



# Lot1 : Plateforme d'intégration système

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## L1.2 : Operational Analysis

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## Document History

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## 1 Introduction

Autonomous vehicles are complex systems, their deployment involves multiple stakeholders. A systems thinking is needed to deploy operational level-4 autonomous vehicles. This document presents the results from the operational analysis phase of the Arcadia methodology. The operational analysis constitutes the first phase in the system engineering process as illustrated in Figure 1. This phase analyzes the system with the perspective of high-level operations, by identifying actors that have to interact with the system, their goals, activities, constraints and the interaction conditions between them.

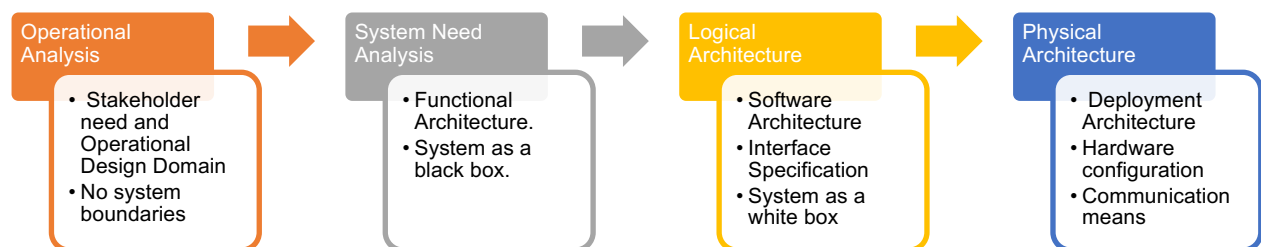


Figure 1 - Arcadia System Engineering Phases

## 2 Operational Analysis

Operational analysis is a means to capture what system users must achieve as part of their work or mission, and the associated conditions, regardless of any solution – and particularly of systems that they will be able to use for this purpose. This analysis aims at ensuring adequate system definition with respect to its real operational use. The results of this engineering phase mainly consist of an operational architecture which describes and structures the need in terms of actors/users, their operational capabilities and activities. During this phase, we have used an iterative approach to identify operational entities, capabilities, activities and scenarios. The first step consists of determining future system and environment users' missions – or more generally their motivations, expectations, goals, objectives, intentions, etc., as well as the capabilities required to assume these missions

### 2.1 Operational Entities

Figure 2 shows operational entity decomposition diagram for mobility services and fleet operator. Mobility services consist mainly of Autonomous vehicles such as AD passenger car and AD shuttle vehicle. Trains are also included for enabling multi-modal transportation system. Fleet Operator includes an application for user, for example, a mobile application and a control center.

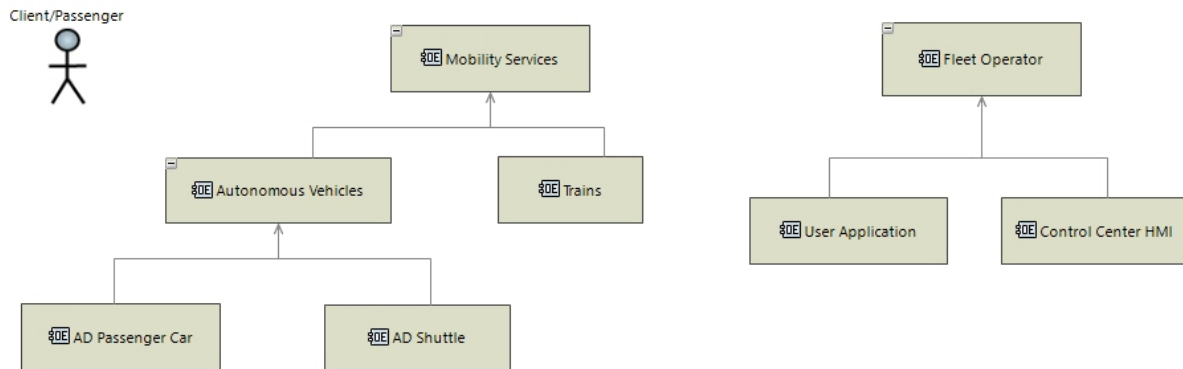


Figure 2 – Operational Entity Decomposition Diagram showing the passenger, mobility services and fleet operator

A vehicle with automated features must have established an Operational Design Domain (ODD). This is a requirement and core initial element from the NHTSA's Highly Automated Vehicle (HAV) policy<sup>1</sup>. Figure 3 models different elements that constitutes the ODD such as intelligent infrastructure, vehicle routes and different types of vehicle parking points and stop locations.

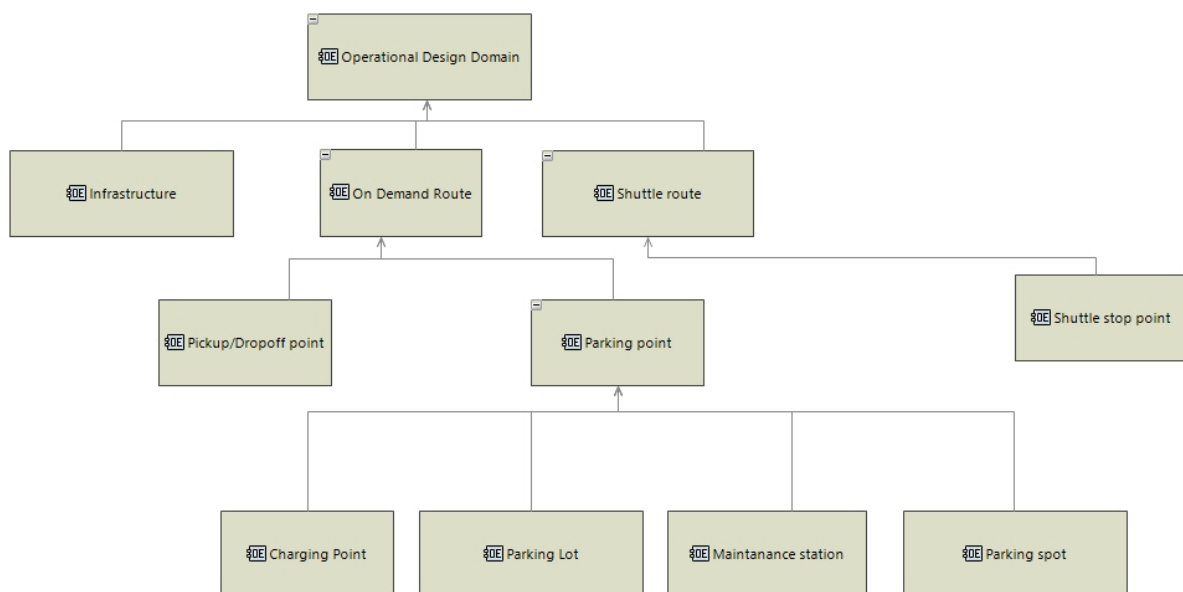


Figure 3 - Operational Entity Decomposition Diagram showing the Operational Design Domain

## 2.2 Operational Capabilities

Figure 4 and 5 shows different operational capabilities of the identified operational elements. Figure 4 shows the capabilities that concerns the passenger and Figure 5 shows the capabilities relating to fleet operator.

<sup>1</sup> NHTSA's HAV policy, published in September 2016, is a regulatory framework and best practices for the safe design, development, testing, and deployment of HAVs for manufacturers and all entities involved.

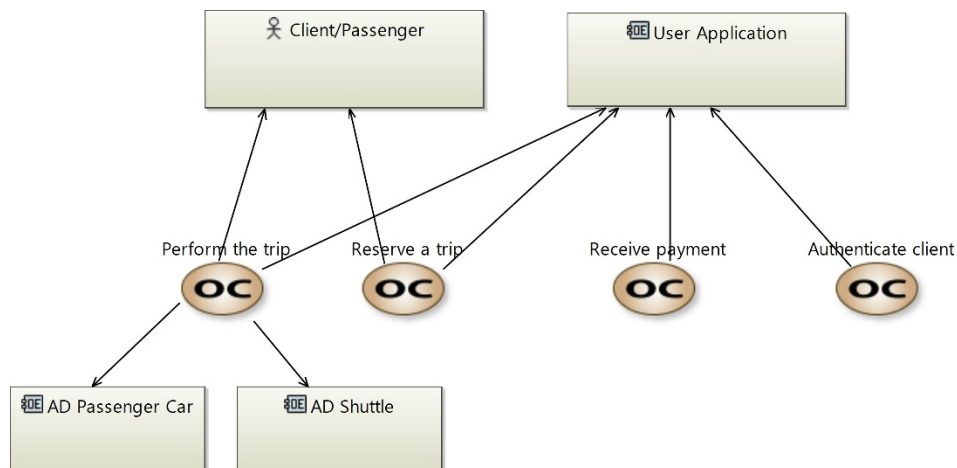


Figure 4 - Operational Capabilities of users

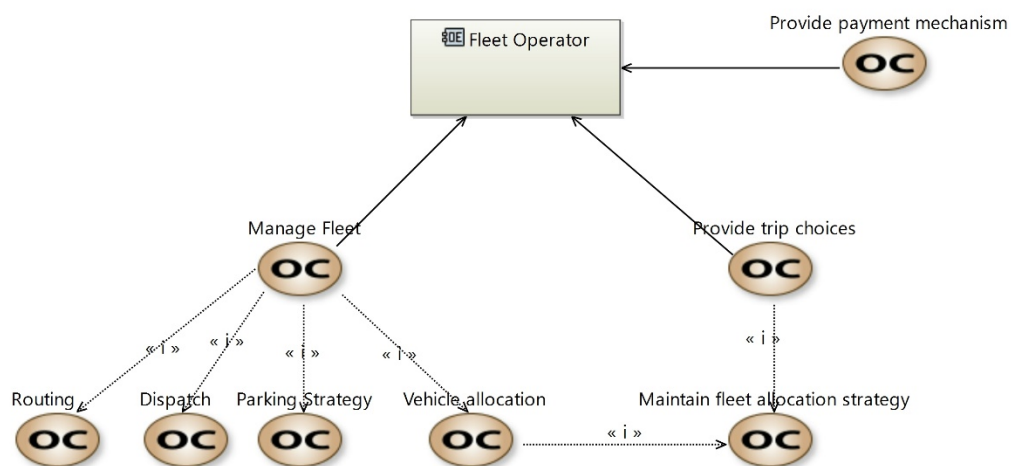


Figure 5 - Operational Capabilities of Fleet Operator

## 2.3 Operational Activities

We have employed an iterative approach to identify different operational activities for each operational entity. Firstly, we modeled the activity interactions for each operational capability identified in Section 2.2. The resulting interaction diagrams are shown in Section 2.3.1. Then the identified operational activities are allocated to operational entities. Figure 6 and Figure 7 shows different operational activities that are allocated to operational entities.

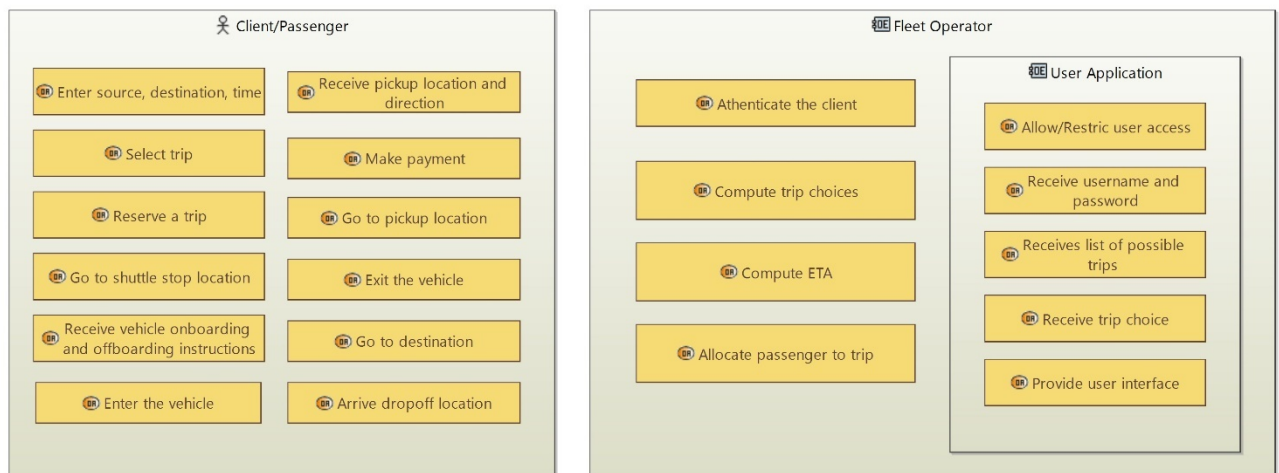


Figure 6 - Allocated operational activities to Client and Fleet Operator

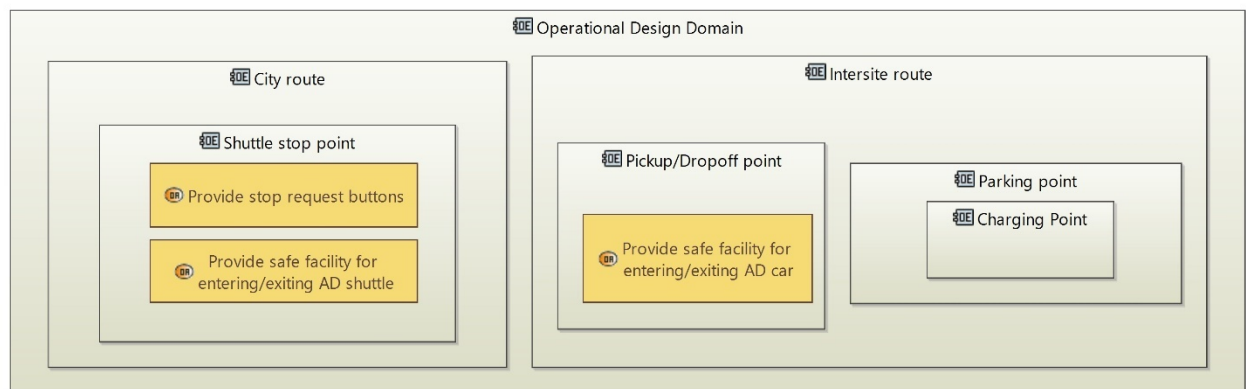


Figure 7 - Allocated operational activities to ODD

### 2.3.1 Operational Activity Interactions

For each operational capability identified, we model the operational activity interaction diagrams in this section. For example, Figure 8 shows the interaction between different operational activity in order to authenticate a client. Similarly, the interaction diagrams for ‘providing trip choices’, ‘trip reservation’ and ‘performing a trip’ operations are modeled. The resulting diagrams are shown in below figures.

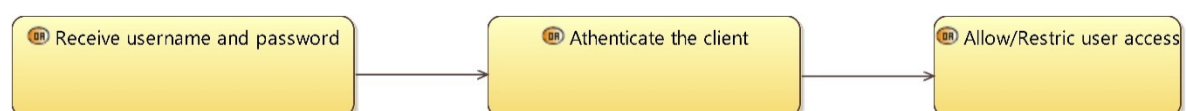


Figure 8 - Client Authentication



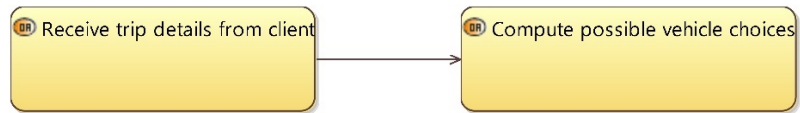


Figure 9 - Provide list of trip choices

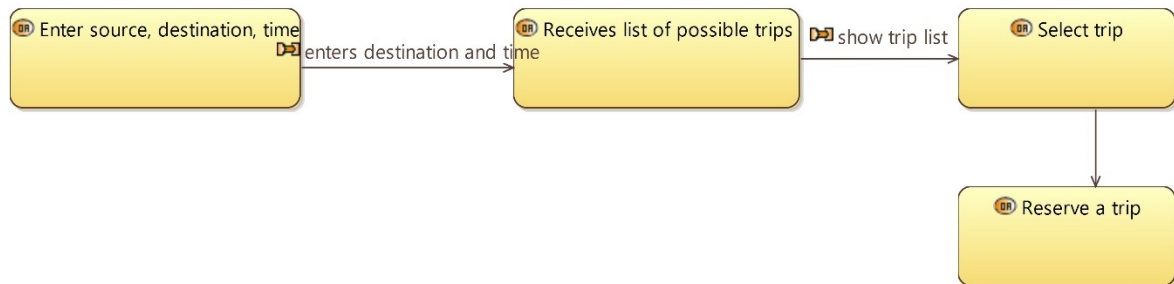


Figure 10 - Reserve a trip

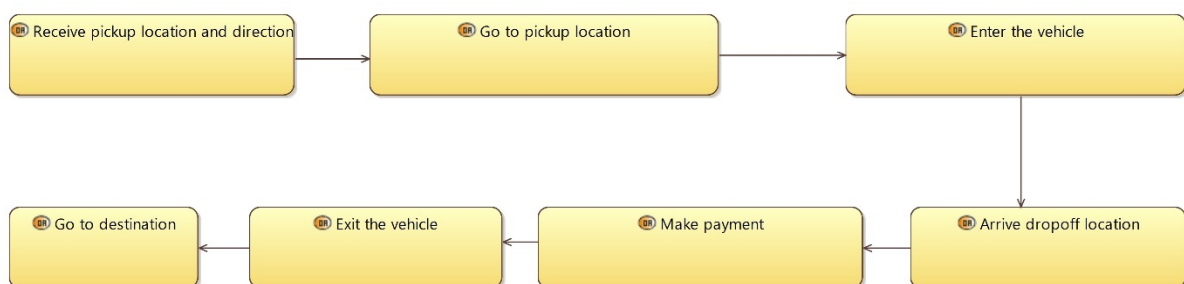


Figure 11 - Perform the trip

## 2.4 Operational states diagram

High-level operational states of the vehicle are shown in Figure 12 **Error! Reference source not found..** It is to be noted that stopping a vehicle in parking point is different from that of a pickup/dropoff location. The basic understanding is that the vehicle can be stopped at a parking point for long period of time as compared to stopping at a pickup/dropoff location.

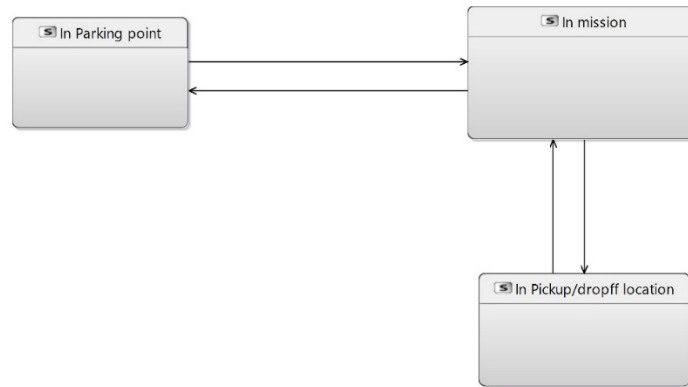


Figure 12 – Operational states of AD Vehicle

Figure 13 shows the different states of required mobile application is captured in the form of a state machine diagram. The states represent the general characteristics of the information that is displayed by the application and the transition represent the events. The events may be user actions or events related to vehicle or passenger.

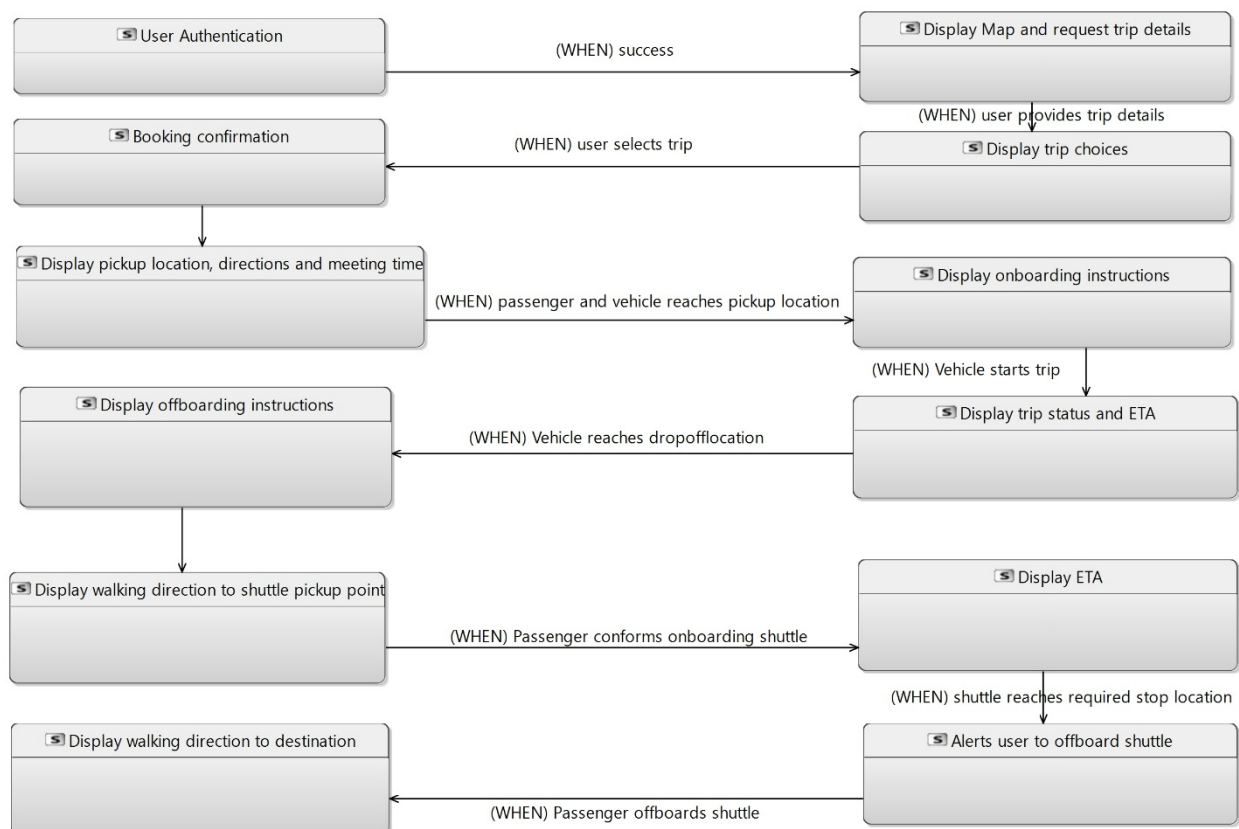


Figure 13 - Operational states of mobile application

## 2.5 Operational Scenarios

Interactions between different operational entities are modeling using sequence diagrams. Figure 14 shows interaction modeled for tip reservation scenario. The participating entities forms the life lines of the sequence diagram. In this scenario, client, user application, and fleet operator are

included. The yellow rectangles and grey ovals corresponds to operational activities and operational states respectively. The connector represents the events generated by the originating operational entity. It is interesting to note that all the modeling elements have been already identified in our previous modeling activities and in the sequence diagram we are designing only the interactions between them. Similarly, Figure 15 models an operational scenario where the passenger is travelling from the train station to a place in the city loop.

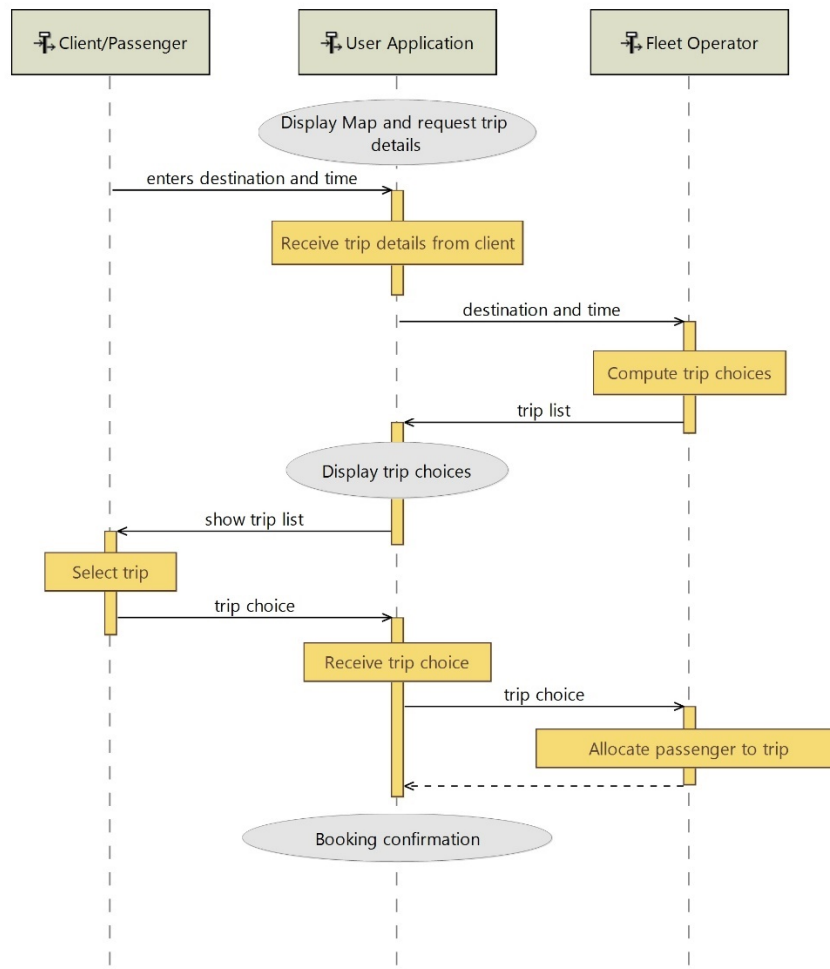


Figure 14 - Trip Reservation Scenario

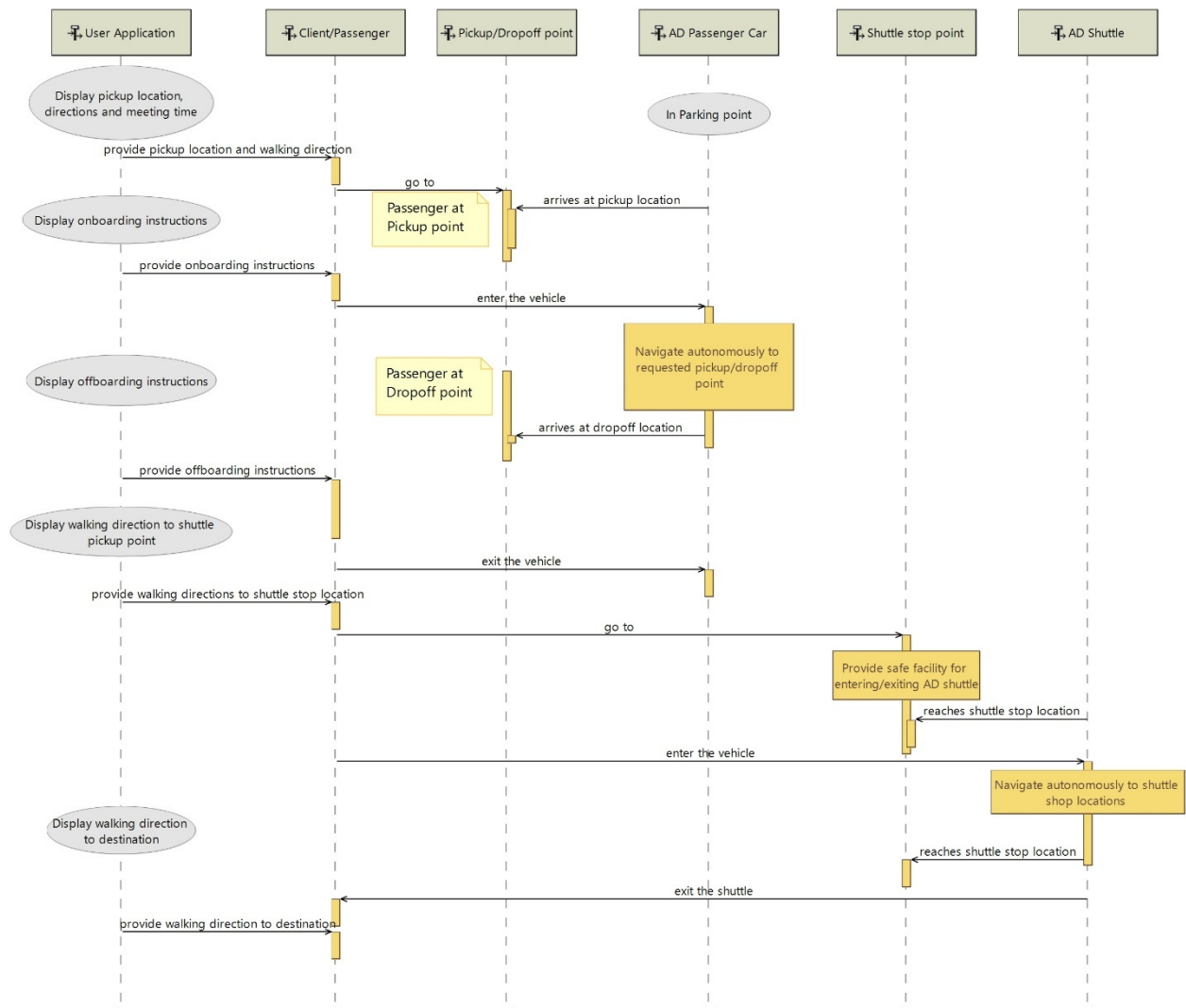


Figure 15 - Passenger operational scenario: station to city loop

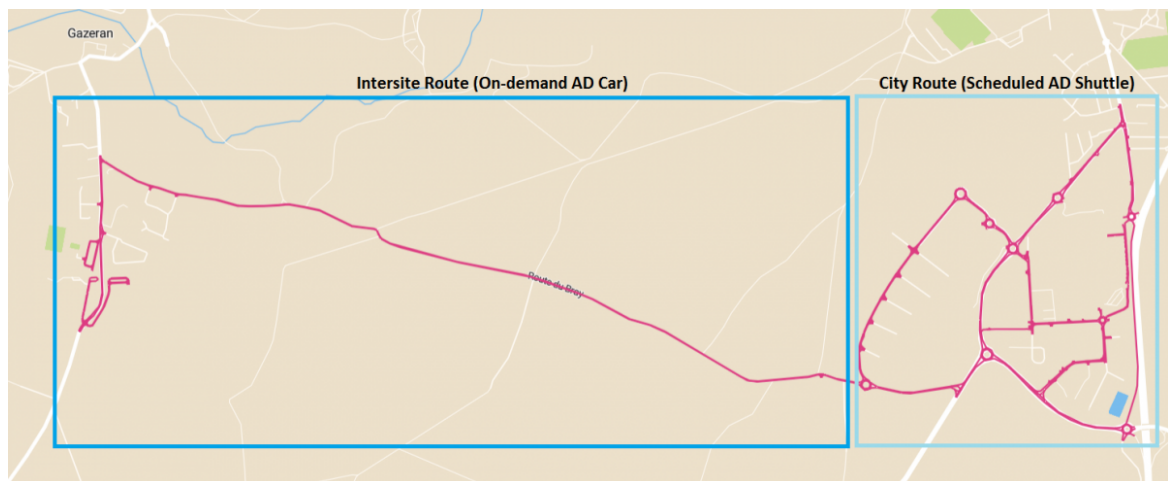
### 3 Summary

The OA perspective defines what the users of the system must accomplish: it analyzes the challenges of operational users, by identifying the actors that have to interact with the system, their goals, activities, constraints and the interaction conditions existing between them. Based on this analysis, the next deliverable will focus on the high-level System Design perspective (or System Analysis), in order to clearly identify the services that will be provided by the Tornado system as well as the interface to interact with external actors.

## 4 Appendix

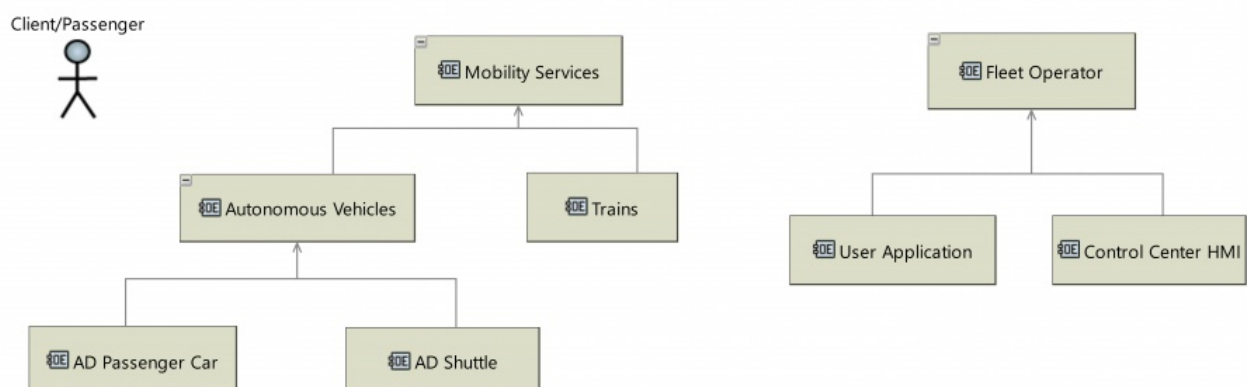
The complete set of model diagrams from the operational analysis phase is given below. High quality images can be found in the URL: <https://wiki.tornado-mobility.com/index.php>

### 4.1 Operational Design Domain

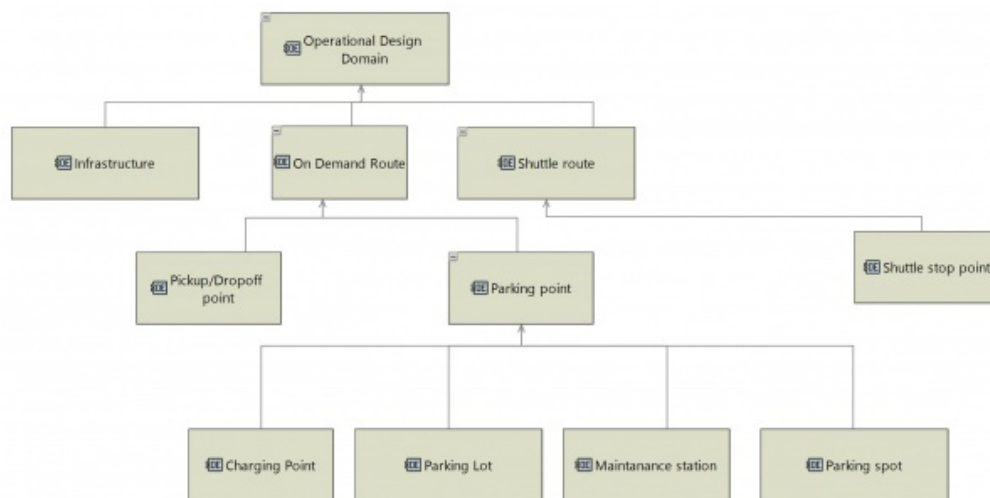


### 4.2 Operational Entity Breakdown

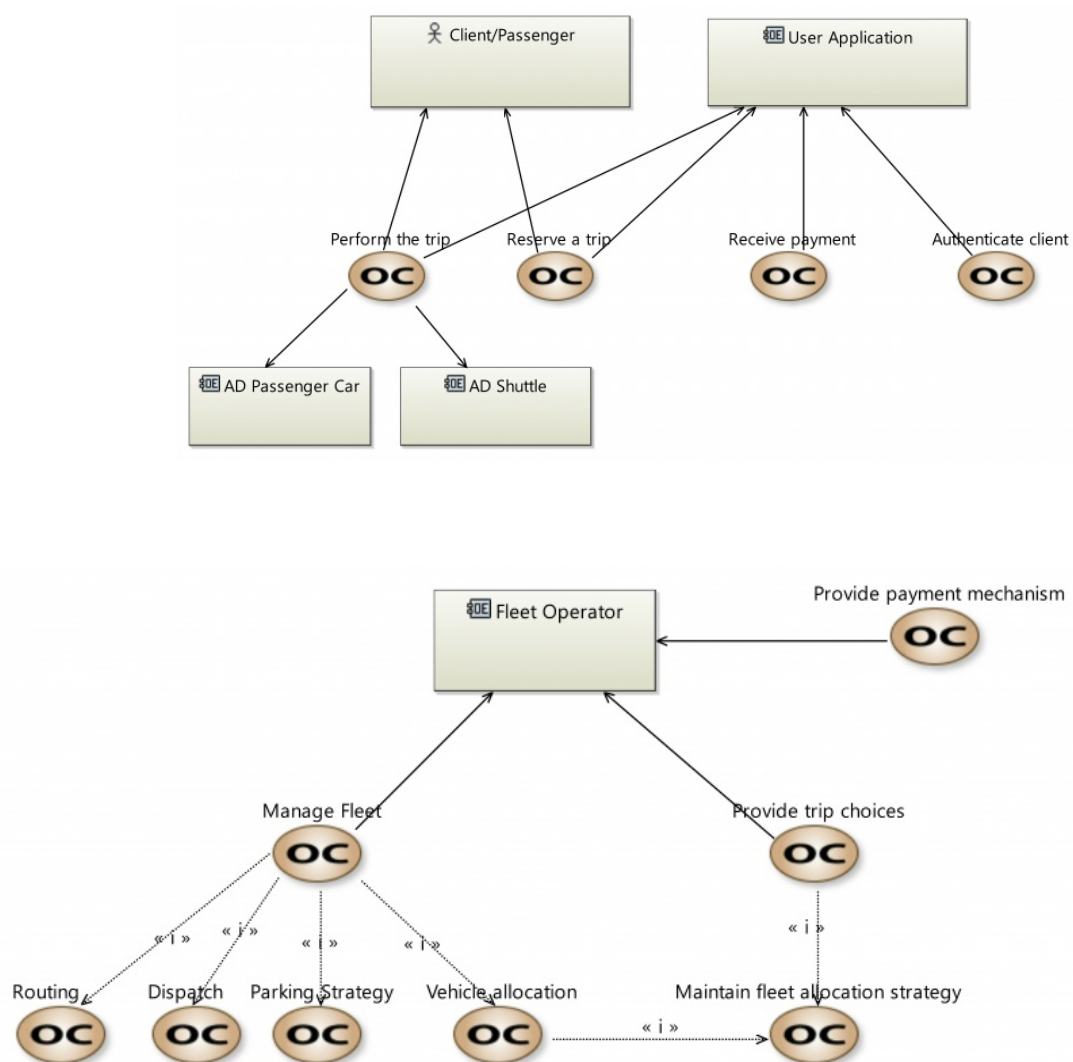
#### 4.2.1 Mobility Services



## 4.2.2 Operational Design Domain



## 4.3 Operational Capabilities Diagram

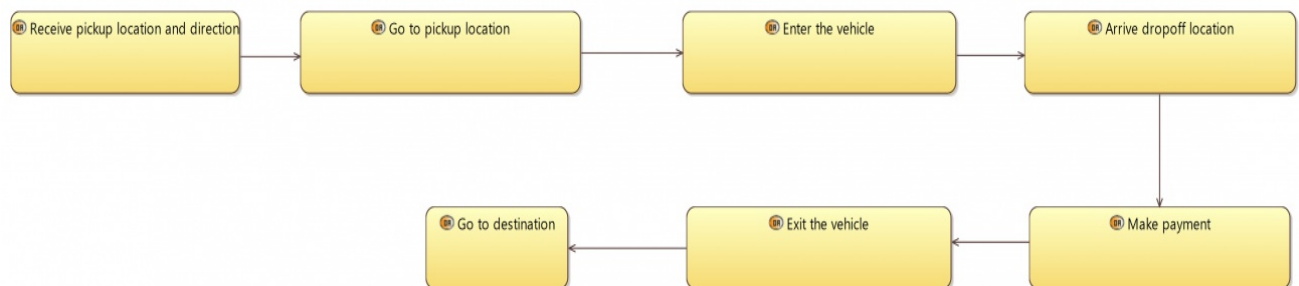


## 4.4 Operational Activity Interaction Diagram

### 4.4.1 Client Authentication



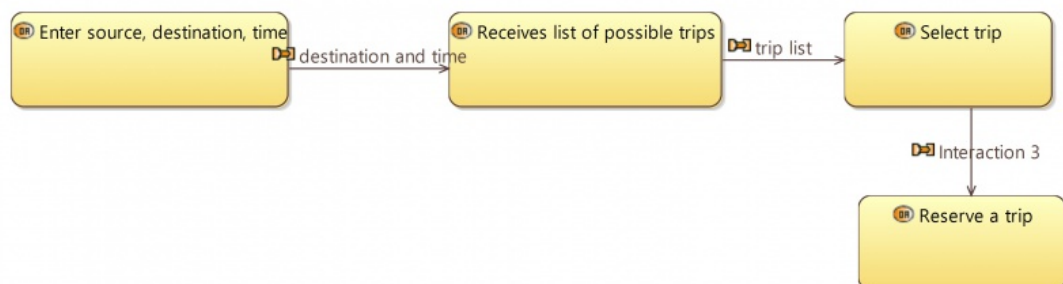
### 4.4.2 Performing the trip



### 4.4.3 Provide list of trip choices

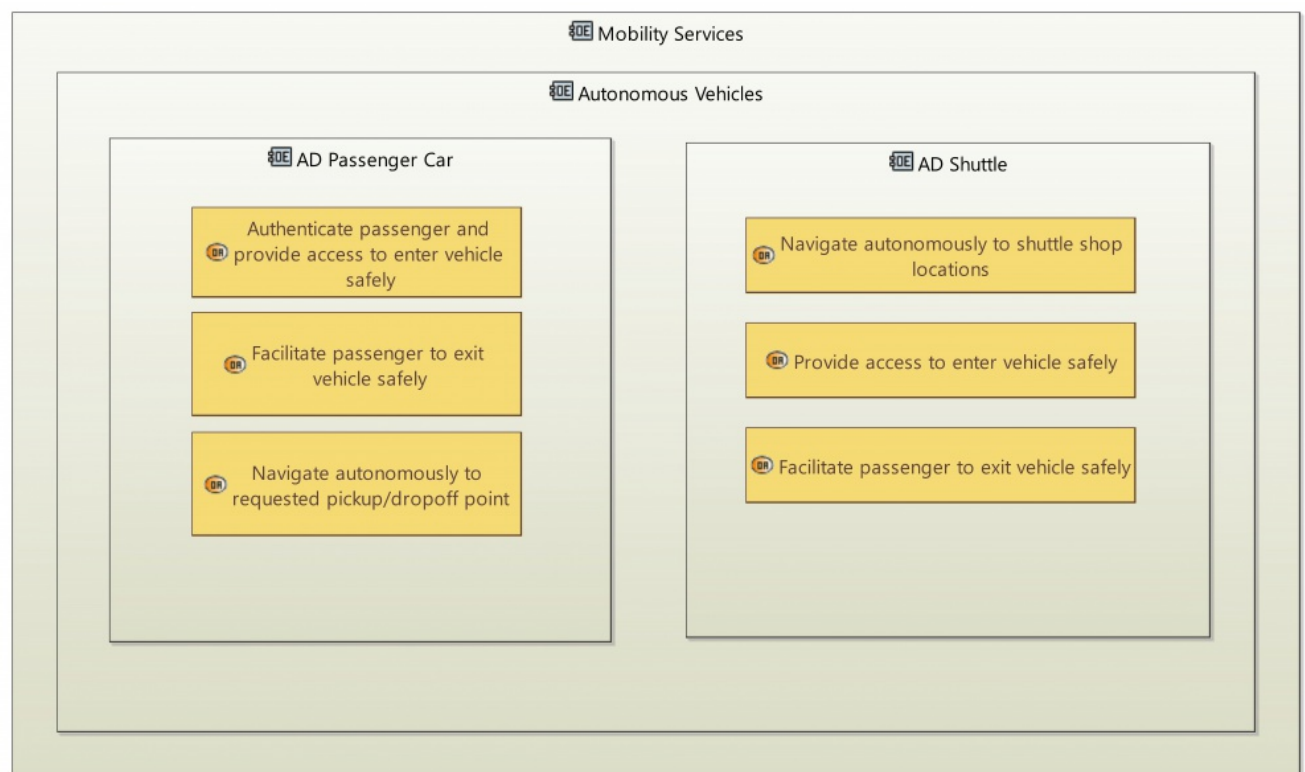
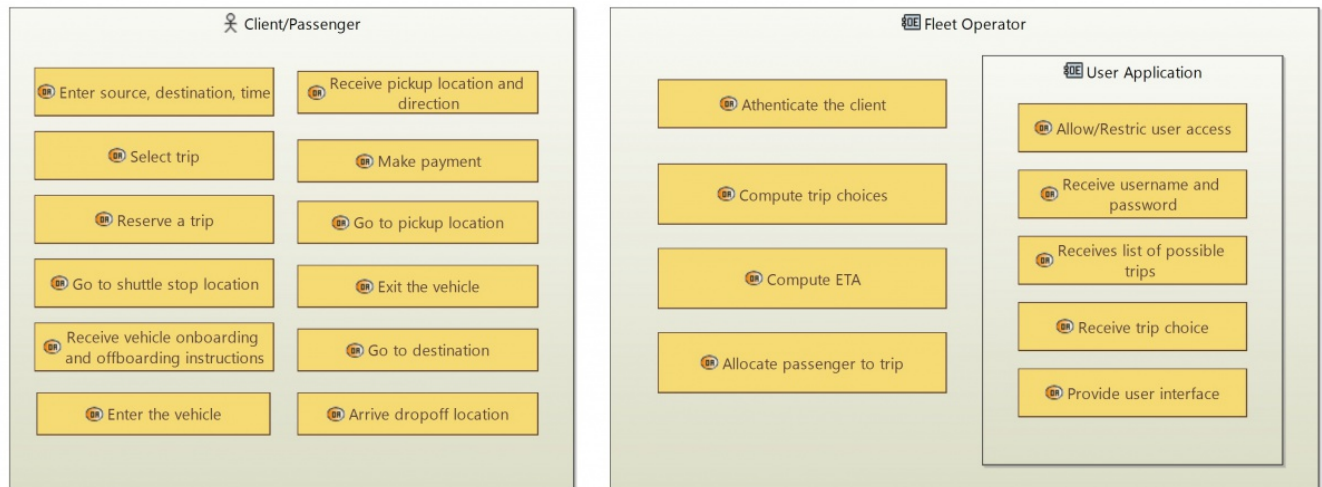


### 4.4.4 Reserve a trip

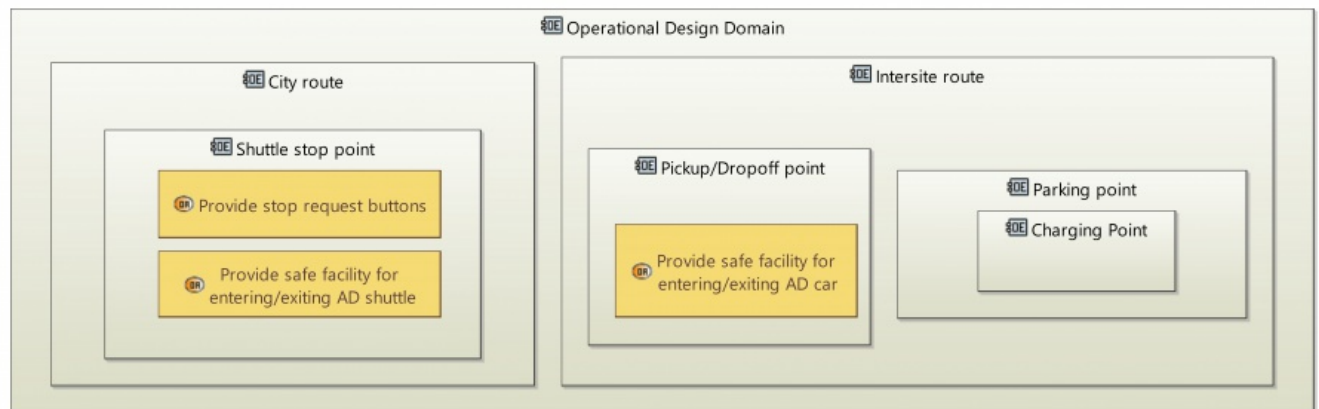




## 4.5 Operational Entities and Activities

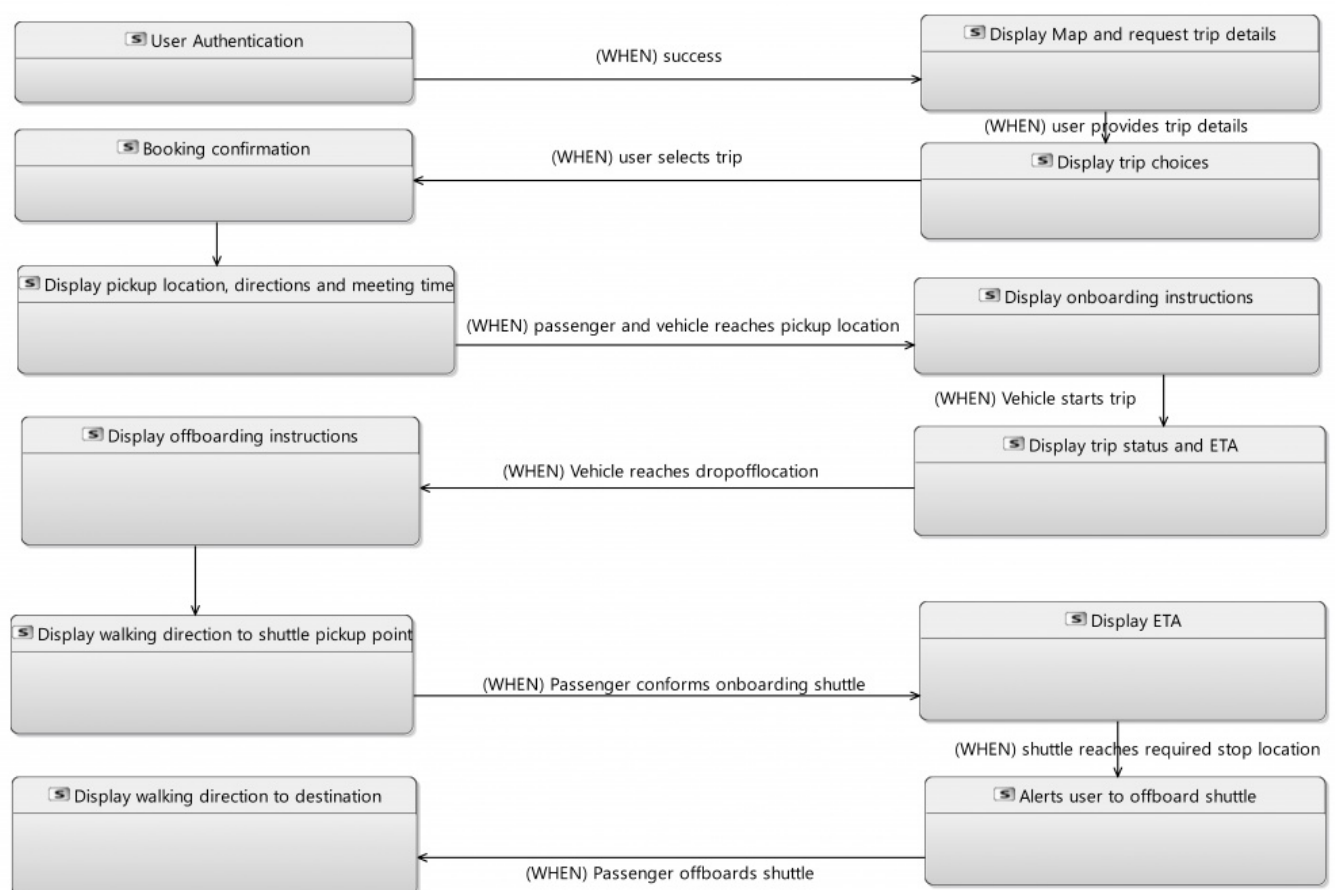






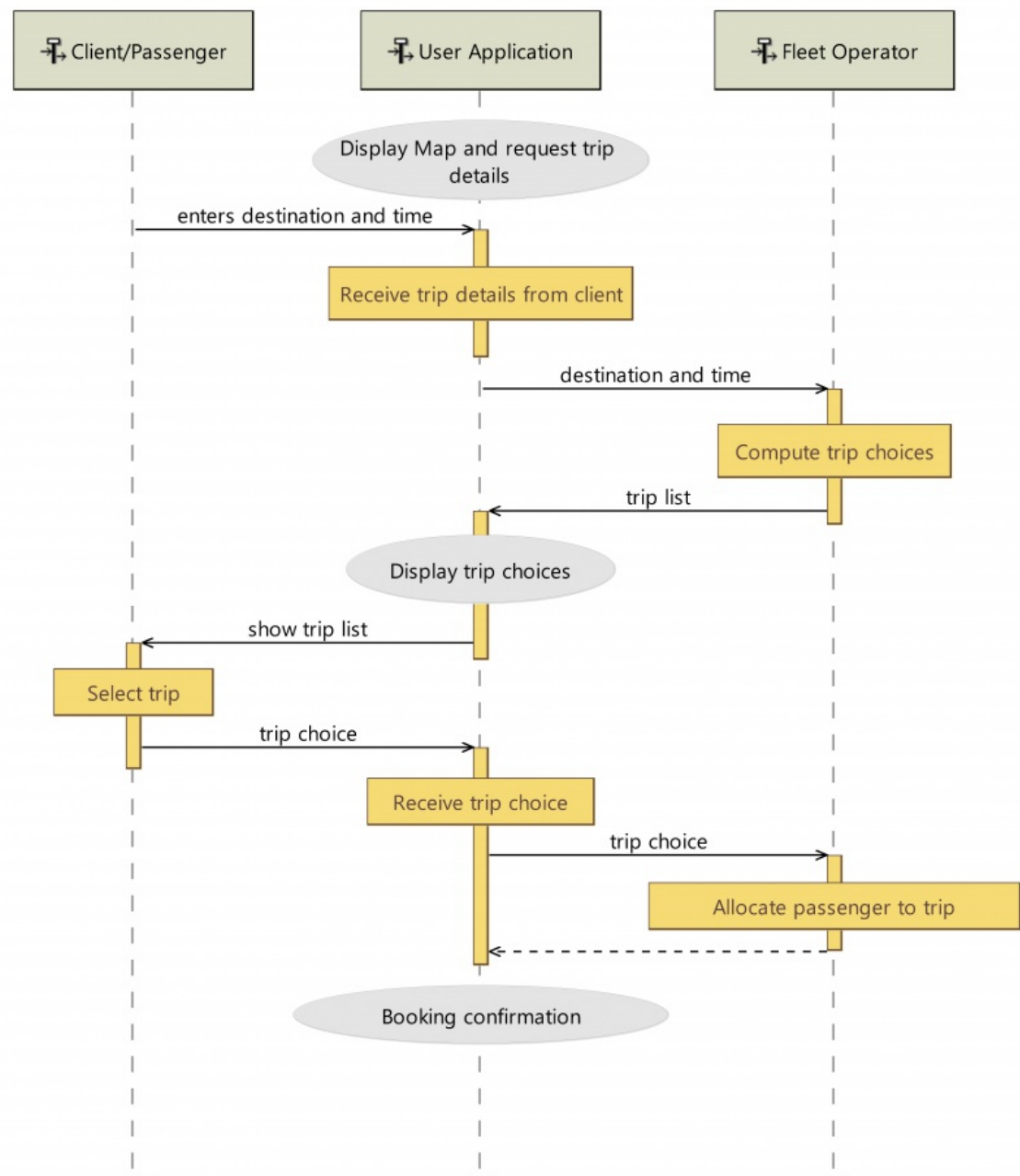
## 4.6 State Machine Diagrams

### 4.6.1 Mobile Application State Diagram



## 4.7 Operational Scenario

### 4.7.1 Trip Reservation Scenario



## 4.7.2 Perform a trip Scenario

