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The Urban Lab of Europe !

# The TUPPAC Project Journal N°1

*Project led by the city of Albertslund*



**URBAN  
MOBILITY**

# The TUPPAC Project

Mobility is a top priority and also a top challenge for many cities. On the one hand there is a need for people and goods transport to support living, work, and business. On the other hand mobility, and in particular private (single occupied) cars, are occupying space and causing emissions and congestion. Those challenges will be even more pronounced in the future, as the urban population is expected to nearly double by 2050. The only sustainable solution to future the mobility challenges in urban areas are shared services based on high capacity public transport complemented with feeder services.

In city centers, the transportation demand is often large enough to have effective high capacity public transport networks based on metro, commuting trains and buses. Farther out from the city center, in the suburban regions the transport demand is distributed over larger areas. A commuting train can connect the suburb to the city center, but the distance from homes or work places to the commuting stations are experienced to be too long. As a consequence, in the suburban regions public transport usage decreases and car usage increases.

The TUPPAC project addresses this challenge of increasing usage of public transport and shared mobility in the suburban regions, by investigating and demonstrating how driverless shuttles can be linked to a high capacity light rail line. By using electric, driverless shuttles the operational costs per vehicle is expected to be significantly lower than for traditional, manually operated buses. Therefore, a larger number of vehicles can be used to provide the first/last kilometers service that connects the suburban areas to the high capacity public transport line.

In TUPPAC, the shuttle service will be tested at two sites with different characteristics: the DTU campus area where speeds are low, streets not so occupied, and students are the main target group; and the Albertslund industrial area with higher speeds, more occupied streets, and a more diverse user group. A demand-responsive service and a smartphone application will be developed and tested in the project.

One interesting aspect of the TUPPAC project is that the light rail is currently about to be built. The route is set, the decisions are made, and the light rail will begin to

operate in 2025. This means that the development of the areas around the new light rail stations is currently going on. Therefore, the TUPPAC solution, with the driverless shuttles, can be a part of the urban planning process already from the beginning.

The partners and their role in the TUPPAC project are presented in Figure 1.

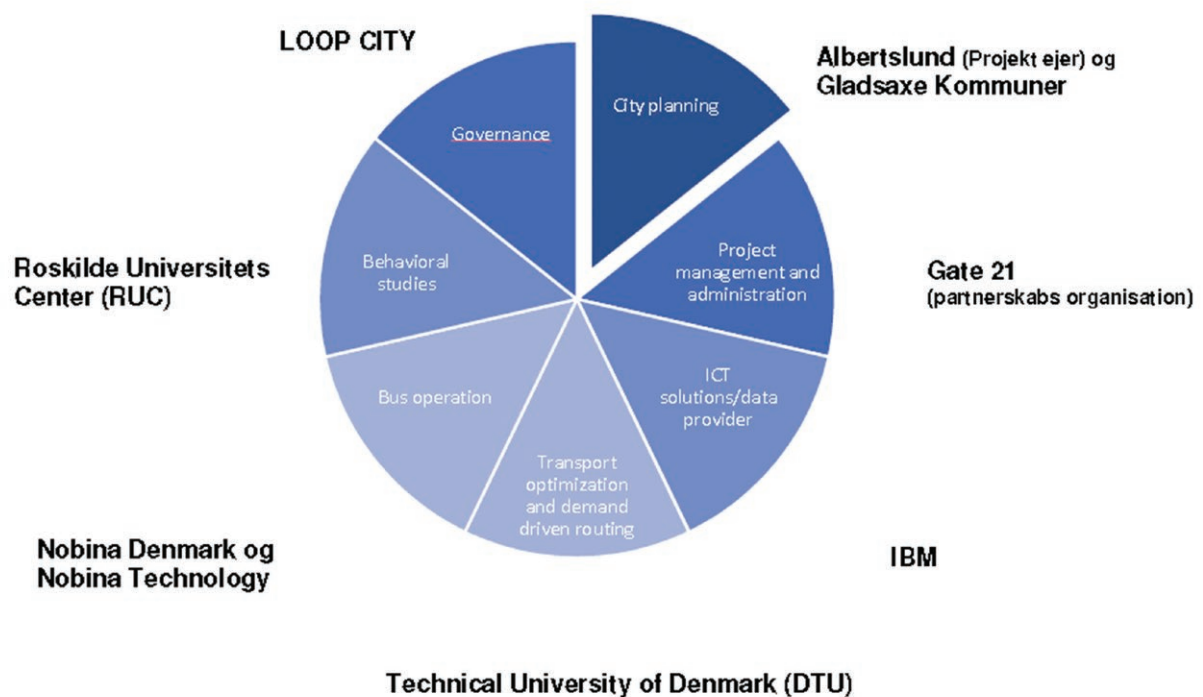


Figure 1. The TUPPAC partners and their role in the project.

### Partnership:

- Albertslund Municipality and the neighbour municipality of Gladsaxe
- Nobina Denmark
- IBM Danmark ApS
- Technical University of Denmark
- Roskilde University
- LOOP CITY
- Gate 21

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# 1. Executive Summary

Transportation and mobility causes congestion and environmental impacts. Therefore, sustainable mobility is a top priority for many cities in Europe and globally. In particular, mobility in suburban regions is often heavily dependent on car usage.

The TUPPAC project aims at exploring how driverless shuttles (mini buses), as a complement to high capacity transport, can contribute to a sustainable, attractive city that is less dependent on car usage. To reach this the TUPPAC project has for main goals: 1) To procure three driverless shuttles and obtain legal permit to operate on public streets in Denmark, 2) To design and build a demand responsive service, 3) To demonstrate the service in on public streets, in two different test sites with 2000 invited test users, and 4) To synthesize the knowledge created in the project into a vision

and strategy for implementing shuttles as a complement high capacity public transport.

Project partners are: Alberstlund and Gladsaxe municipalities, LOOP city – collaboration organization for municipalities along the light rail under construction around Copenhagen, Gate21 – non-profit organization for public-private partnership in the region, IBM – ICT solution provider, Technical University of Denmark (DTU) – competence in transport optimization, Roskilde University Centre (RUC) – behavioral studies, Nobina – public transport operator.

This report is the first of a series of journals following the TUPPAC project. It outlines the context for the project on international and national level, describes the key components of the project, and describes the challenges for TUPPAC.

This journal is authored by Dr. Anna Pernestål, UIA Expert for the TUPPAC project.

## 2. The context for TUPPAC

### 2.1 Urban mobility challenges

Transportation accounts for 20% of CO<sub>2</sub> emission globally. In cities there are also challenges with local emissions affecting air quality and noise. Single occupied cars contribute to emissions and congestion, and congestion levels of 30-50% are common in European cities<sup>1</sup>. The challenges for urban mobility are expected to be further increased in the future. Today (2018) 55% of the world population to live in urban. UN predicts this number to increase to 68% by 2050. At the same time, the cities are struggling with making that are attractive and “livable”, with focus on people rather than cars.

Mobility of goods and people is crucial, and shared mobility is the only sustainable solution. To achieve effective shared mobility solutions, they should be based on high capacity collective transport where demand is high. However, this is a challenge in the suburban regions, where the distance to the collective transport is longer and the frequency of the local buses typically is lower. For a long time, using the car has been the only solution in these regions.

### 2.2 Technical development

New technology, such as digitalization and automation provides new opportunities for mobility with driverless cars and vehicles. There are several potential paths for the development of driverless vehicles: automation can be used to make (private) cars more attractive and useful, to provide shared taxi services (leading to more cars on the road), or to complement and improve high capacity public transport by providing feeder services. Research studies show that the first two of these alternatives will be attractive to users, but at the same time significantly increase the vehicle kilometers travelled. The third alternative, to complement public transport, provides a sustainable solution.

The idea of using shuttles, i.e. driverless bus-like vehicles designed for about 6-12 passengers,

providing first/last kilometer solutions to public transport has been discussed in Europe during the last ten or so years. Tests and demonstrations have been performed in several sites in Europe, but so far the tests have primarily had technical focus and operated shuttles in fairly easy traffic back and forth.

Driverless vehicles have gained a lot of focus the last few years, both IT companies and vehicle manufacturers have shown driverless vehicles and communicated visions of a driverless future. In short: the expectations on driverless vehicles are high! At the same time, research about user's acceptance and willingness to use driverless vehicles show that users are concerned about the safety and security of such vehicles and may not be willing to use.

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<sup>1</sup> Congestion level is the increase in overall travel time compared to an uncongested situation.

To summarize: the technology is promising, but there are challenges: 1) will the technology be ready? 3) will users accept driverless vehicles,

and 3) will the TUPPAC concept with shuttles complementing public transport be sufficiently attractive compared to driverless cars?

## 2.3 The view from Albertslund

In Denmark, municipalities have a relatively large responsibility in the urban and social development (compared to regional and national levels). Creating and building cities that are attractive with humans in focus, is highly prioritized.

In 2002 the metro in Copenhagen opened for operation, and it was completed with a line to the airport in 2007. The metro improved the high capacity public transport in the central parts of Copenhagen, and now focus has shifted to development in the suburban regions. One important step in this development is the 28 km long Light Rail that will pass through 9 municipalities and have 29 stops (<https://www.dinletbane.dk/in-english/stations-and-trains/>). The new light rail provides many opportunities for the municipalities, and the collaboration network LOOP city was formed to utilize these opportunities.

One of the 10 municipalities in LOOP City is Albertslund, where the goal is to grow from 25.000 inhabitants today to 15.000 inhabitants in the coming 10-15 years. Their vision is to create a sustainable, “liveable” city, with a decreased need for and use of private cars. In particular, Hersted industry park is one development area. The business park is currently a traditional industry area, hosting more than 400 businesses.

It is also the home of DOLL Living Lab, one of the largest test centers for urban light and smart city technologies in public environments. Today, transportation within and to and from Hersted is largely performed with cars, and significant amount of land is used for roads and parking. With the light rail, a new station will be built in one side of the business area. The ambition is to use the opportunity brought by the Light Rail to develop the Hersted area, and using the TUPPAC project to explore how new mobility solutions can become a part of the urban planning strategies.

Ambitious innovation projects like TUPPAC, that explores new technology and also taps into urban planning and policy making, are challenging. For Albertslund municipality there are several factors in the context that provides a good platform for being successful in this task: the LOOP city collaboration platform, the experiences from DOLL living lab, and the fact that the Mayor of Albertslund is also leading a network where several municipalities are collaborating with the aim to develop metropolitan Copenhagen (also beyond the light rail). Furthermore, the partners in the TUPPAC project already have experiences of collaboration between academia, authorities, and industry in the Gate21 organization.



## 3. The TUPPAC concept

### 3.1 What is the aim?

The aim of TUPPAC is to explore how driverless shuttles, as a complement to high capacity transport, can contribute to a sustainable, attractive city that is less dependent on car usage.

To reach this the TUPPAC project has for main goals:

- 1) To go through the procurement and approval process for driverless shuttles, to procure vehicles and make them ready for operation. As the driverless technology is new, also the legislation and approval processes are new and under development and going through these processes is a learning process in itself, both for the applicants and the approving authority.
- 2) To design and build a demand responsive service, including driverless shuttles and a smartphone application. The system will be prepared to collect user and vehicle data to optimize the routes.
- 3) To demonstrate the service in on public streets, with 2000 invited test users. The service will be demonstrated in two different sites, with increasing complexity. The aim is to fulfill a real transportation tasks for the user.
- 4) To share the knowledge created about the physical and digital infrastructure required for driverless shuttles and sustainable city development to city planners. In particular, to synthesize the knowledge created in the project into a LOOP city vision and strategy for implementing shuttles as a complement to the light rail in the 10 municipalities.

### 3.2 Which are the key components?

To reach the aim, TUPPAC project has four key components.

The **driverless shuttles**. Three driverless shuttles are procured in the project. The type of shuttles that will be used are shown in Figure 2. The next step is to apply for permit to operate them on public streets, test them and make sure that they operate safely. Nobina, the operator of the busses are responsible for this task. The approval process in Denmark requires an external assessor.

The **mobility service** and the smartphone application. This component involves both the actual smartphone application, but also the design of the demand-responsive service.

Designing a demand-responsive service includes several parts, including: deciding which roads and routes to operated, where passengers should be allowed to get on or off, setting the rules for how trips are ordered, and developing the route optimization algorithm.

Operation at the **DTU test site**. The 106 ha DTU Campus has 11,200 students and 6,000 employers, and more than 100 buildings. There will be a light rail station at DTU, but as that is not ready yet, the service will connect to today's bus stops with different places at the campus. The line can also be used for internal transportation at the campus area. The DTU route is 3.3 km long and is shown in figure 3. At DTU the shuttles will operate in





Figure 2. The shuttles that will be used in TUPPAC – photo credit @Easymiles

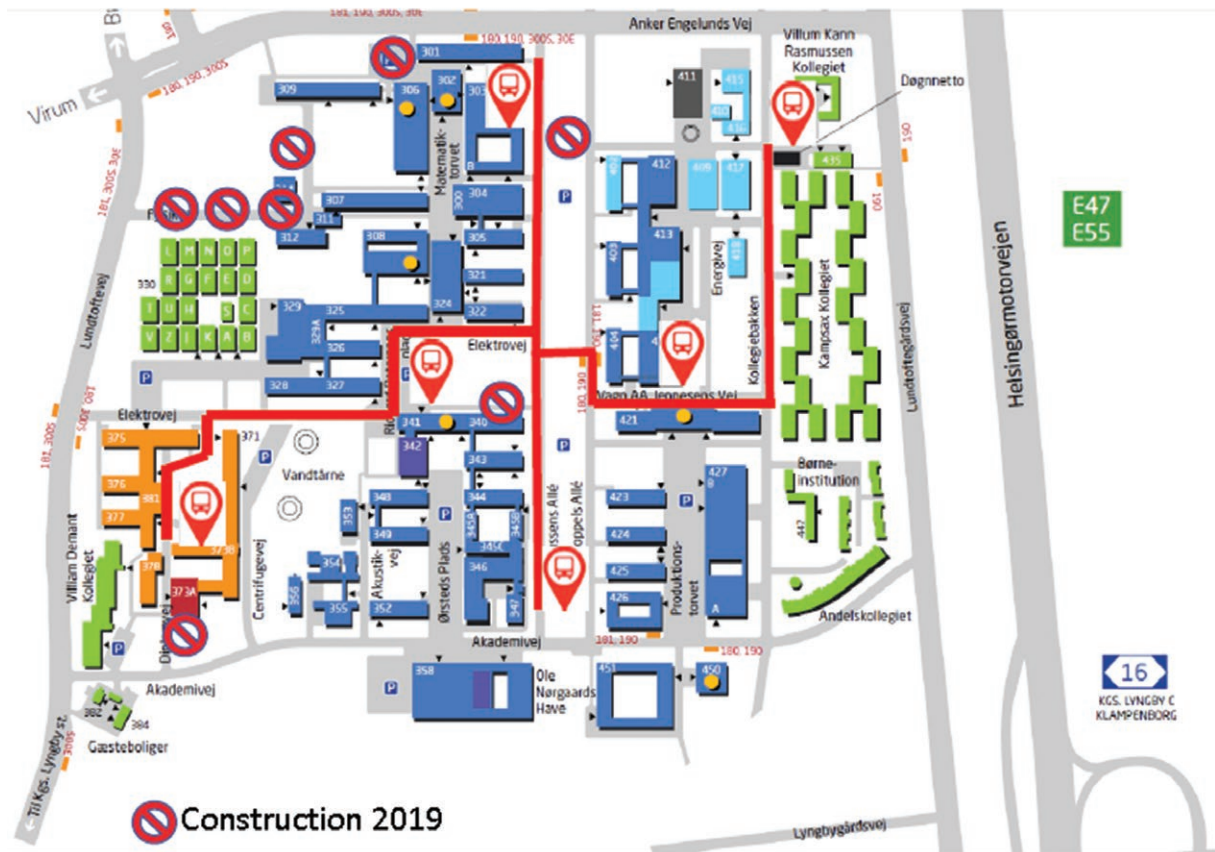


Figure 3. The DTU Campus test routes.

mixed traffic, but the speed is relatively low and the traffic situation is of reasonable complexity.

Operation at the **Albertslund test site**. In Albertslund, the 160 ha industry park Hersted is selected to be the test site. Within Hersted there are more than 10.000 work places. The route for the Albertslund test site is not yet planned in detail. The long term goal is to connect to the light rail station, but the light rail will not be in place until 2025. Therefore, other relevant use cases are currently discussed. As the area is large, routes of different complexity can be chosen.



*Picture from Hersted industry park in Albertslund municipality.*

### 3.3 Stakeholders

There are five main groups of stakeholders and actors in the TUPPAC project. Except for the users, all stakeholder groups are involved in the project.

The **users** of the service. During the project time there will be selected users, around 1000 users per site, that will get access to the service and the application.

The **Employers, business owners and facility owners** in the area. At DTU the employer/facility owner is part of the project team and sees great potential in this service, since there are many employees and students moving around in the area. In Hersted industry park the role of the business owners and employers is currently less clear, but the project is working on investigating and defining it. This stakeholder group will most likely be part of the business model during the upscaling of the TUPPAC service both in Hersted and in the other municipalities in Copenhagen area, as the shuttle service provides services to their employees. Their exact role is a topic for the project to investigate.

The **service suppliers**, i.e. the organisations delivering the service. Both the operation of the vehicles, the on-demand service including the

mobile application. One of their main challenges is to develop a service that the users accept, while the paying customers are (at least to a large extent) other organizations (municipalities and/or the group above).

The **municipalities**, with their aim to use driverless shuttles as a tool for creating attractive and sustainable cities. More concrete, in the TUPPAC project the aim for the municipalities around the new light rail is to utilize the light rail to change and grow. The light rail, provides new opportunities to build new houses for living and create new work places. Furthermore, the light rail combined with the shuttles, can provide a sustainable transportation without car-dependency. One main challenge for the planners in the municipalities is to meet the needs from different modes of transportation, so that heavy trucks, cars and shuttles can share the same street space.

The **researchers**, that uses the project to increase the knowledge about optimal routing, on-demand services, and user behavior and acceptance. This is important channel for the project to share knowledge world wide.

## 3.4 Innovation, Challenges, Risks

### Overview of challenges

An overview of the established UIA, as well as two identified project specific challenges, is presented in Table 1. In the table, the levels of the challenges are classified as follows: Red level challenges are important issues that are necessary to focus on during the coming six to

twelve months. If not resolved, they may impact the project result. Amber level challenges either have a plan or that are potential show stoppers later in the project. Green level challenges have plan or platform in place to mitigate them. The main challenges (red level) are further discussed below the table.

**TABLE 1: MAPPING TUPPAC PROJECT AGAINST THE ESTABLISHED UIA CHALLENGES AND IDENTIFIED PROJECT SPECIFIC CHALLENGES**

UIA Challenges		
Challenge	Level	Observations
Leadership for innovation	Low	The TUPPAC project has strong political support at several levels. Municipalities recognize the need for development and the opportunities of the light rail complemented with driverless shuttles to improve cities and mobility. Albertslund municipality has the experience in working with technical innovation in public environments in the DOLL living lab.
Public Procurement	Low	The main procurement in the TUPPAC project is the three shuttles and the assessor service. This procurement took longer time than expected and has delayed some activities in the project with a few months. However, at the time of writing this journal, the procurement is finished, and the vehicles are expected to be delivered in the beginning of 2019.
Integrated cross-departmental working	Low	LOOP city provides a well-established network for collaboration between the 10 municipalities along the planned light rail. This network provides a good platform for the uptake of the project results. Most of the project partners are partners in Gate 21, so relationships are already established. The experience from the site visit is that all project partners, representing a wide variety of stakeholders and perspectives, are engaged and involved in the project work.
Adopting participative approach	Medium	The TUPPAC project is still in the phase of preparing for the tests. The vehicles have been procured and focus has been on getting the permit to operate the vehicles on public street. Therefore, users are not yet involved in the project.  The development of the service (including the app) will start during the fall. At this point it is important for the TUPPAC project to find the right balance between user involvement and technically driven innovation. To meet this, design workshops involving users, designers and developers are planned.



Monitoring & evaluation	High	The vision and targets for the TUPPAC project are set high. The challenge for the project is now to make the aims and goals concrete, and to identify measurable KPI's that monitor the projects progress towards the goals. These KPI's will also be important for design choices and prioritizations during the project.
Financial sustainability	Medium	The TUPPAC project aim to test a completely new solution for public transport, and the business models are not clear. Who are the users, and who is the customer? However, business models and future business opportunities are appointed as one of the main questions to investigate during the project.
Communication with target beneficiaries	High	Politicians, municipalities, city developers and users have very high expectations on what driverless shuttles and on-demand services, as well as the TUPPAC project can and will deliver. As the technology is still under development and the TUPPAC project is one of the first attempts to deploy these services, the high visions will not be met. Communication with target beneficiaries to manage expectations and explain how the gap between the TUPPAC services and the vision is crucial.
Upscaling	Medium	The model for service and operation is not set yet, but a part of the project. One important question for the project to address is whether the service will be suitable for upscaling. This also relates to the financial sustainability.  If the service is found to be suitable for upscaling, The LOOP City collaboration network provides a good platform for sharing of learnings and facilitate upscaling.

### Project Specific Challenges

Technical readiness	High	The technology that is aimed to be put on the streets, including driverless technology and the algorithms for on-demand service, is still under development. There are questions about whether the on-demand technology will be good enough to meet the expectations of the users.
Legislative readiness	Medium	As driverless vehicles are a new phenomenon on public roads, legislation approval processes are under development. To mitigate this risk, Nobina uses their experiences for getting approvals from authorities in Norway and Sweden. The project also collaborates with another project in Denmark currently going through the approval process. There is a risk for delay in the start of operation at the DTU campus.

## Monitoring & Evaluation

The project will be able to operate the shuttles and collect user data as well as learnings also with a basic monitoring plan. However, the aim with the project goes beyond just operating driverless shuttles: the ultimate goal in TUPPAC is also to understand how the shuttles can complement the light rail and support the

development in the municipalities. To reach this goal, a thought-through monitoring and evaluation plan is needed. The challenge lies within transforming the project partners' visions and goals to Key Performance indicators (KPI:s), so that relevant things are monitored. The vision and targets for the TUPPAC project are high, and the potential of the shuttles and the on-demand service is recognized as high by all stakeholders.

However, although the overall vision is shared by all project partners, they all have different perspectives on this vision as they represent different stakeholders.

Currently, the challenge for the project is to make the vision concrete, and to identify in detail how the project results can support the vision and the creation of the LOOP city strategy for implementation of sustainable shuttle services to complement the light rail. When that is done, measurable KPI's that monitor the projects progress towards the goals should be identified. A clearly defined vision, together with the KPI:s will also support the project in decisions during the test design for DTU and Hersted.

This challenge is recognized by the project, and the project is currently working on defining a hierarchy of success criteria, and from there identifying relevant KPI:s.

### Communication with target beneficiaries

With LOOP city, the engagement from the municipalities of Gladsaxe and Alberstlund, and the role of Gate 21, the TUPPAC project has several established platforms for communication with municipalities and cities. The project has started to prepare a showroom for the project, in the same hall where the vehicles will be parked during nights in the Hersted test site. Communication channels with users will be built up during the project.

The challenge within communication is related to what to communicate, and to expectation management. Politicians, municipalities, city developers and users have very high expectations on what driverless shuttles, on-demand services, and in particular the TUPPAC project will deliver. Having a vision for how the shuttles can be used

in sustainable urban design is important to push development and to realize the potential with the new technology. At the same time, the technology is under development and it is likely that the high expectations will not be met. Therefore communication must be made so that the vision is explained, while at the same time it is clear what can be expected by the services at the test sites, and how the gap between the demonstrated services and the vision can be filled in the future. This challenge is related to monitoring and evaluation.

### Technical readiness

The TUPPAC project is technologically innovative from two aspects. Each of them has its challenges, and overcoming these challenges is crucial to get a successful project.

First, the technology of operating driverless shuttles on public streets is still not mature (despite several previous tests). In particular, TUPPAC project is aiming to solve real transportation challenges, meaning that the users of the service will have real transport demand. There are several challenges related to operating the vehicles in this challenging environment.

Second, TUPPAC aims to operate an on-demand service. Although on-demand services with driverless shuttles has been discussed and investigated in research for several years and there are numerous simulations, the real trials are still very limited. Thus, previous experience on how to design and operate on-demand services is very limited. The first step is to build the app that should also be user friendly, and to tune the optimization algorithms. Building an on-demand service is much more than only build a mobile application – it is also about understanding user expectations and practices, and setting rules for the service.

These challenges are recognized by the team, but there are still many open questions:

- Will the driverless vehicles be able to operate in the complex environments?
- Will the mobile application be developed to meet the challenge of on-demand service?
- Will the users accept and adopt the on-demand service?

To minimize this risk, the project has planned to create a “technical sand box environment”. The vehicles will arrive to Denmark before

the permit for operation on public streets will be finished. While waiting for the permit, the plan is to test the buses in a closed-off area to understand how they operate. Furthermore, Nobina in Sweden has experience from operating the same type of vehicles on public streets and this knowledge will be transferred to the TUPPAC project. Furthermore, TUPPAC has several skilled research teams involved in the project, focusing on route optimization as well as user behavior. This knowledge, combined with the experience of applications in production that IBM has provides a good platform to meet the technical challenges.

## 4. Early learning points and next steps

### 4.1 What progress has been made so far?

- Setting the collaboration framework. During the first phase of the project efforts are put into setting the collaboration framework in the project, and defining in detail the roles of the different partners, and setting up the project internal communication structures.
- Getting the vehicles. One important milestone that is reached is the selection of the vehicle supplier and the procurement of the vehicles. The EZ10 vehicle from Easymile is selected, and will be delivered early in 2019. According to Danish law, an external assessor needs to be used in the approval process. The contract with an assessor is now signed.
- Defining the route at DTU Campus. The route at DTU campus is set in detail together with the DTU facility owner and the researchers working with route optimization. Selecting the route may sound as an easy task, but there are several perspectives that should be taken into account: the roads and bus stops should be manageable for the vehicle to operate on (i.e. not too complex), the bus stops should be at relevant positions for



*Example of the route at DTU.*



the users so there is a travel demand, the route should be designed to be relevant for testing on-demand services. In addition, road works due to the construction of the light rail are planned at the DTU campus and has impacted the routing of the shuttles.

- Review of research literature. To increase the competence level of the project team members a review of research literature

focusing on opportunities and risks with driverless vehicles and their implications on policy making and planning has been performed. The main conclusion is that in all central aspects – road capacity, energy consumption, increased accessibility, and traffic safety – the literature points on both opportunities and risks, and that the learnings from the real trials in TUPPAC project will also fill research gaps.

## 4.2 Take-aways from TUPPAC so far

Sustainable mobility in attractive cities is a top priority for many cities. Although TUPPAC is in the preparation phase, there are some early learnings that can be made from the project.

- The vision about “sustainable future mobility” differs between different stakeholders and organizations, and different stakeholders put different meanings into the same words and phrases. To achieve a common understanding, time needs to be spent on understanding each other’s visions. In innovative projects there are often many different aspects that the project can explore and develop, and things tend to take longer time than expected while the time and/or budget is limited. Then it is important to be prepared to prioritize among the different questions the project aims to answer: is it more important to test new technology, to test new services, or fulfilling the users’ real demands. In the TUPPAC project, the municipalities is the problem owners, and as such they should be the ones indicating the direction without closing the doors for the other partner’s skills and innovation. Harmonizing the roles in the projects may take time, in particular in complex projects such as TUPPAC where mobility is not just
- seen as mobility but also as a part of urban planning and development. At the same time, it is this aspect of mobility that makes the TUPPAC project unique.
- The legislation related to operating driverless vehicles on public streets in Denmark is preliminary and newly implemented. As per today, no application has completed the process of applying and obtaining permit, and the TUPPAC project is one of the first going through. Furthermore, there are two different authorities involved, one responsible for homologation and one responsible for approving the driverless operation. This means that the way forward is not always straight, and the application process has taken much time for the project. TUPPAC project has gained by collaborating and sharing insights with other projects, both in Denmark and in the other Nordic countries.
- One unexpected learning is the challenge of choosing a suitable project acronym. In the TUPPAC project it was realized that the project name related to Tupac (2pac), a renowned and criminalized American rapper that was killed by a drive-by-shooting in 1996. This correlation was completely unintended and unwanted by the project,

who decided to change name to LINC. LINC relates to the service and the aim of the project in many ways, including the aim that the project has to provide a link between

the new light rail and the business in the municipalities. Therefore, in the future, the project will be referred to as the LINC project.

## 4.3 Next steps

This journal has provided a baseline for the TUPPAC project, presented the solution the project is providing, and discussed the main challenges for this project. Focus of the first part of the project has been to procure the vehicles and start the process to get the approval for the vehicles. These

steps are now passed, and focus will now shift into designing the first test at DTU campus in more detail and on developing the mobile application. In the next journal of the TUPPAC project, produced in the spring 2019, we will explore the TUPPAC service and the DTU test site further.

Urban Innovative Actions (UIA) is an Initiative of the European Union that provides urban areas throughout Europe with resources to test new and unproven solutions to address urban challenges. Based on article 8 of ERDF, the Initiative has a total ERDF budget of EUR 372 million for 2014-2020.

UIA projects will produce a wealth of knowledge stemming from the implementation of the innovative solutions for sustainable urban development that are of interest for city practitioners and stakeholders across the EU. This journal is a paper written by a UIA Expert that captures and disseminates the lessons learnt from the project implementation and the good practices identified. The journals will be structured around the main challenges of implementation identified and faced at local level by UIA projects. They will be published on a regular basis on the UIA website.



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