Autonomous Vehicles to Evolve to a New Urban Experience

DELIVERABLE 4.10

Integration to the existing Public transport services' platforms

Co-funded by the Horizon 2020 programme of the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769033

Disclaimer

This document reflects only the author's view and the European Commission is not responsible for any use that may be made of the information it contains.

Document Information

Grant Agreement Number	769033
Full Title	Autonomous Vehicles to Evolve to a New Urban Experience
Acronym	AVENUE
Deliverable	D4.10 Integration to the existing Public transport services' platforms
Due Date	31.08.2022
Work Package	WP4
Lead Partner	Autonomous Mobility
Leading Author	Chrisitan Zinckernagel, Nanna May Felthaus, Sophie Green
Dissemination Level	Public

Document History

Version	Date	Author	Description of change
0.1	03.03.2022	Christian Zinckernagel, Nanna Felthaus, Christian Bering, Sophie Green, Holo	First draft
1.0	16.11.2022	Christian Zinckernagel	Final version
1.1	15.01.2023	Vedran Vlajki	Formatting and adaption
1.2	15.07.2023	Vedran Vlajki	Update adding the TPG integration
2.0	04.09.2023	Helfer Laurent	Multiple improvements and corrections

Table of Contents

List of Figures

List of Tables

Acronyms

ADS	Automated Driving Systems
AI	Artificial Intelligence
AM	Automated Minibus
API	Application Protocol Interface
AV	Automated Vehicle
BM	Bestmile
BMM	Business Modelling Manager
CAV	Connected and Automated Vehicles
CB	Consortium Body
CERN	European Organization for Nuclear Research
D7.1	Deliverable 4.10
DC	Demonstration Coordinator
DI	The department of infrastructure (Swiss Canton of Geneva)
DMP	Data Management Plan
DSES	Department of Security and Economy - Traffic Police (Swiss Canton of Geneva)
DTU test track	Technical University of Denmark test track
EAB	External Advisory Board
EC	European Commission
ECSEL	Electronic Components and Systems for European Leadership
EM	Exploitation Manager
EU	European Union
EUCAD	European Conference on Connected and Automated Driving
F2F	Face to face meeting
FEDRO	(Swiss) Federal Roads Office
FOT	(Swiss) Federal Office of Transport
GDPR	General Data Protection Regulation
GIMS	Geneva International Motor Show
GNSS	Global Navigation Satellite System
HARA	Hazard Analysis and Risk Assessment
IPR	Intellectual Property Rights
IT	Information Technology
ITU	International Telecommunications Union
LA	Leading Author
LIDAR	Light Detection And Ranging
MEM	Monitoring and Evaluation Manager
MT	MobileThinking
OCT	General Transport Directorate of the Canton of Geneva
ODD	Operational Domain Design
OEDR	Object And Event Detection And Response
OFCOM	(Swiss) Federal Office of Communications
PC	Project Coordinator
PEB	Project Executive Board
PGA	Project General Assembly
PRM	Persons with Reduced Mobility
PSA	Group PSA (PSA Peugeot Citroën)
PTO	Public Transportation Operator
PTS	Public Transportation Services
QRM	Quality and Risk Manager
QRMB	Quality and Risk Management Board
RN	Risk Number
SA	Scientific Advisor
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SAN	(Swiss) Cantonal Vehicle Service
SDK	Software Development Kit
SLA	Sales Lentz Autocars
SMB	Site Management Board
SoA	State of the Art
SOTIF	Safety Of The Intended Functionality
SWOT	Strengths, Weaknesses, Opportunities, and Threats.
T4.10	Task 4.10
TM	Technical Manager
TPG	Transport Publics Genevois
UITP	Union Internationale des Transports Publics (International Transport Union)
V2I	Vehicle to Infrastructure communication
WP	Work Package
WPL	Work Package Leader

Executive Summary

This deliverable presents an overview of the integration of the AVENUE AMs' fleet to the PTOs' MaaS system. Indeed, AVENUE's AM services were integrated to the MOVIA public transportation services in the Slagelse site (Denmark), and to the TPG-Flex service of the Geneva Canton in the Belle-Idée site (Switzerland). It should be noted that this deliverable is a Demonstrator deliverable and not a report. In this document, we provide an overview of the AM services integration into regular PT networks within the framework of the AVENUE project's demonstration sites.

1 Introduction

AVENUE aims to design and carry out full-scale demonstrations of urban transport automation by deploying, for the first time worldwide, fleets of Automated minibuses in low to medium demand areas of 4 European demonstrator cities (Geneva, Lyon, Copenhagen, and Luxembourg) and 2 to 3 replicator cities. The AVENUE vision for future public transport in urban and suburban areas, is that Automated vehicles will ensure safe, rapid, economic, sustainable, and personalised transport of passengers. AVENUE introduces disruptive public transportation paradigms based on demand, door-to-door services, aiming to set up a new model of public transportation, by revisiting the offered public transportation services, and aiming to suppress prescheduled fixed bus itineraries.

Vehicle services that substantially enhance the passenger experience as well as the overall quality and value of the service will be introduced, also targeting elderly people, people with disabilities and vulnerable users. Road behaviour, security of the Automated vehicles and passengers' safety are central points of the AVENUE project.

At the end of the AVENUE project four-year period the mission is to have demonstrated that Automated vehicles will become the future solution for public transport. The AVENUE project will demonstrate the economic, environmental, and social potential of Automated vehicles for both companies and public commuters while assessing the vehicle road behaviour safety.

1.1 On-demand Mobility

Public transportation is a key element of a region's economic development and the quality of life of its citizens.

Governments around the world are defining strategies for the development of efficient public transport based on different criteria of importance to their regions, such as topography, citizens' needs, social and economic barriers, environmental concerns, and historical development. However, new technologies, modes of transport and services are appearing, which seem very promising to the support of regional strategies for the development of public transport.

On-demand transport is a public transport service that only works when a reservation has been recorded and will be a relevant solution where the demand for transport is diffuse and regular transport is inefficient.

On-demand transport differs from other public transport services in that vehicles do not follow a fixed route and do not use a predefined timetable. Unlike taxis, on-demand public transport is usually also not individual. An operator or an automated system takes care of the booking, planning and organization.

It is recognized that the use and integration of on-demand Automated vehicles has the potential to significantly improve services and provide solutions to many of the problems encountered today in the development of sustainable and efficient public transport.

1.2 Fully Automated Vehicles

A self-driving car, referred in the AVENUE project as a **Fully Automated Vehicle** (**AV**), or as Autonomous Vehicle, is a vehicle that can sense its environment and moving safely with no human input.

The terms *automated vehicles* and *autonomous vehicles* are often used together. The Regulation 2019/2144 of the European Parliament and of the Council of 27 November 2019 on type-approval requirements for motor vehicles defines "automated vehicle" and "fully automated vehicle" based on their autonomous capacity:

An "automated vehicle" means a motor vehicle designed and constructed to move autonomously for certain periods of time without continuous driver supervision but in respect of which driver intervention is still expected or required.

"Fully automated vehicle" means a motor vehicle that has been designed and constructed to move autonomously without any driver supervision.

In AVENUE we operate ***Fully Automated minibuses for public transport***, (previously referred as Autonomous shuttles, or Autonomous buses), and we refer to them as simply *Automated minibuses* or *the AVENUE minibuses.*

In relation to the SAE levels, the AVENUE project will operate SAE Level 4 vehicles.

SAE INTERNATIONAL

SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You **are** driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You **are not** driving when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			These are automated driving features		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/ acceleration support to the driver	These features provide steering AND brake/ acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering OR • adaptive cruise control	• lane centering AND • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/ steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

Table 1: SAE Driving Automation levels (©2020 SAE International)

1.2.1 Automated vehicle operation overview

We distinguish in AVENUE two levels of control of the AV: micro-navigation and macro-navigation. Micro navigation is fully integrated in the vehicle and implements the road behaviour of the vehicle, while macro-navigation is controlled by the operator running the vehicle and defines the destination and path of the vehicle, as defined the higher view of the overall fleet management.

For micro-navigation Automated Vehicles combine a variety of sensors to perceive their surroundings, such as 3D video, LIDAR, sonar, GNSS, odometry and other types of sensors. Control software and systems, integrated in the vehicle, fusion and interpret the sensor information to identify the current position of

the vehicle, detecting obstacles in the surround environment, and choosing the most appropriate reaction of the vehicle, ranging from stopping to bypassing the obstacle, reducing its speed, making a turn etc.
For the Macro-navigation, that is the destination to reach, the Automated Vehicle receives the information from either the in-vehicle operator (in the current configuration with a fixed path route), or from the remote-control service via a dedicated 4/5G communication channel, for a fleet-managed operation. The fleet management system considers all available vehicles in the services area, the passenger request, the operator policies, the street conditions (closed streets) and send route and stop information to the vehicle (route to follow and destination to reach).

1.2.2 Automated vehicle capabilities in AVENUE

The Automated vehicles employed in AVENUE fully and automatically manage the above defined, micro-navigation and road behaviour, in an open street environment. The vehicles are automatically capable to recognise obstacles (and identify some of them), identify moving and stationary objects, and automatically decide to bypass or wait behind them, based on the defined policies. For example, with small changes in its route the AVENUE minibus is able to bypass a parked car, while it will slow down and follow behind a slowly moving car. The AVENUE mini-buses are able to handle different complex road situations, like entering and exiting round-about in the presence of other fast running cars, stop in zebra crossings, communicate with infrastructure via V2I interfaces (ex. red light control).
The minibuses used in the AVENUE project technically can achieve speeds of more than 60Km/h. However, this speed cannot be used in the project demonstrators for several reasons, ranging from regulatory to safety. Under current regulations the maximum authorised speed is 25 or 30 Km/h (depending on the site). In the current demonstrators the speed does not exceed 23 Km/h, with an operational speed of 14 to 18 Km/h. Another, more important reason for limiting the vehicle speed is safety for passengers and pedestrians. Due to the fact that the current LIDAR has a range of 100m and the obstacle identification is done for objects no further than 40 meters, and considering that the vehicle must safely stop in case of an obstacle on the road (which will be "seen" at less than 40 meters distance) we cannot guarantee a safe braking if the speed is more than 25 Km/h. Note that technically the vehicle can make harsh break and stop with 40 meters in high speeds (40 -50 Km/h) but then the break would too harsh putting in risk the vehicle passengers. The project is working in finding an optimal point between passenger and pedestrian safety.
Due to legal requirements a **Safety Operator** must always be present in the vehicle, able to take control any moment. Additionally, at the control room, a **Supervisor** is present controlling the fleet operations. An **Intervention Team** is present in the deployment area ready to intervene in case of incident to any of the minibuses. Table 2 provides an overview of the AVENEU sites and ODDs.

	Summary of AVENUE operating sites demonstrators							
	TPG		Holo		Keolis	Sales-Lentz		
	Geneva		Copenhagen	Oslo	Lyon	Luxembourg		
Site	Meyrin	Belle-Idée	Nordhavn	Ormøya	ParcOL	Pfaffental	Contern	Esch sur Alzette
Funding	TPG	EU + TPG	EU + Holo	EU + Holo	EU + Keolis	EU + SLA	EU + SLA	EU + SLA
Start date of project	August 2017	May 2018	May 2017	August 2019	May 2017	June 2018	June 2018	February 2022
Start date of trial	July 2018	June 2020	September 2020	December 2019	November 2019	September 2018	September 2018	April 2022
Type of route	Fixed circular line	Area	Fixed circular line	Fixed circular line	Fixed circular line	Fixed circular line	Fixed circular line	Fixed circular line
Level of on-demand service*	Fixed route / Fixed stops	Flexible route / On-demand stops	Fixed route / Fixed stops	Fixed route / Fixed stops	Fixed route/Fixed stops	Fixed route / Fixed stops	Fixed route / Fixed stops	Fixed route / Fixed stops
Route length	2,1 km	38 hectares	1,3 km	1,6 km	1,3 km	1,2 km	2,3 km	1 km
Road environment	Open road	Semi-private	Open road	Open road	Open road	Public road	Public road	Main pedestrian road
Type of traffic	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Pedestrians, bicycles, delivery cars
Speed limit	30 km/h	30 km/h	30 km/h	30 km/h	8 to 10 km/h	30 km/h	50 km/h	20 km/h
Roundabouts	Yes	Yes	No	No	Yes	No	No	No
Traffic lights	No	No	No	No	Yes	Yes	Yes	No
Type of service	Fixed line	On demand	Fixed line	Fixed line	Fixed line	Fixed line	Fixed line	On Demand
Concession	Line (circular)	Area	Line (circular)	Line (circular)	Line (circular)	Line (circular)	Line (circular)	Line (circular)
Number of stops	4	> 35	6	6	2	4	2	3
Type of bus stop	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Bus stop infrastructure	Yes	Sometimes, mostly not	Yes	Yes	Yes	Yes	Yes	Yes
Number of vehicles	1	3-4	1	2	2	2	1	1
Timetable	Fixed	On demand	Fixed	Fixed	Fixed	Fixed	Fixed	On-demand
Operation hours	Monday-Friday (5 days)	Sunday-Saturday (7 days)	Monday-Friday (5 days)	Monday-Sunday (7 days)	Monday-Saturday (6 days)	Tuesday & Thursday Saturday, Sunday & every public holiday	Monday - Friday	Monday – Saturday
Timeframe weekdays	06:30 – 08:30 / 16:00 – 18:15	07:00 – 19:00	10:00 – 18:00	7:30 – 21:30	08:30 – 19:30	12:00 – 20h00	7:00 – 9:00 16:00 – 19:00	11:00 – 18:00 11:00 – 18:00
Timeframe weekends	No service	07:00 – 19:00	No service	9:00 – 18:00	08:30 – 19:30	10:00 – 21:00	No Service	On Suterday only
Depot	400 meters distance	On site	800 meters distance	200 meters distance	On site	On site	On site	500 m distance
Driverless service	No	2021	No	No	No	No	No	No
Drive area type/ODD	B-Roads	Minor roads/parking	B-Roads/minor roads	B-Roads	B-Roads	B-Roads	B-Roads/parking	
Drive area geo/ODD	Straight lines/plane	Straight lines/ plane	Straight lines/ plane	Curves/slopes	Straight Lines/ plane	Straight lines/ plane	Straight lines/ plane	Straight lines / plane
Lane specification/ODD	Traffic lane	Traffic lane	Traffic lane	Traffic lane	Traffic lane	Traffic lane	Traffic lane	Open area
Drive area signs/ODD	Regulatory	Regulatory	Regulatory, Warning	Regulatory	Regulatory	Regulatory	Regulatory	Regulatory
Drive area surface/ODD	Standard surface, Speedbumps	Standard surface, Speedbumps	Standard surface Speedbumps, Roadworks	Frequent Ice, Snow	Standard surface, Potholes	Standard surface	Standard surface	Standard Surrface

Table 2: Summary of AVENUE operating site (+ODD components)

1.3 Preamble

The working package 4, titled “Development, Adaptation and integration of Passenger Transport and in-, out-of-, vehicle services”, aims to design, develop, adapt and integrate specific services to support users of autonomous vehicles before, during and at the end of the trip. The main objective of WP4 is to provide services in order to demonstrate that, thanks to these services, the user experience can be seamless and secure, and that people embrace this new technology.

This deliverable is linked to task T4.4 that aims to integrate the AVENUE AM services into an existing Public Transportation service network. The deliverable 4.10 is a demonstrator of the developed and operated integration of AM services into an existing public transportation service. Such integrations were made within the AVENUE’s Copenhagen and Belle-Idée demonstration sites.

2 Copenhagen - On-demand integration

In the Slagelse context, the goal of the on-demand service is that the hospital staff can book trips for patients and visitors and that patients and visitors can book their own trips. Transportation between parking lots and other entrances is particularly helpful because of the large distances in the hospital area. The status of the trips booked are updated through the tool used by the hospital staff, so passengers can get information on when to expect pickup time. The safety steward greets passengers when the vehicle arrives at the pickup point and without any direct input from him, the vehicle begins its trip once the doors are closed.

The on-demand service was initiated with one vehicle, then followed by a second one once several technical issues were corrected, which involved:

- The update of Navya vehicle software to 6.1
- The Integration of the Holo system with Navya API
- The Integration of the Holo system with the dispatcher at Movia

The focus of these technical development and integration was to improve the stability and performance of the AM integration and of the new service created.

There was a lower focus on the development of mobile software applications and screen content, thereby limiting the investigations into the whole AM customer journey. This is in order to favour the technical development and achievement on back-end software (customer interfaces are owned by Movia). This priority was possible because the users who are booking the trips via the Movia interfaces will be the hospital staff and the passengers. The passengers will receive the necessary information from the hospital staff and the interfaces. Furthermore, the safety operator still has to be present in the vehicles and will be there to give the needed information to the users.

The practical test process can be briefly described as follows:

- Outline vehicle behaviour in all possible on-demand situations on Holo's test track in Copenhagen. Holo internally dispatches missions to vehicles.
- Outline vehicle and integration behaviour in all possible on-demand situations with missions received from Movia. Still on Holo's test track.
- Move to Slagelse and perform similar tests on the real route. Reach a satisfactory level of performance before servicing passengers.

2.1 Software integrations

In the illustration below, the technical components are presented. A main software component is the dispatcher, which matches passenger requests and vehicle capacity, by dispatching missions and thereby fully controlling the destinations of vehicle movement.

The dispatcher used is a piece of software that is currently being used for manual-driven transports. From Movia's point of view, this is a key point to test and learn about. The aim there is to include self-driving vehicles into the existing software architecture.

A couple of existing Holo products will be used to support the on-demand service.

- Holo's operator app in order for the safety operator to be informed about the incoming mission and passengers, but also to report issues manually for data analytic purposes.
- The supervision portal for remote monitoring and assistance.
- The end-user app for public information about the service and the project.

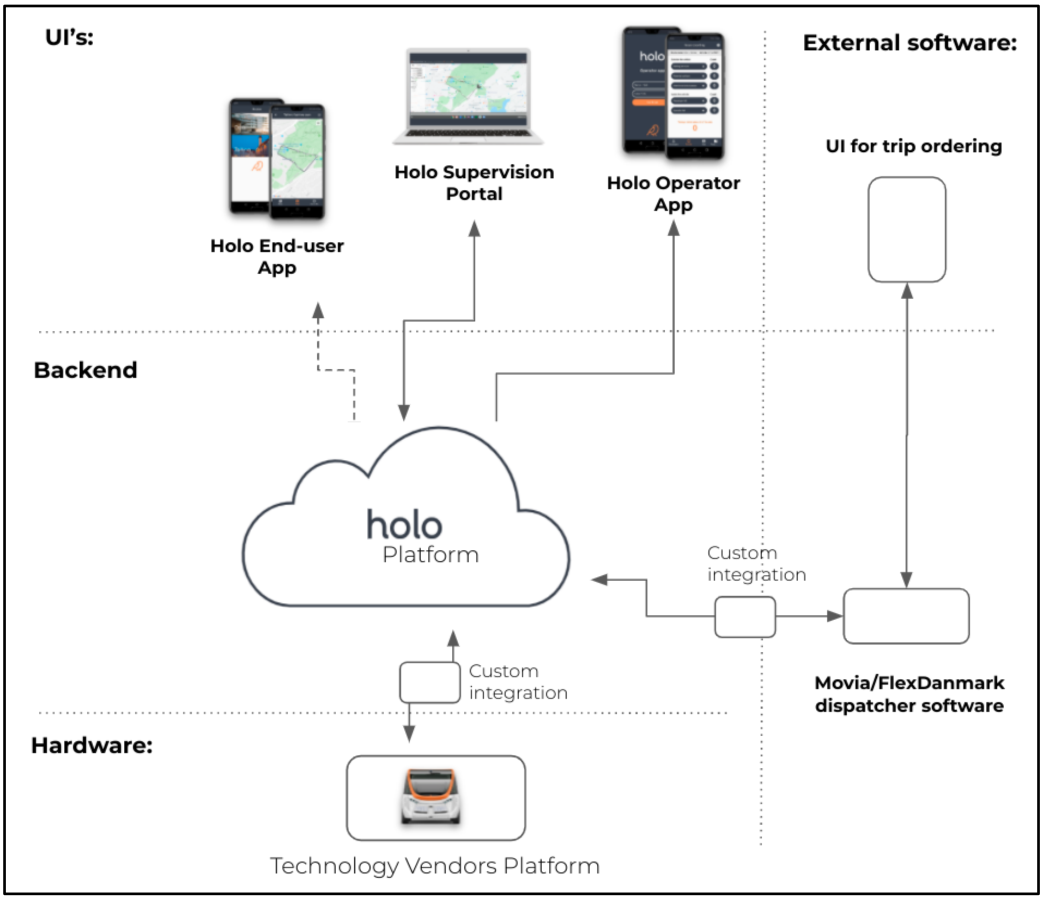

Figure 1 Systems and software integrations done in the Slagelse project

In the above illustration two integrations are shown. This is where most of the development work will take place.

- Navya API <--> Holo Platform
- Movia <--> Holo Platform

The task of coupling an on-demand service to a vehicle demanded a series of integrations. A middle layer is in this case added to support and works as a translator. A general-purpose dispatcher is used where the missions are translated into vehicle-specific language on Holo's platform. Also, the support function is located at Holo, which makes sense as it has the information from all components.

There are many learnings that were created from this technical setup:

- Introduction of AV's into standard dispatchers. What limitations will be met?
- Outlining the content and dependencies of the integrations?
- With this setup of an on-demand service, how well can it be operated?

N.b: receive a mission (demand) → forward a mission to the vehicle → vehicle execution.

2.2 Technical On-demand integrations learnings

2.2.1 Navya integration

The key takeaways for on demand integration with Navya are:

- Until mid/late 2022, Navya did not share the mission state/progress which means it was not possible to see if a mission was in execution state, deleted or finished. Holo, was then forced to estimate the mission state based on location and door state which overcomplicated things.
- The lack of Navya API stability at random moments. It was also impossible to scale-up without any agreement on API up-time and support.
- The safety stewards did not fit very well into the workflow of sending a mission/destination to a vehicle. In a best-case scenario, the vehicle starts driving without any notice inside the vehicle making it slightly uncomfortable for the safety stewards to use the on-demand mode, which technically is called the "Partner mode" in Navya language.
- Navya needs a lifelike simulator to build and test the on-demand integration. Holo had tested basic things on a real vehicle, which under optimal circumstances should have been tested in a simulated environment.
- Despite the challenges and the immaturity of Navya's on demand capabilities throughout the project, it has been extraordinarily instructive for Holo to be the middle layer/integrator putting the puzzle together to make things possible.

2.2.2 Movia integration (planet)

The dispatch management system used by Movia is called Planet and is provided by Flexdanmark. It is a widely used product that can serve many purposes. As with most dispatch management systems, it can dispatch trips from booking requests including many sorts of parameters like the number of passengers, the presence of luggage or special needs, etc.

An interesting thing about making some integration via Planet is that the communication is based on the SUTI (Structured Unified Transportation Information) protocol which is a Nordic standard for demand-responsive transportation that was built and targeted for manual-driven vehicles. A simple illustration is shown below.

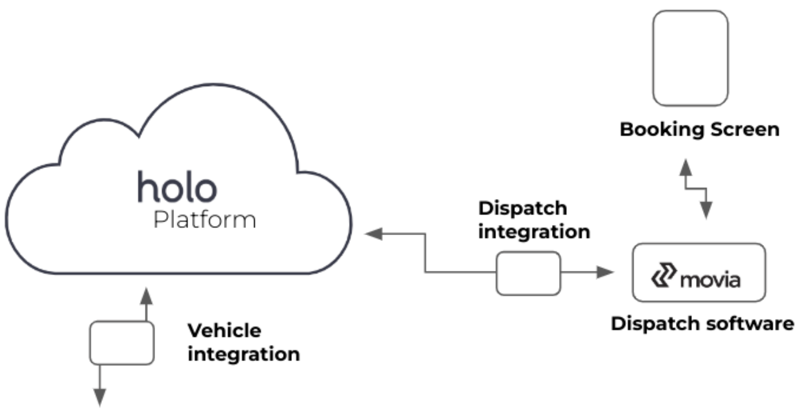

Figure 2 System description

The key takeaways for integrating with Planet using SUTI are:

- When using a protocol like SUTI, we are challenging its intended usage. Movia should involve Flexdanmark to a high degree for the support (and to take part in the learnings). Often the Planet system had behaviour that Movia was not able to explain, due to the different applications of autonomous vehicles.
- Holo has a role of middle layer, abstracting the communication from Planet to the vehicle. Standardized communication protocol is really the way forward for the dispatch software suppliers. However, there is a long way to go and if the SUTI protocol is not modified/updated because in its present form it's hard to include it within autonomous vehicles systems. The main reasons are:
    - The contents of the messages need to be human-readable; a much more stringent and limited amount of content in the messages is needed.
    - The inability to publish the state and progress of the vehicle back into the system.
    - SUTI and Planet need to take some of the limitations of autonomous vehicles into account.
- Holo as an operator needs the possibility to investigate Planet to see the booking requests made on the booking screens.
- There is a need for a support hotline that Holo can contact when the autonomous vehicles are not behaving like the Planet system is expecting.

2.2.3 Booking screen integration (MultiQ)

The booking screens are physical touch screens placed at each stop. Here any passenger can order a trip from the bus-stop they are to the destination they choose. The trip is confirmed and an ETA for pickup is shown to the passenger. The software running on the screen belongs to MultiQ, a partner of Movia, who chose this supplier for the Slagelse demonstration site.

Figure 3 Booking User interface of AMobility integration

The key takeaways with these ordering screens are:

- Do not use an experimental setup for a pilot project (well-known/tested equipment is needed). Indeed, enough challenges are present in a project like this to begin with.
- As Planet does not know the exact progress of the vehicles, the ETA presented on the screen are not precise enough. It's not the screens or the supplier's fault, but customers want precise information.

2.2.4 User experience learnings

- **Patients**
  Moving patients from A to B on a hospital site has proven to be a very good use case for the Navya vehicles, as patients often do not need high speeds but rely on comfort and the ability to be moved. This means that even if the AMs' top speed is 18 km/h the patients still consider the service as a high-value one (as the alternative would be to walk or wait for local flex taxis, etc).

- **Relatives/visitors**
  Being a patient relative visiting a hospital site is often associated with difficult parking conditions and lots of walking on the hospital sites. With the service provided in the AVENUE project, relatives and visitors have had the opportunity to park in large parking areas away from the hospital entrances before being carried by the shuttle to the entrances. Meaning less congestion and car hassle at the entrances of the hospital, allowing the emergency vehicles to have more space and less reckless parking from visitors.

- **Employees**
  As for the relatives and the visitors, the employees have used the shuttle service to get from larger parking areas to the entrances of the different departments, but also to escort patients from one department to another, cutting off time from walking and waiting on flex taxis.

3 Belle-Idee – TPG-Flex integration

TpgFlex, is the on-demand bus service developed by the TPG (inspired by the AVENUE services). The service is fully integrated in the TPG system and is accessed via the TPG mobile app (as the service requires a reservation). It mainly serves the Champagne region of the Canton of Geneva (the communities of Aire-la-Ville, Avully, Avusy, Cartigny, Chancy, Laconnex, Soral and as far as Viry -France) and the train station of La Plaine (Dardagny), as well as the Belle-Idée site. In the Champagne area the service is offered with traditional thermal or electric driver-based vehicles, while in Belle-idée the service is supported by AMs.

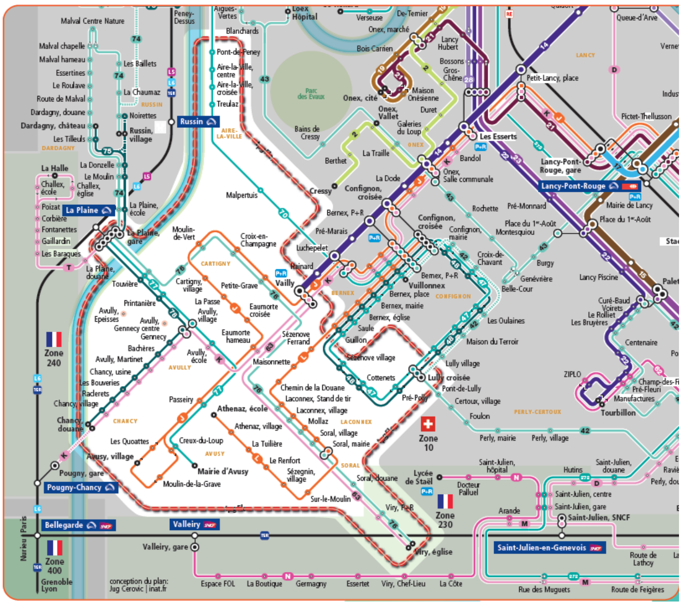

Figure 4 TPG Flex main deployment area

TPG extended their platform to incorporate the on-demand services and developed the TPG Flex mobile app, which is fully integrated into the overall transport service. The service allows citizens to reserve on-demand travel with small buses. The TPG offer is accessible with unireso tickets (that is the integrated Geneva canton public transportation ticket) for journeys within the canton of Geneva (season tickets and tickets valid in the unireso zone 10 perimeter). The TPG-flex also serves Viry in France, but with the Léman Pass ticket (season tickets and tickets valid in zone 230 + unireso zone 10).

The Belle-Idée site service was integrated in the TPG-Flex, using the same interface and procedure.

3.1 Integration to the TPG system

The on-demand services offered by AVENUE at the Belle-Idée site became part of the new service model of TPG, where the on-demand service will be expanded to cover a very large part of the Geneva canton. The integration of on-demand services (and obligatory use of the dedicated mobile app) was achieved as an extra layer of the existing system.

3.2 Ticketing

The ticketing issue was solved using the standard Geneva Canton model, where a ticket is valid for all public transportation for 60 minutes. No differentiation was introduced by the on-demand services. This allowed the seamless integration of on-demand requests, without introducing any complexity for ticket calculation based on distance or other criteria. In addition, the ticket control was also based on the existing model, with random verifications from mobile teams.

3.3 User Interface – Mobile App

The mobile app allows the user to reserve based on a specific bus stop. The bus will then arrive within a maximum of 15 minutes and this whatever the time of the day.

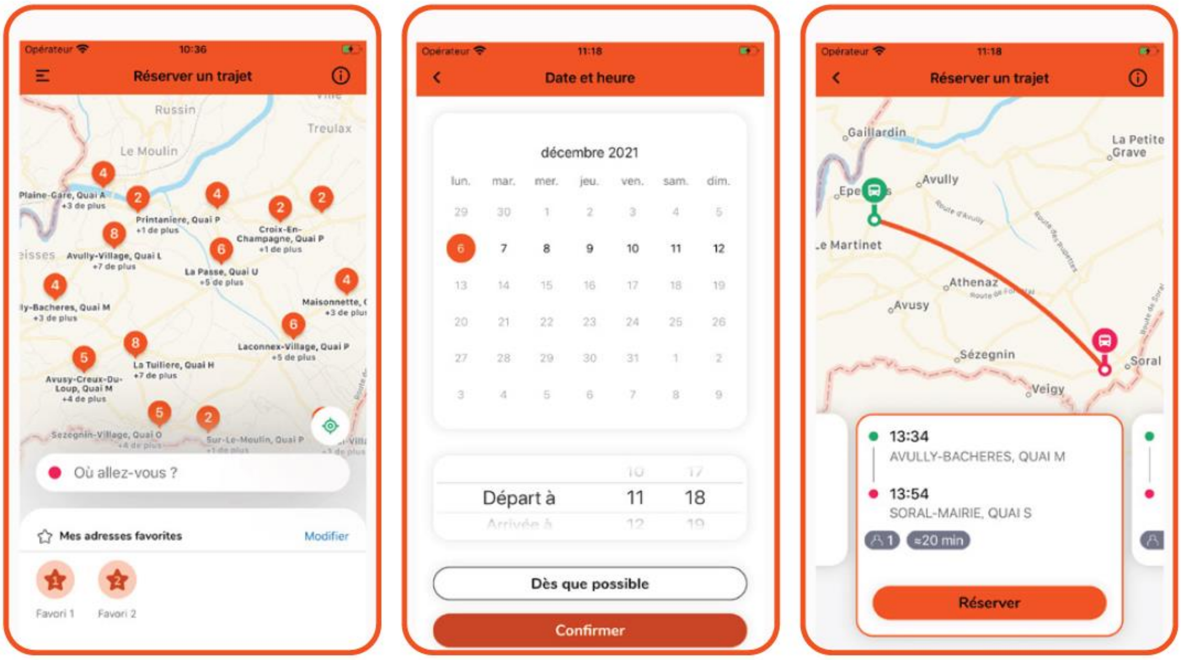

Figure 5 TPG Flex Booking app interface.

3.4 User experience

The seamless integration to the TPG system, pushed the acceptance of the service to all potential users. The user experience is very positive, especially with women, who constitute 80% of the users. Students are also very positive, since before the service there were gaps in the timetable and a student had to wait more than an hour to catch the next regular bus.

The municipal authorities are also very positive, since it offers a better quality of service, reducing at the same time the pollution from the empty buses circulating during low demand hours.

3.5 Future plans

The next step is to replace the driver buses with driverless ones, and to expand the service to other areas with low transport demand (as it was targeted by the AVENUE project).