of Events:	
Actor Action	**System Action**

1. The use case starts when a user selects “Cancel Ride” option	
	2. The TOS accepts user input.
	3. The TOS locates ride ID and returns confirmation check to the user.
5. The student acknowledges the question and selects “Yes” to cancel the ride.	
	7. The TOS acknowledges user input and deletes the ride request from the pod database.
	8. The TOS displays the confirmation message.
9. User proceeds with next input.	
Secondary Scenarios: • User wants to change the time of the ride. • User wants to change the pickup location of the ride. • User decides they want to go to the same location but with a different pod style.	
Post conditions: The TOS is ready for the next input item from user.	

12.6 Normal Scenario 5 - Perform User Account Maintenance

Use Case: Perform user account maintenance	
ID: UC5	
Actors: 1. User 2. User database	
Preconditions: Web-based / application system has validated user id/password, and user has successfully logged in.	
Flow of Events:	
Actor Action	**System Action**
1. The use case starts when user is on their home page.	
2. User selects option to change their password.	
	3. The TOS acknowledges request and displays screen for password change instructions.
	4. The TOS requests user to enter new password.
5. User enters new password.	
	6. The TOS links to User database and checks password to verify it meets criteria - not used in previous 10 passwords, at least 8 characters, 1 character must be a special character, and 1 must be a number.
	7. The TOS acknowledges password is acceptable.
	8. The TOS asks user to re-enter new password.
9. User re-enters new password.	
	10. The TOS confirms re-entry of password matches first entry of password.
	11. The TOS changes password and notifies User database.
12. User selects other maintenance option.	
Secondary Scenarios: • User decides they want a different password and repeats the process. • User wants to change their home location/station. • User wants to update their name. • User wants to change their payment method.	
Post conditions: The TOS is ready for the next input item from user.	

12.7 Normal Scenario 6 - Validate User Pickup

Use Case: Validate user pickup	
ID: UC7	
Actors: 1. User 2. Pod database	
Preconditions: Web-based / application system is online and available for use. User has requested a ride.	
Flow of Events:	
Actor Action	**System Action**
1. The use case starts when user enters selected pod.	
2. User scans QR code to verify the pickup.	
	3. The TOS system reads the input from the user.
	4. The TOS system matches the pod ID with the user's ride request and updates status in the pod database.
	5. The TOS returns confirmation message of pickup.
6. The user acknowledges they have been picked up.	
Secondary Scenarios: • User enters wrong pod and scans unmatching QR code.	
Post conditions: The Pod departs towards the user's location of choice.	

12.8 Abnormal Scenario 1 - The TOS Does Not Recognize Location That the User Submits

Use Case: Display ride information (type, location, and capacity status) **Secondary Scenario**: The TOS does not recognize the location that the user submits.	
ID: AUC1	
Actors: 1. User 2. Pod database	
Preconditions: User is logged in and has requested a ride.	
Flow of Events:	
Actor Action	**System Action**
1. The use case starts when the user enters the location of interest when requesting a ride.	
	2. The TOS is unable to find the entered location name.

	3. The TOS displays message that it is unable to find the entered location.
4. User re-enters location name.	
	5. The TOS is still unable to find the location and offers a map option to find close location alternatives.
6. Student clicks to open the map.	
	7. The TOS displays map of the line with potential locations.
8. User selects location for ride drop-off.	
	9. The scenario now follows the path at step 2 in the normal scenario
Post conditions: User requests ride with valid location.	

12.9 Abnormal Scenario 2 – User Enters Wrong ID and/or Password

Use Case: Validate user identity **Secondary Scenario**: User enters wrong ID and/or password	
ID: AUC2	
Actors: 1. User 2. User database	
Preconditions: Web-based / application system is online and available for use.	
Flow of Events:	
Actor Action	**System Action**
	1. The use case starts at step 3 of the normal scenario when the TOS connects to the User database.
	2. The TOS acknowledges either the user ID or the password is wrong.
	3. The TOS displays an error message and tells the user the ID and/or the password submitted was wrong and to re-enter it.
4. The user reads the message and re-enters the ID and password.	
	5. The use case starts again with step 3 in the normal scenario.
Post conditions: • The TOS is ready for the next input from the user.	

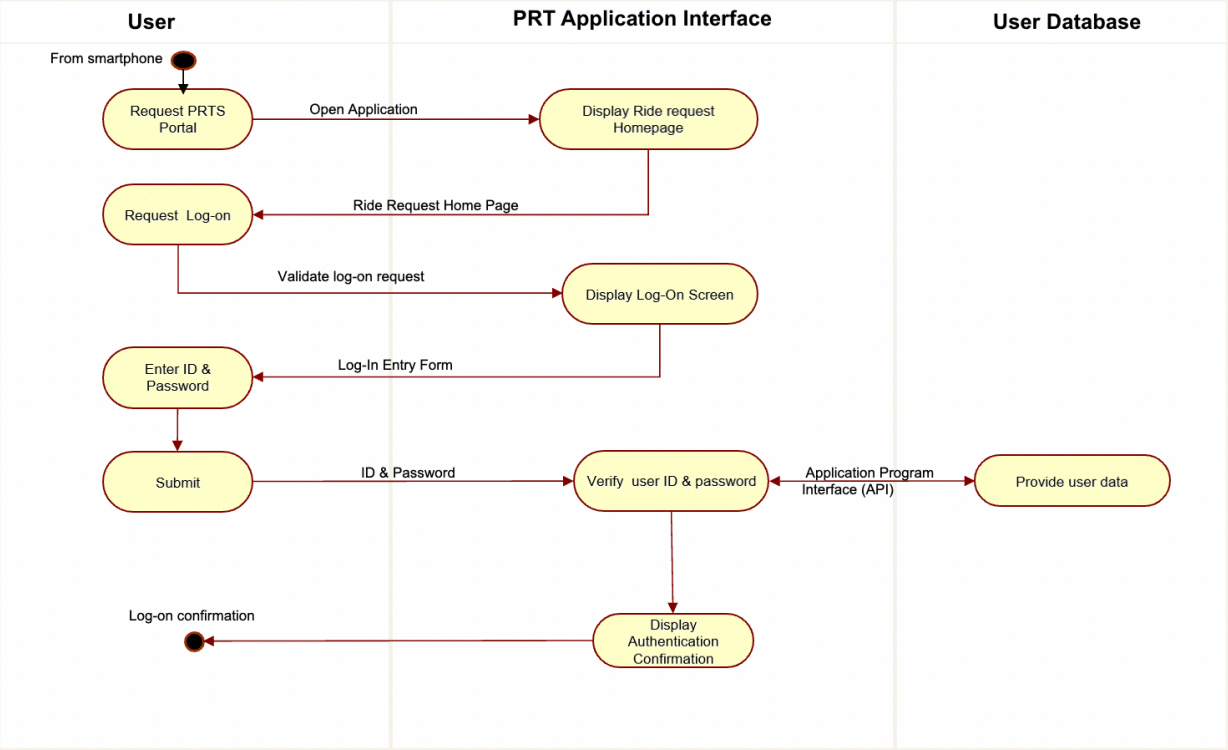
12.10 Misuse Scenario 1 - Hacker Tries to Log In

Misuse Case: Hacker tries to log in to obtain user credit card information	
ID: MUC1	
Actors: 1. Hacker 2. User 3. System Administrator	
Preconditions: User is logged in.	
Flow of Events:	
Actor Action	**System Action**
1. The misuse case begins when a hacker sends a pop-up message, posing as the System administrator and asking user to submit their password for account maintenance.	

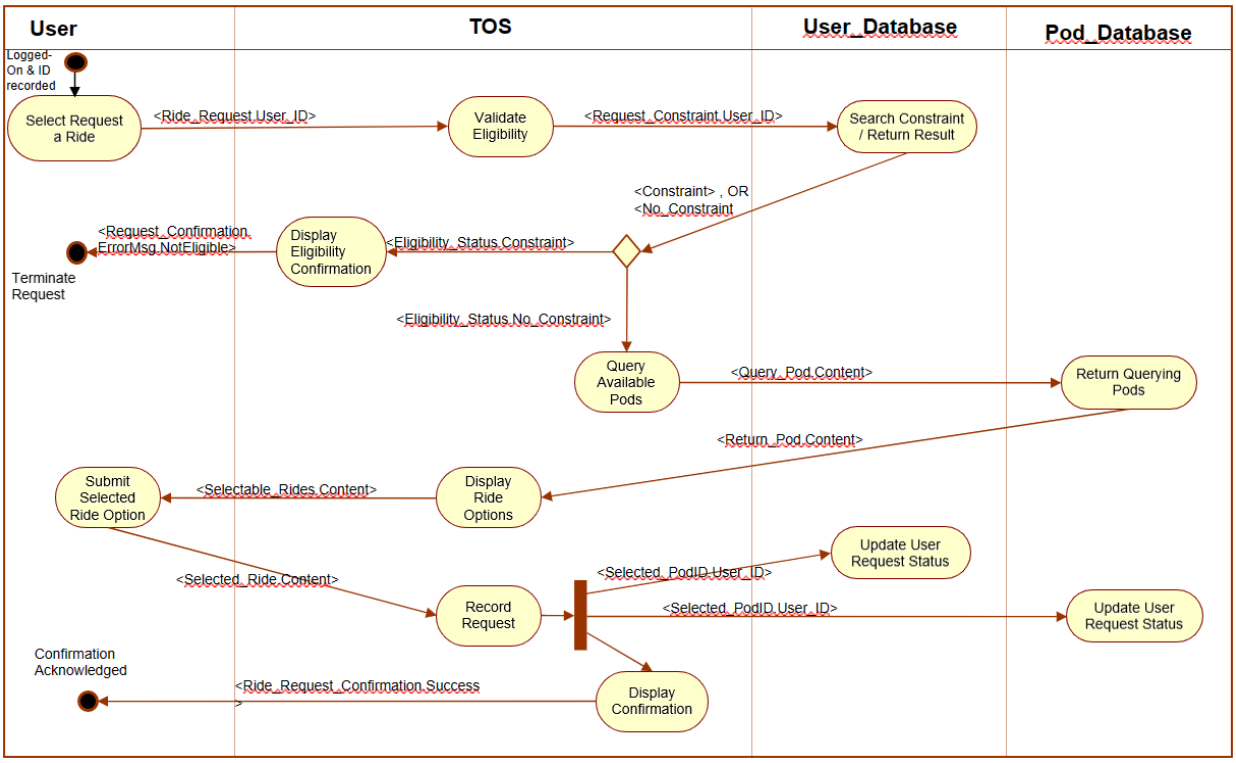
	2. The TOS has an automatic pop-up sensor and displays a warning to user never to give out personal information.
3. User acknowledges warning and closes pop-up.	
4. After user finishes session, reports incident to online System administrator.	
	5. The TOS acknowledges incident report.
Secondary Scenarios: • User logs off as soon as warning is displayed.	
Post conditions: • The TOS continues to process incident reports in an effort to improve online security.	

13.0 Activity Diagrams

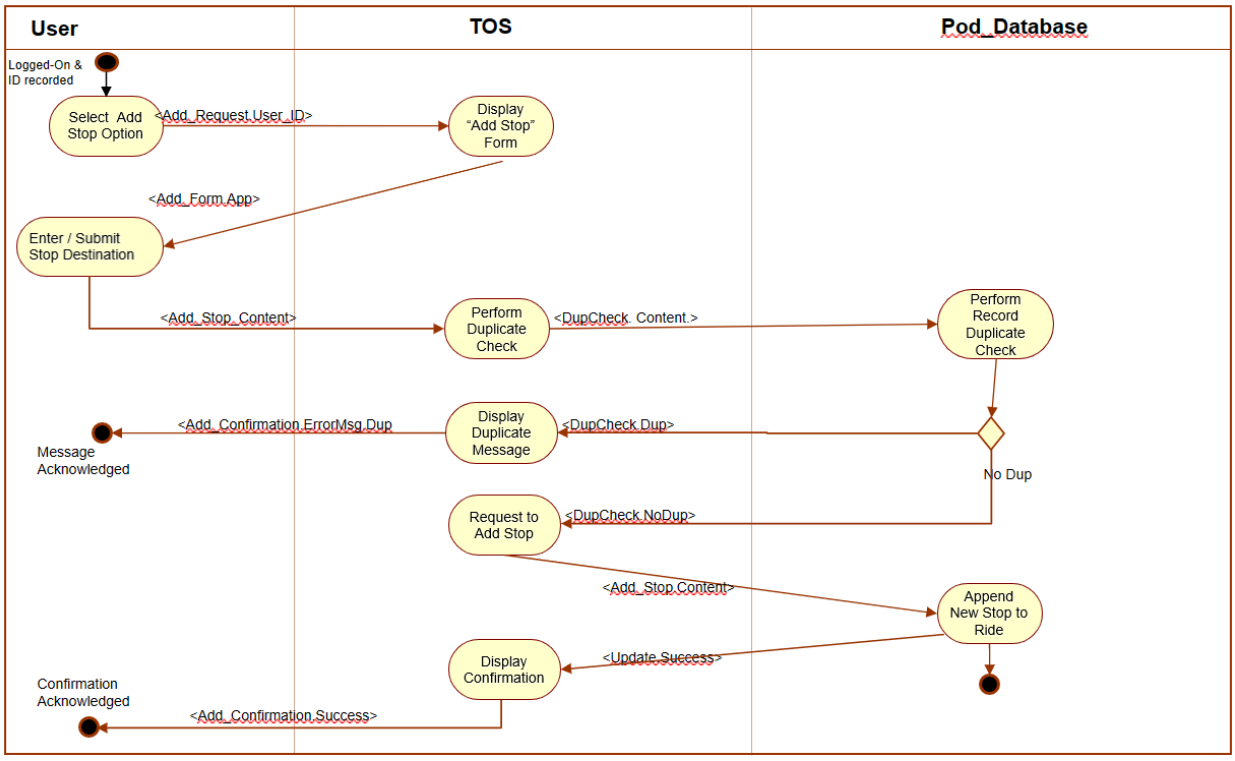
13.1 Normal Scenario 1 – User Authentication



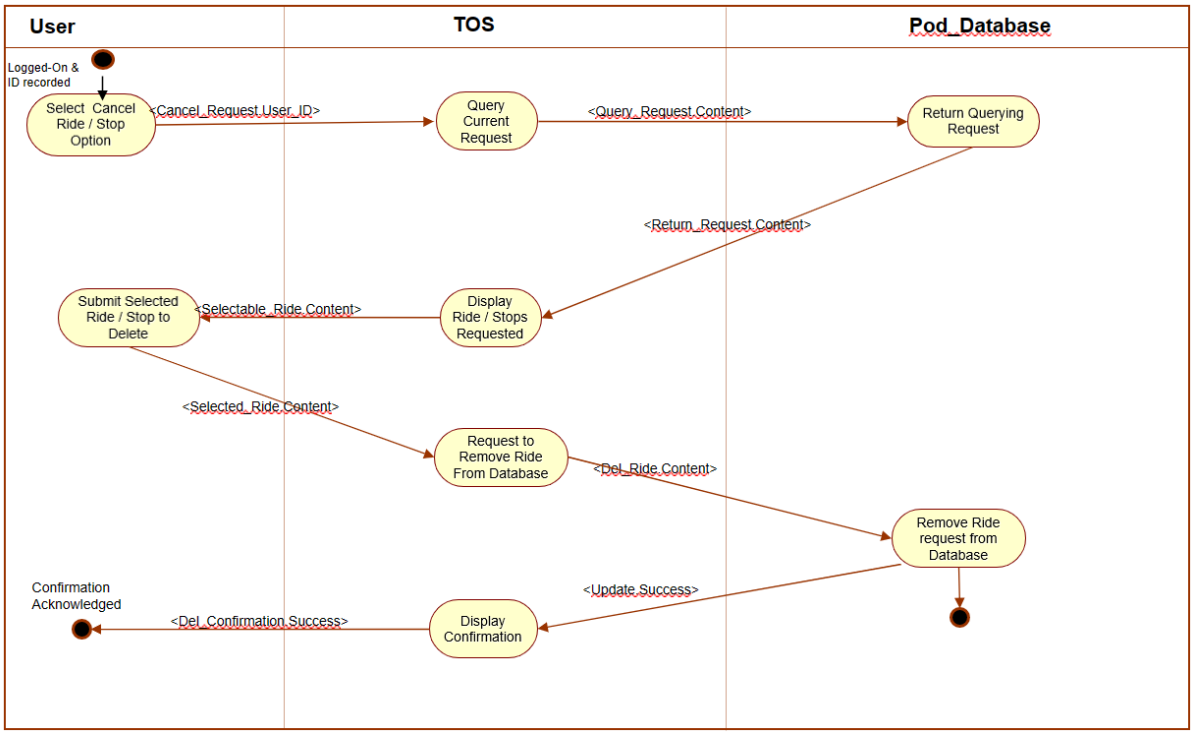
13.2 Normal Scenario 2 – Request a Ride



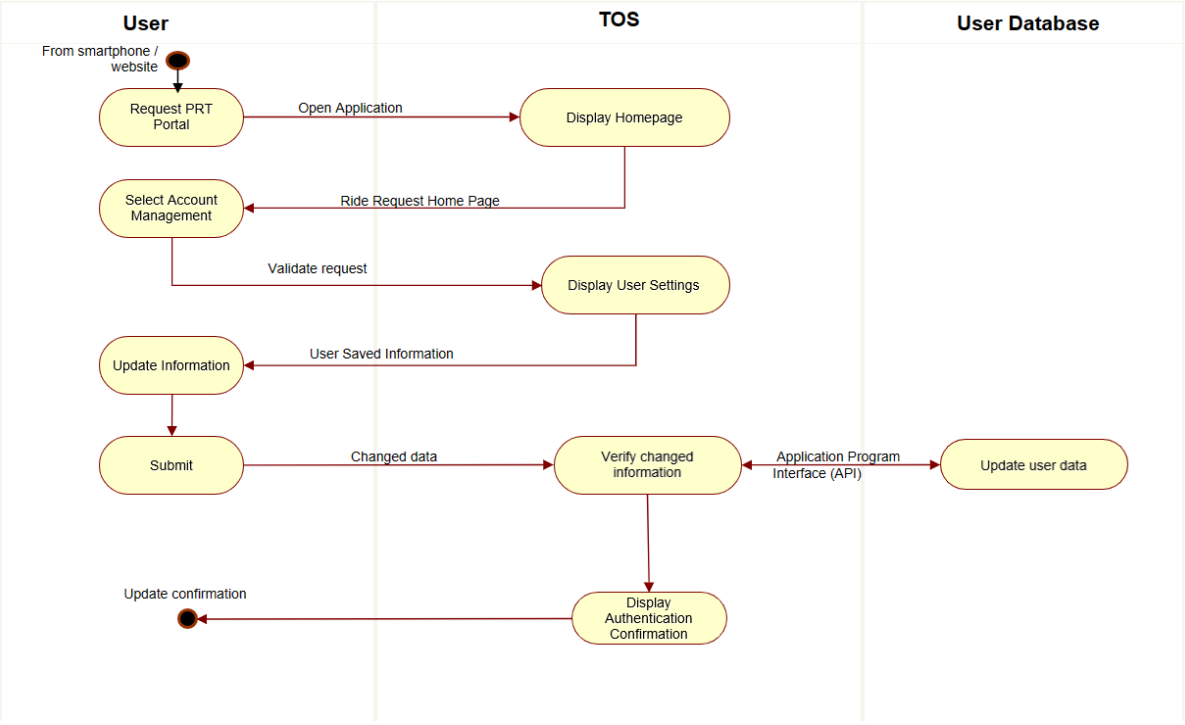
13.3 Normal Scenario 3 – Add Stop



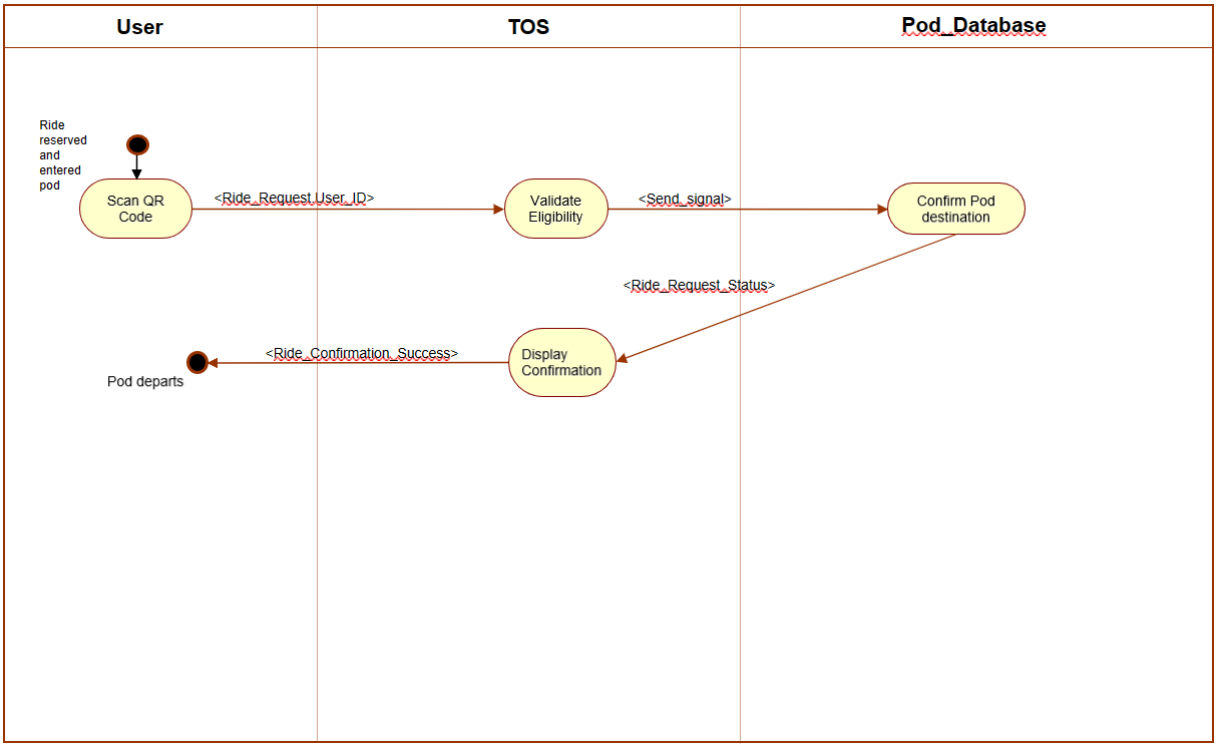
13.4 Normal Scenario 4 – Cancel Ride



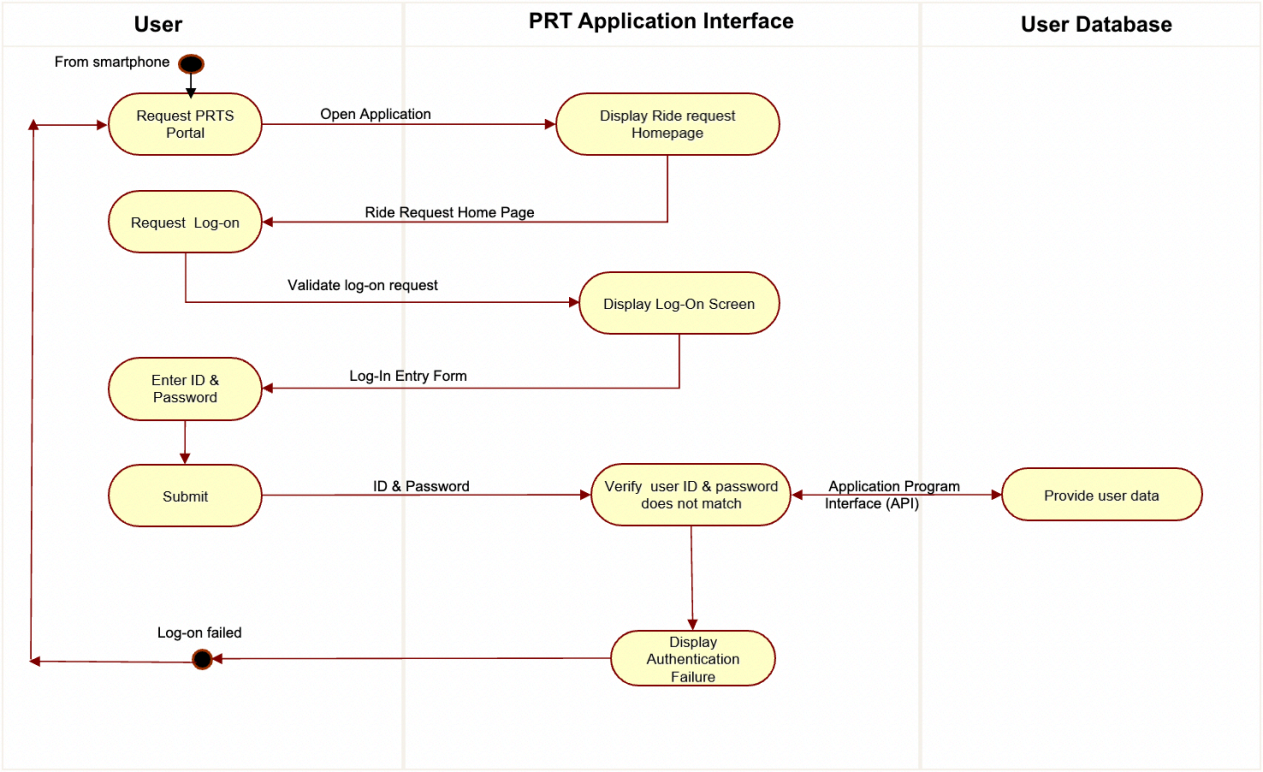
13.5 Normal Scenario 5 – User Account Management



13.6 Normal Scenario 6 – Validate Ride Pickup

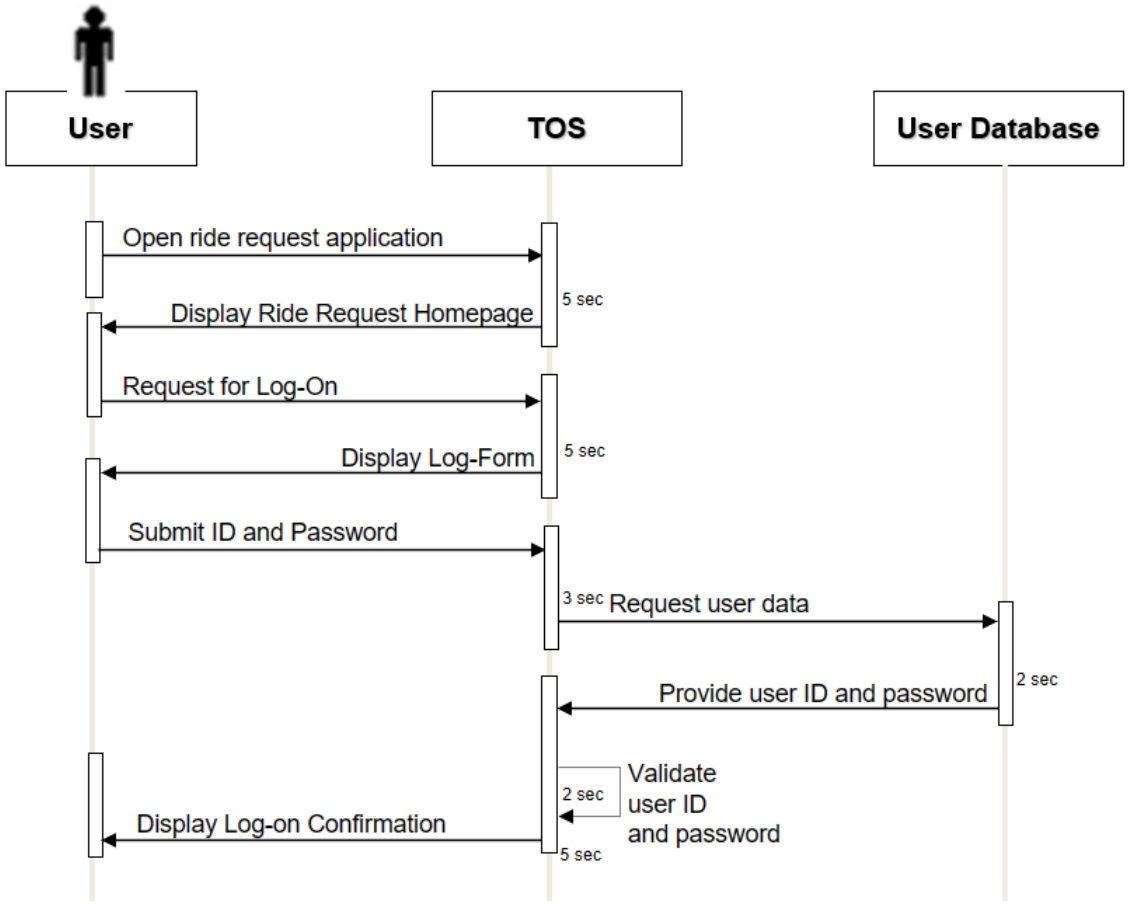


13.7 Abnormal Scenario 2 – User provides Invalid Username and/or Password



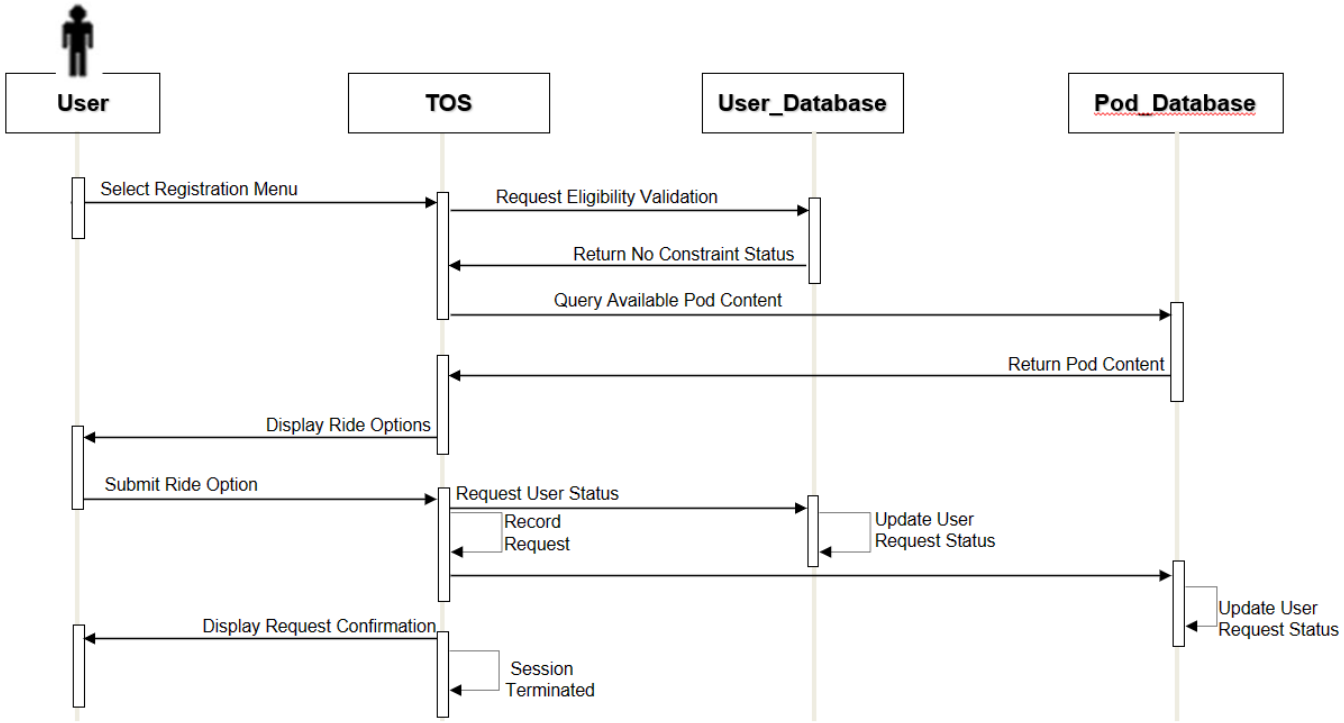
14.0 Sequence Diagrams

14.1 Normal Scenario 1 – User Authentication (No Timeline)



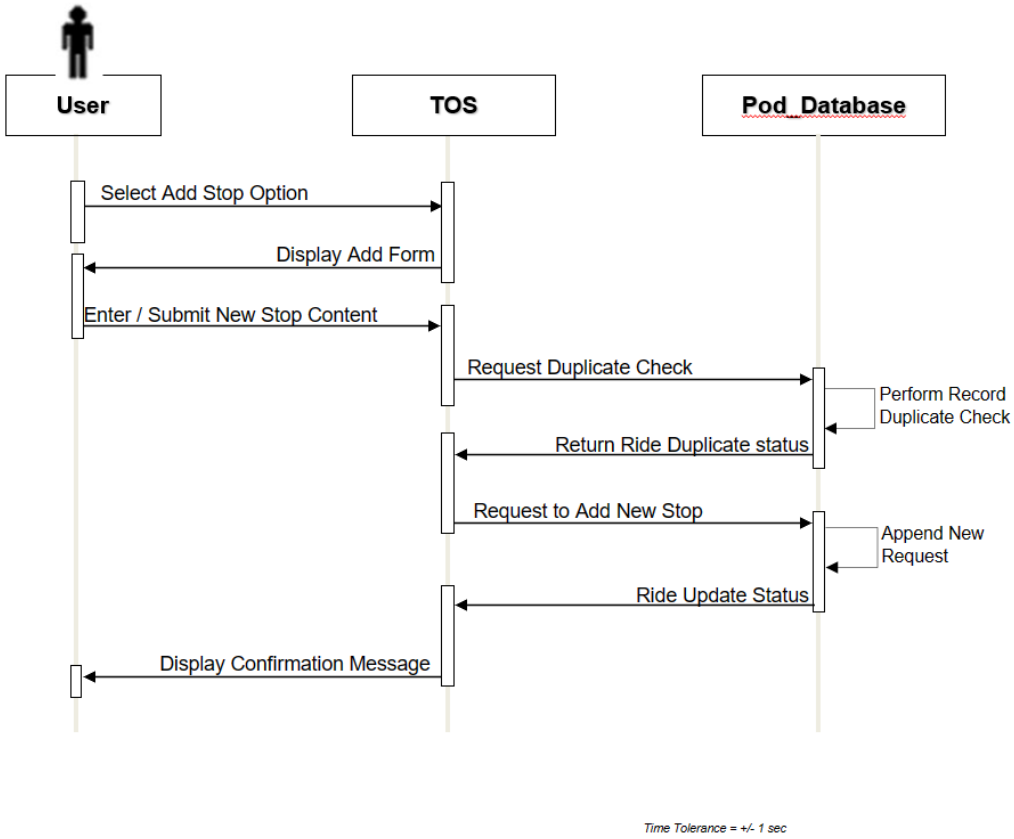
Time Tolerance = +/- 1 sec

14.2 Normal Scenario 2 – Request a Ride

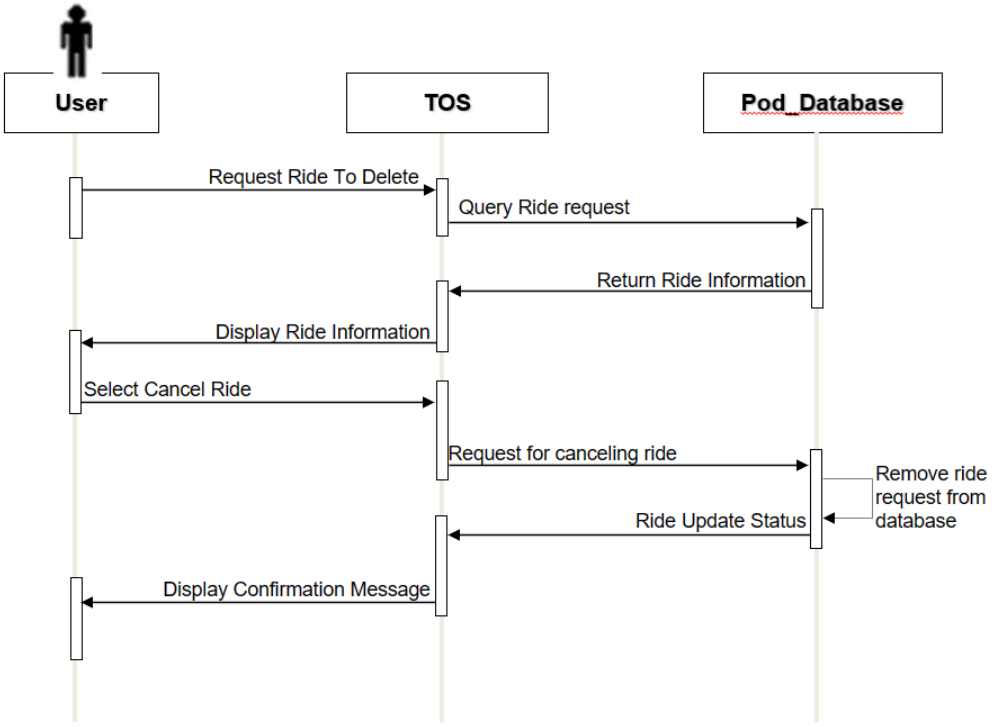


Time Tolerance = +/- 1 sec

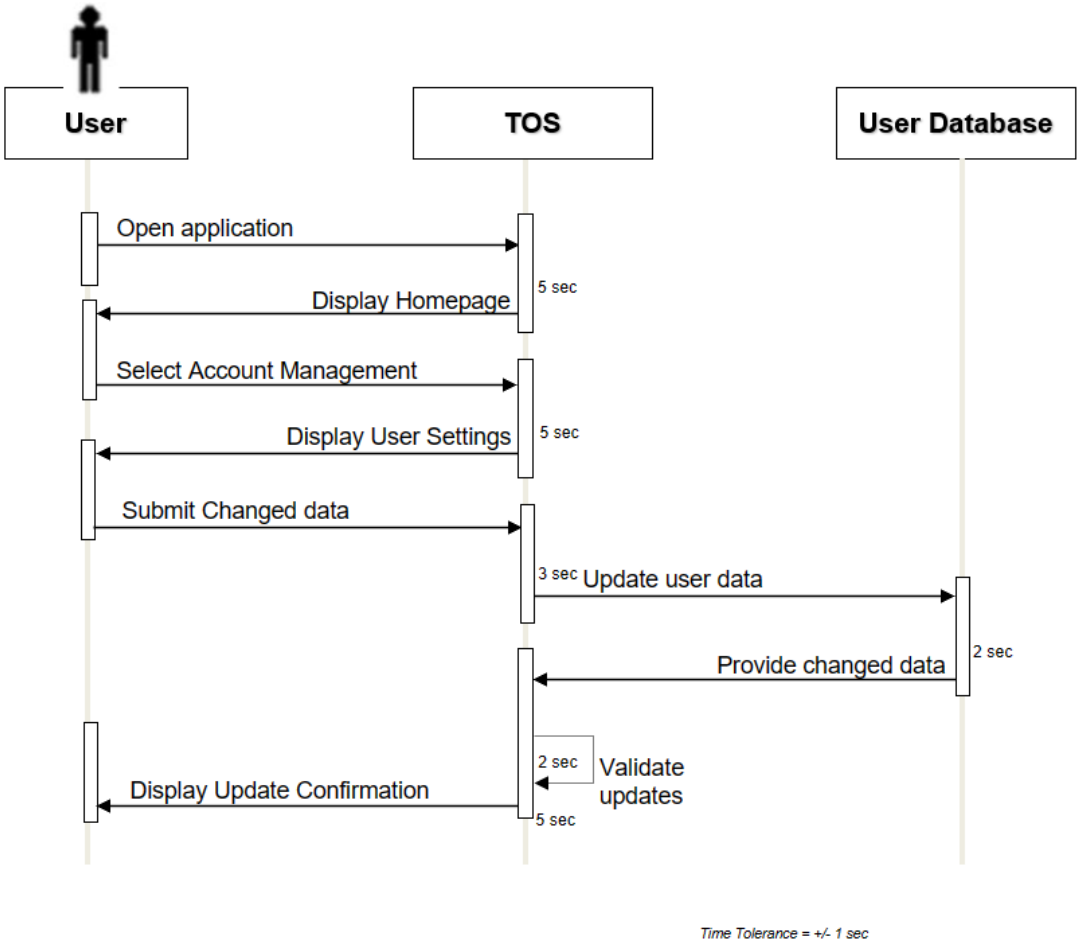
14.3 Normal Scenario 3 – Add Stop



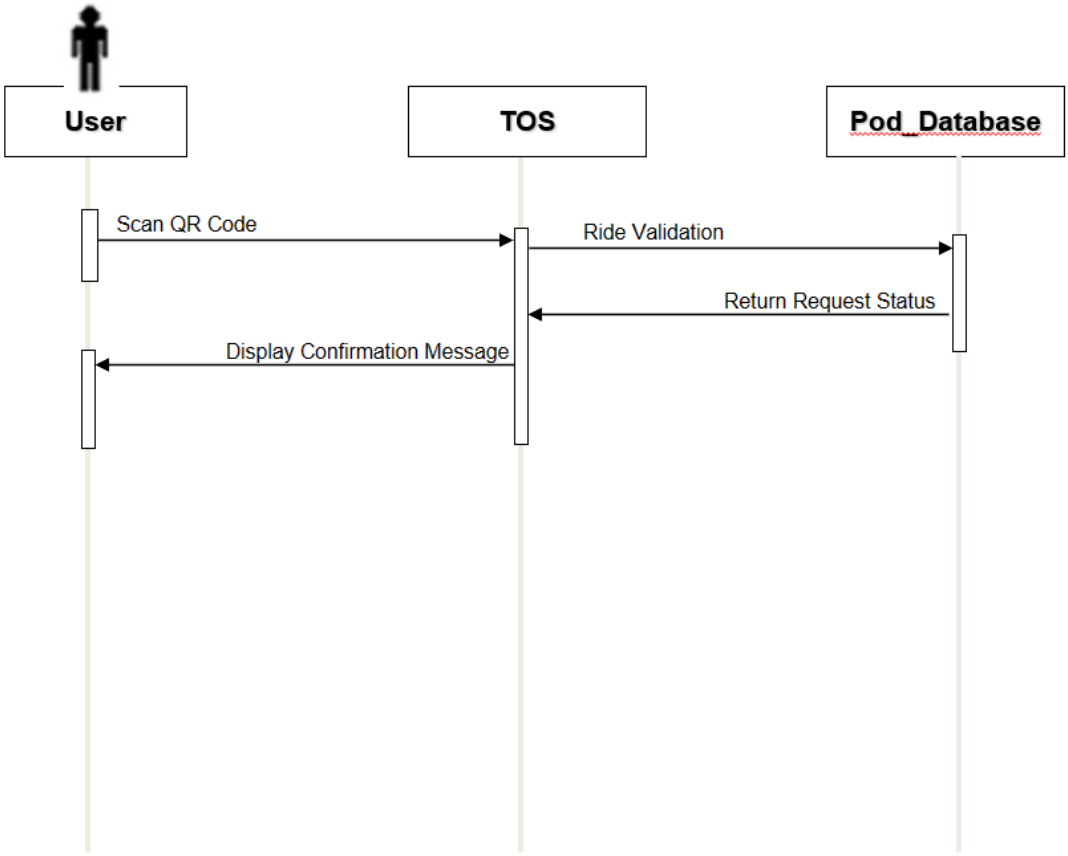
14.4 Normal Scenario 4 – Cancel Ride



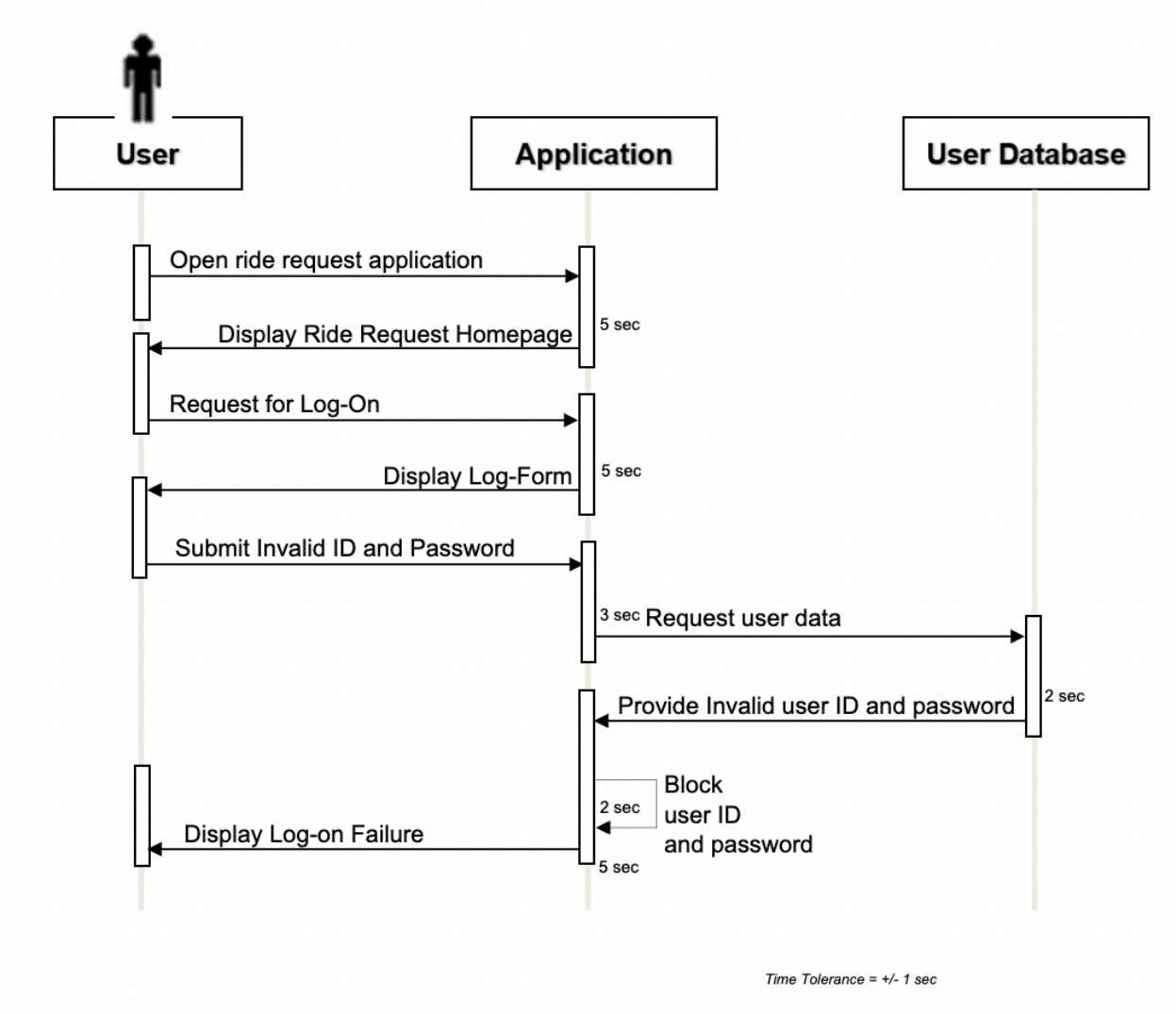
14.5 Normal Scenario 5 – User Account Management



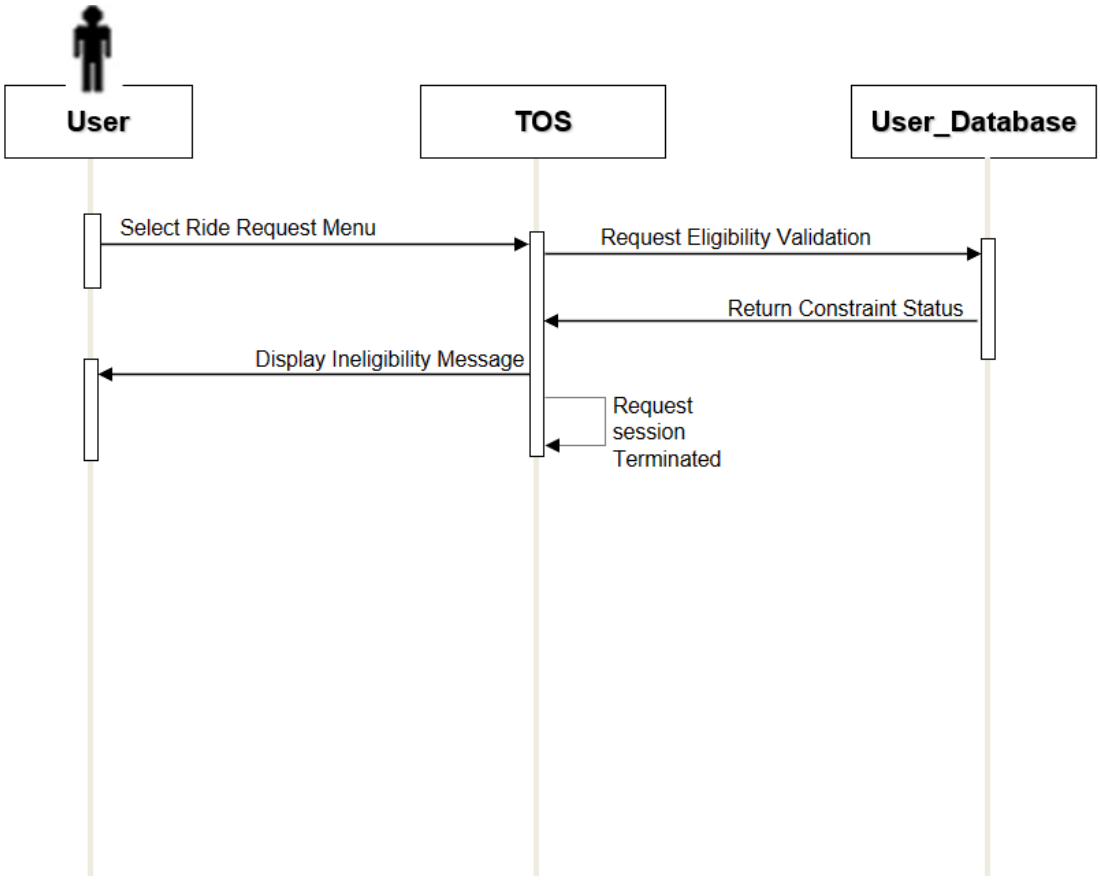
14.6 Normal Scenario 6 – Validate Ride Pickup



14.3 Abnormal Scenario 2 – User Provides Invalid User ID and/or Password



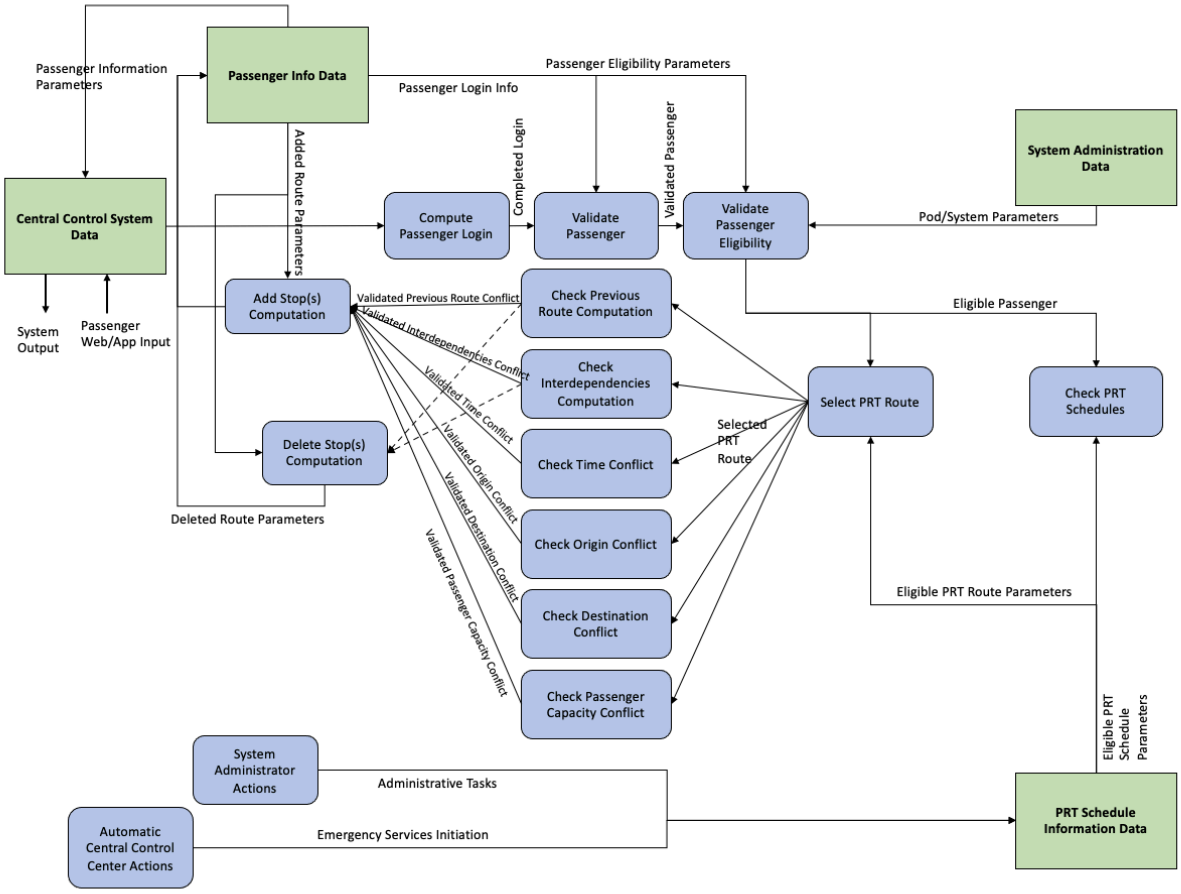
14.4 Abnormal Scenario 3– User Account Has Constraint



Time Tolerance = +/- 1 sec

15.0 Data Flow Diagram

The Data Flow Diagram shows the visual flow of information within the PRT system. The diagram depicts relationships between data and their instances and the information flow between the two. For the sake of the diagram below, we are tracing the flow of passenger information throughout the PRT, assuming the user is a civilian rider. The flow would be the same for business and admin users, with different capacity limits.



16.0 Sequence Enumeration

16.1 Assumptions

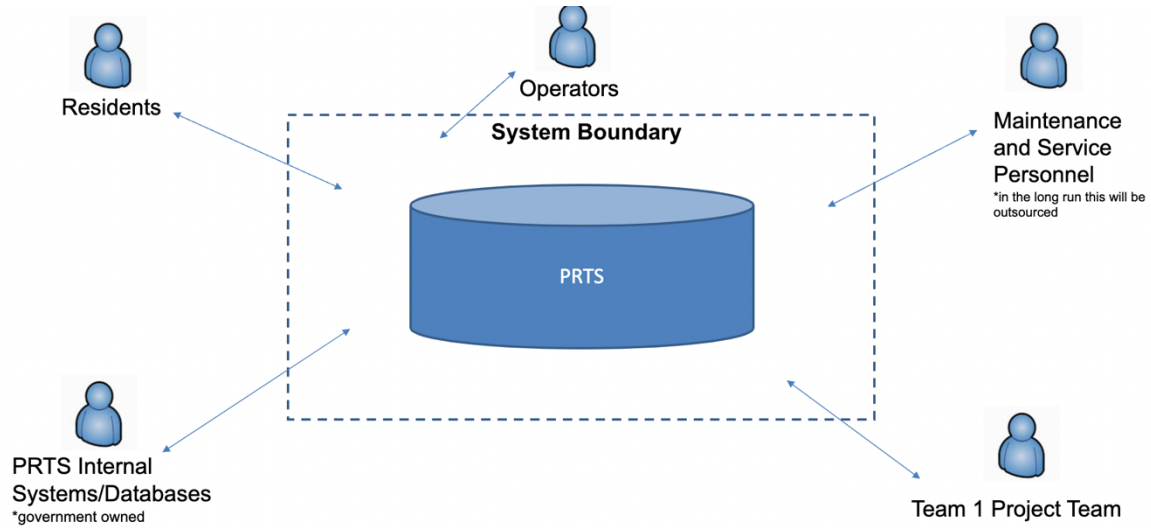
The user must have a connection to the internet, and the TOS is up and running.

Note that the user must log in before he/she can log out.

Stimuli	Responses
Bad Login Request = B	Access Denied
Good Login Request = G	Access Granted
Valid Ride Request = V	Ride Request Completed
Invalid Ride Request = I	Ride Request Denied
Operator Valid Command = Y	Operator Command Completed
Operator Invalid Command = N	Operator Command Denied

Log-out request = O	System Log OUT

16.2 System Boundary



17.0 Functional Requirements

Req ID	Description
	1. User Authentication - Use Case
Title	The system shall control the authentication, creation, and usage of user accounts and their criteria:
FR 1.1	1. The system shall verify if the entered user ID and password can be permitted to use the PRT
FR 1.2	2. The system shall retrieve data from the data center to check the validity of the user.
FR 1.3	3. The system shall allow/deny user access to the PRT with respect to the database.
FR 1.4	4. The system shall display the corresponding information along with the details to the user.
FR 1.5	5. On access, the system shall allow the user to enter the homepage to book a ride; otherwise, the user shall be asked to resolve the shown error.
Req ID	**Description**
	2. Request a Ride - Use Case
Title	The system shall provide the functionality for all users to reserve a ride along with additional information regarding the travel (see below):
FR 2.1	1. The system shall prompt the user to enter the ride details, such as destination, stops, and departure time.
FR 2.2	2. The system shall verify if the request can be completed depending on the user eligibility and availability of the pods.
FR 2.3	3. On confirmation, the system shall display all the travel options to the entered destination along with their attributes, such as the quickest, most comfortable, special pods, etc.
FR 2.4	4. The system shall confirm the booking as per the user's preference and reserve the seat.
FR 2.5	5. On ineligibility to complete the request due to user/system constraints, the system shall terminate the ongoing session after displaying the respective error.
Req ID	**Description**
	3. Add Stop - Use Case
Title	The system shall provide functionality for the passengers to modify/add extra ride stops:
FR 3.1	1. The system shall allow the user to access the add stop option in the PRT portal (before or during travel-if applicable).
FR 3.2	2. The system shall prompt the user to submit the desired stop(s) to the ride.
FR 3.3	3. The system shall verify if the stop is possible and check if it is already configured in the current course of the pod to ensure no duplicates halts are done.
FR 3.4	4. On successful verification, the stop shall be updated to the system routing coordinates.
FR 3.5	5. The system shall provide the user with confirmation once the stop is configured.

Req ID	Description
	4. Cancel Ride - Use Case
Title	The system shall provide functionality for the passengers to modify/cancel their rides:
FR 4.1	1. The system shall allow the user to access the ride-delete option in the PRT portal (before or during travel-if applicable).
FR 4.2	2. The system shall approve a canceled ride if the ride is canceled within the allocated time limit.
FR 4.3	3. The system shall verify if cancellation is possible during the current travel scenario.
FR 4.4	4. On successful evaluation, the system shall allow the ride to be canceled immediately.
FR 4.5	5. The system shall provide the user with confirmation once the cancellation is finalized.
Req ID	**Description**
	5. User Account Management - Use Case
Title	The system shall provide the functionality for all users to manage their account settings:
FR 5.1	1. The system shall allow the user to log onto the PRT service app or website at all times.
FR 5.2	2. The system shall allow user access to the ‘profile’ and ‘preferences’ sections in the site or application to manage the details and settings.
FR 5.3	3. The user shall be allowed to change details such as personal information, payment method, and other relevant data.
FR 5.4	4. Upon any confirmation, the system shall update the most recent changes to the database, which will then be reflected in the user service immediately.
Req ID	**Description**
	6. Validate Ride Pickup - Use Case
Title	The system shall have functionality to facilitate the validation of the user pickup at the entry points:
FR 6.1	1. Before entry into the pod, the system shall prompt the passenger to scan their generated QR code from the app/ web service.
FR 6.2	2. The system shall verify the user's eligibility for that ride by checking the respective credentials.
FR 6.3	3. On successful validation, the system shall confirm the destination coordinates.
FR 6.4	4. The system shall display the confirmation message on the system screen and the user app/site.
Req ID	**Description**
	7. Maintain & Repair - Use Case
Title	The system shall provide the functionality to maintain and repair the pod whenever necessary:
FR 7.1	1. The system shall alert and request maintenance/repair work on a specific pod, station, or section of the network.
FR 7.2	2. The system shall enable the transportation of its maintenance crew to the location with all the necessary equipment.
FR 7.3	3. The system crew performs maintenance works such as repair, replacement, diagnosis, service, inspection, etc., as required for the respective pods.

FR 7.4	4. Upon completion, the system shall update the central control center regarding the work done, the status of the pod, and its operational capability.
FR 7.5	5. The system confirms the maintenance work done and updates the relevant records and maintenance schedules to the pod log and control center database.
Req ID	**Description**
	8. Request Emergency Services - Use Case
Title	The system shall provide emergency services to the pods at all times:
FR 8.1	1. The system shall allow the passenger to press the emergency button in the pod.
FR 8.2	2. The central command center shall receive the emergency request to verify the threat level and nature of the threat.
FR 8.3	3. On comprehension and confirmation, the system shall permit the pod to enter a state of emergency, allowing it to reach the required location in the quickest way by redirecting all obstructing pods in its way.
FR 8.4	4. The system shall also send passenger emergency details to the nearest respective relief department (like medical availability, resources, doctors, or other facilities as needed) to keep the facilities ready on arrival time.

18.0 Non-Functional Requirements

Req ID	Description	Use Case
	Availability/Reliability	All
QR 1.1	The system shall be capable of supporting at least 2/3rd of the actual population of the NEOM at any given time.	All
QR 1.2	The system shall have an MTBM (Mean Time Between Maintenance) of at least 12 months.	All
QR 1.3	The system shall have MDT (Mean Down Time) of not more than 20 minutes per pod.	All
QR 1.4	The system shall have an operational reliability score of 99.7% at all times of operation.	All
QR 1.5	The system shall employ a backup power source during emergencies which can power the key systems for up to 4 hours.	Request Emergency Services
	Safety/Security	
QR 2.1	The system shall use government security channels to block 90% of hacker attacks while providing high-level encryption against the rest.	All
	Performance/Efficiency	
QR 3.1	The system shall be tested against the NEOM operating rules in the operational environment to ensure the system is capable of meeting the key performance metrics.	All

QR 3.2	The system shall operate at its optimal capability while maintaining a load of less than 75% on the engine.	Maintenance and Repair
	Platform	
QR 4.1	All user interactions with the PRT shall be made online or through the application with support for Windows, Mac OS, Android, Linux, and iOS.	Authenticate User, Request/Add/Cancel a Ride, Account Management
	Usability	
QR 5.1	Any user changes shall be reflected in the system within 5 seconds for all feasible scenarios.	Request/Add/Cancel a Ride
QR 5.2	All crew members must undergo a separate training program to operate the PRT with respect to its standard operating procedure.	Maintenance and Repair, Request Emergency Services

19.0 Traceability Tables

19.1 Functional Requirements to Use Case Trace

Functional Requirements	User Authentication (UC1)	Request a Ride (UC2)	User Adds Stop to Their Ride (UC3)	User Cancels Their Ride (UC4)	Perform User Account Management (UC5)	Validate Ride Pickup (UC6)	Maintenance & Repair (UC7)	Request Emergency Services (UC8)
FR 1.1	X							
FR 1.2	X							
FR 1.3	X							
FR 1.4	X							
FR 1.5	X							
FR 2.1		X						
FR 2.2		X						
FR 2.3		X						
FR 2.4		X						
FR 2.5		X						
FR 3.1			X					
FR 3.2			X					
FR 3.3			X					
FR 3.4			X					
FR 3.5			X					
FR 4.1				X				
FR 4.2				X				
FR 4.3				X				
FR 4.4				X				
FR 4.5				X				
FR 5.1					X			
FR 5.2					X			
FR 5.3					X			
FR 5.4					X			
FR 6.1						X		
FR 6.2						X		
FR 6.3						X		
FR 6.4						X		
FR 7.1							X	
FR 7.2							X	
FR 7.3							X	
FR 7.4							X	
FR 7.5							X	

Functional Requirements	User Authentication (UC1)	Request a Ride (UC2)	User Adds Stop to Their Ride (UC3)	User Cancels Their Ride (UC4)	Perform User Account Management (UC5)	Validate Ride Pickup (UC6)	Maintenance & Repair (UC7)	Request Emergency Services (UC8)
FR 8.1								X
FR 8.2								X
FR 8.3								X
FR 8.4								X

19.2 Non-Functional Requirements to Use Case Trace

Functional Requirements	User Authentication (UC1)	Request a Ride (UC2)	User Adds a Stop to Their Ride (UC3)	User Cancels Their Ride (UC4)	Perform User Account Management (UC5)	Exit PRT After Validation (UC6)	Maintenance & Repair (UC7)	Request Emergency Services (UC8)
QR 1.1	X	X	X	X	X	X	X	X
QR 1.2	X	X	X	X	X	X	X	X
QR 1.3	X	X	X	X	X	X	X	X
QR 1.4	X	X	X	X	X	X	X	X
QR 1.5								X
QR 2.1	X	X	X	X	X	X	X	X
QR 3.1	X	X	X	X	X	X	X	X
QR 3.2							X	
QR 4.1	X	X	X	X	X			
QR 5.1		X	X	X				
QR 5.2							X	X

20.0 System Level Test Plan

Test Case Id	Test Case	Expected Output	Pass / Fail	Functional Requirements Covered	Non-Functional Requirements Covered
Use Case 1 – User Authentication					
TC1	User attempts to log in with valid UserID and password	System validates user and allows access		FR 1.1, FR 1.2, FR 1.3, FR 1.4, FR 1.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
TC2	User attempts to log in with invalid UserID and password	System prompts user of invalid ID or password and is asked to try again		FR 1.1, FR 1.2, FR 1.3, FR 1.4	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
TC3	User attempts to log in with valid UserID and invalid password	System prompts user of invalid ID or password and is asked to try again		FR 1.1, FR 1.2, FR 1.3, FR 1.4	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
TC4	User attempts to log in with invalid UserID and valid password	System prompts user of invalid ID or password and is asked to try again		FR 1.1, FR 1.2, FR 1.3, FR 1.4	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
Use Case 2a – Request a Ride - Verify User's Eligibility to Request a Ride					
TC5	User requests a ride with an account balance > $0	The user's request is denied, and the system prompts user to check account balance		FR 2.1, FR 2.2, FR 2.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
TC6	User requests a ride without a form of payment on their account	The user's request is denied, and the system prompts user to update payment method		FR 2.1, FR 2.2, FR 2.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
TC7	User requests a ride with an account balance of $0, has a form of payment on their account, and the TOS and user database systems are available	The user's request is granted, and ride user receives ride confirmation message		FR 2.1, FR 2.2, FR 2.3, FR 2.4	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1

Test Case Id	Test Case	Expected Output	Pass / Fail	Functional Requirements Covered	Non-Functional Requirements Covered
TC8	User requests a ride, but the TOS application and/or web-based platform is unavailable	System prompts user of TOS platform unavailability		FR 2.1, FR 2.2, FR 2.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
TC9	User requests a ride, but the user database is unavailable	System prompts user of platform cannot connect to user database		FR 2.1, FR 2.2, FR 2.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
Use Case 2b – Request a Ride - Display Ride Information (type, location, and capacity status)					
TC10	User sees data while pod is not at capacity but then selects pod after it reaches capacity	System prompts user that the pod is at capacity, and they are sent to the previous page		FR 2.1, FR 2.2, FR 2.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
TC11	User enters a stop that the TOS doesn't recognize	System prompts user that the location entered is invalid, and the user is sent to the previous page		FR 2.1, FR 2.2, FR 2.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
Use Case 3 – User Adds Stop to Their Ride					
TC12	User requests to add a stop to their ride, and the stop is already on the route of the ride	System prompts user that the stop is on the route and doesn't need to be added		FR 3.2, FR 3.3	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
TC13	User requests to add a duplicate stop	System prompts user that the request is a duplicate		FR 3.2, FR 3.3	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
TC14	User requests to add a stop to their ride before the ride starts, and the stop is compatible with the current ride	System gives user a confirmation the stop has been added		FR 3.1, FR 3.2, FR 3.3, FR 3.4, FR 3.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
Use Case 4 – User Cancels Their Ride					
TC15	User attempts to cancel their ride once the ride has already started	System informs user it is too late to cancel ride		FR 4.1	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1

Test Case Id	Test Case	Expected Output	Pass / Fail	Functional Requirements Covered	Non-Functional Requirements Covered
TC16	User attempts to cancel before the ride has started	System allows user to cancel their ride		FR 4.1, FR 4.2, FR 4.3, FR 4.4, FR 4.5	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1, QR 5.1
Use Case 5 – Perform User Account Maintenance					
TC17	User requests to change their password, but the new password they entered doesn't meet criteria (not used in previous 10 passwords, at least 8 characters, 1 character must be a special character, & 1 must be a number)	System prompts user to choose a different password that meets password requirements		FR 5.1, FR 5.2, FR 5.3	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
TC18	User requests to change their password, and the new password they entered matches the password criteria	System allows user's password to be changed		FR 5.1, FR 5.2, FR 5.3, FR 5.4	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
TC19	User requests to change their payment method, but the new payment method entered is invalid	System prompts user to enter a valid method of payment		FR 5.1, FR 5.2, FR 5.3	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
TC20	User requests to change their payment method, and the new payment method entered is valid	System allows user's payment method to be changed		FR 5.1, FR 5.2, FR 5.3, FR 5.4	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
TC21	User requests to change their home station, but the station entered is invalid	System prompts user to enter a valid station		FR 5.1, FR 5.2, FR 5.3	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
TC22	User requests to change their home station, and the station entered is valid	System allows user's home station to be changed		FR 5.1, FR 5.2, FR 5.3, FR 5.4	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1, QR 4.1
Use Case 6 – Validate User Pickup					
TC23	User scans valid QR code before entering pod	User's pickup is validated		FR 6.1, FR 6.2, FR 6.3, FR 6.4	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1
TC34	User scans invalid QR code before entering pod	User isn't allowed on the pod and is prompted to find the correct pod		FR 6.1, FR 6.2	QR 1.1, QR 1.2, QR 1.3, QR 1.4, QR 2.1, QR 3.1

*Note: this is not a complete list of test cases, as this is a student project

21.0 Glossary

Acronym	Spelled Out	Description
PRTS	Personal Rapid Transportation System	This is the transportation system being built/designed in this report for The Line. It is to provide a high-speed and efficient transportation solution for passengers and cargo between designated locations.
TOS	Transportation Operating System	This is the operating system (application/website) for the PRTS being built/designed in this report for The Line.
FR	Fault Requirement	This is a reference in several tables, such as the Traceability Matrix, Functional Requirements, and Test Cases.
QR	Qualitative Requirement	This is a reference in several tables, such as the Traceability Matrix, Non-Functional Requirements, and Test Cases.
TC	Test Case	A reference ID for the Test Cases.
UC	Use Case	A reference ID for the Use Cases.

22.0 Works Cited

The Engineering Design of Systems – Models and Methods, 3rd edition Dennis M. Buede, 2016

"How Does Virgin Hyperloop Work?" *Virgin.com*, https://www.virgin.com/about-virgin/latest/how-does-virgin-hyperloop-work.

Tim Simmons, Ph.D. - USSI Director of Industrial Acoustics. "Acoustical Rules of Thumb and Demystifying the Decibel." *United Steel Structures - The USSI Blog - Acoustical Rules of Thumb and Demystifying the Decibel*, https://www.ussi.com/acoustical-rules-and-demystifying-decibel.php.