

November 2019

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The Urban Lab of Europe !

The LINC (TUPPAC) project Journal N° 3

Project led by the City of Albertslund



**URBAN
MOBILITY**



The LINC - TUPPAC Project

The Transforming Urban Planning Providing Autonomous Collective mobility (LINC/TUPPAC) project will test electric autonomous shuttle busses as a solution for the first and last mile “mobility gap”. Four driverless vehicles will be tested, for the first time, to ensure the link to and from two pilot Light Rail Transport (LRT) stations built in the framework of the new LRT infrastructure of the Greater Copenhagen Region. During the controlled deployment of the vehicles, partners will be able to design the control systems, demonstrate the overall feasibility in two different urban environments while collecting and analyzing feedback from users on three key aspects such as scheduling, routes and communication. Special attention will be given to how pedestrians and cyclists experience interactions with the autonomous busses as well as to user experiences regarding in-buss safety, service inclusiveness and reliability. The knowledge generated during the testing phase will be used to integrate recommendations and guidelines for urban planning to incorporate autonomous busses as collective mobility services in a new Sustainable Urban Mobility Plan for the metropolitan area.

Partnership:

- Albertslund Municipality
- 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

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

This third UIA journal describes the progress of the LINC-TUPPAC during the last six months. It has a special focus on challenges with running complex innovation projects involving new and pre-mature technology. The journal discusses the main challenges within the project so far, and how the project is tackling them.

The most important issue in the LINC – TUPPAC during the last six months has been the work with the application to get legal approval to drive the self-driving buses on public streets. The process has taken a longer time than expected since the legislative process is new in Denmark, and the project is one of the first to apply for such approval. Therefore, the project had to send additional information to the approving authorities several times. The project is still waiting for approval, so the tests on public streets will be further delayed.

At the same time, the project is preparing on all other fronts so as to be ready for starting the test when they get the approval. For example, a smartphone application for the users to access the mobility service and for the researchers to collect data has been developed. The project plan and test plan has been revised and updated. Furthermore, the delays have given the project members time to harmonize their expectations in the project.

Currently, there are three main challenge areas for the project: upscaling, financial sustainability, and legislative readiness. The LINC - TUPPAC team is aware of the challenges and has strategies about how to tackle the challenges.

Major learnings so far include how to build resilient projects when dealing with new technology and new legislative contexts; how to conduct research in complex innovation projects; and the importance of the process to involve users in the service design to include all relevant types of users.

2. WHAT PROGRESS HAS BEEN MADE SINCE LAST TIME?

2.1 Steps are taken towards legal approval to operate the autonomous buses

The current main issue for the LINC-TUPPAC project is to get permission to operate the automated vehicles on public streets. There is a legislative process in place for automated driving in Denmark. The process includes two main steps: first, to obtain a type approval of the automated vehicle, and, second, to obtain permission to operate the vehicle on the (selected) streets. The LINC-TUPPAC project is one of the first projects going through the process, and getting legal approval has turned out to be even more challenging than expected.

Currently, the focus is on obtaining the type approval of the vehicles that the project will use. In particular, it has shown to be challenging to

prove the fulfillment of braking functionality and electromagnetic compatibility (EMC). Therefore, the project has performed additional tests. The LINC-TUPPAC project has now applied to the approving authority and is currently waiting for the response.

To speed up the approval process as much as possible, the project has participated in networking events with other projects and operators in the same situation in Denmark. The project has also made a study visit to Sweden, where the same type of autonomous buses is already operating. At this visit, the project met with the Swedish approving authority to learn from the Swedish process.



The LINC – TUPPAC project at study visit in Barkaby, Sweden.

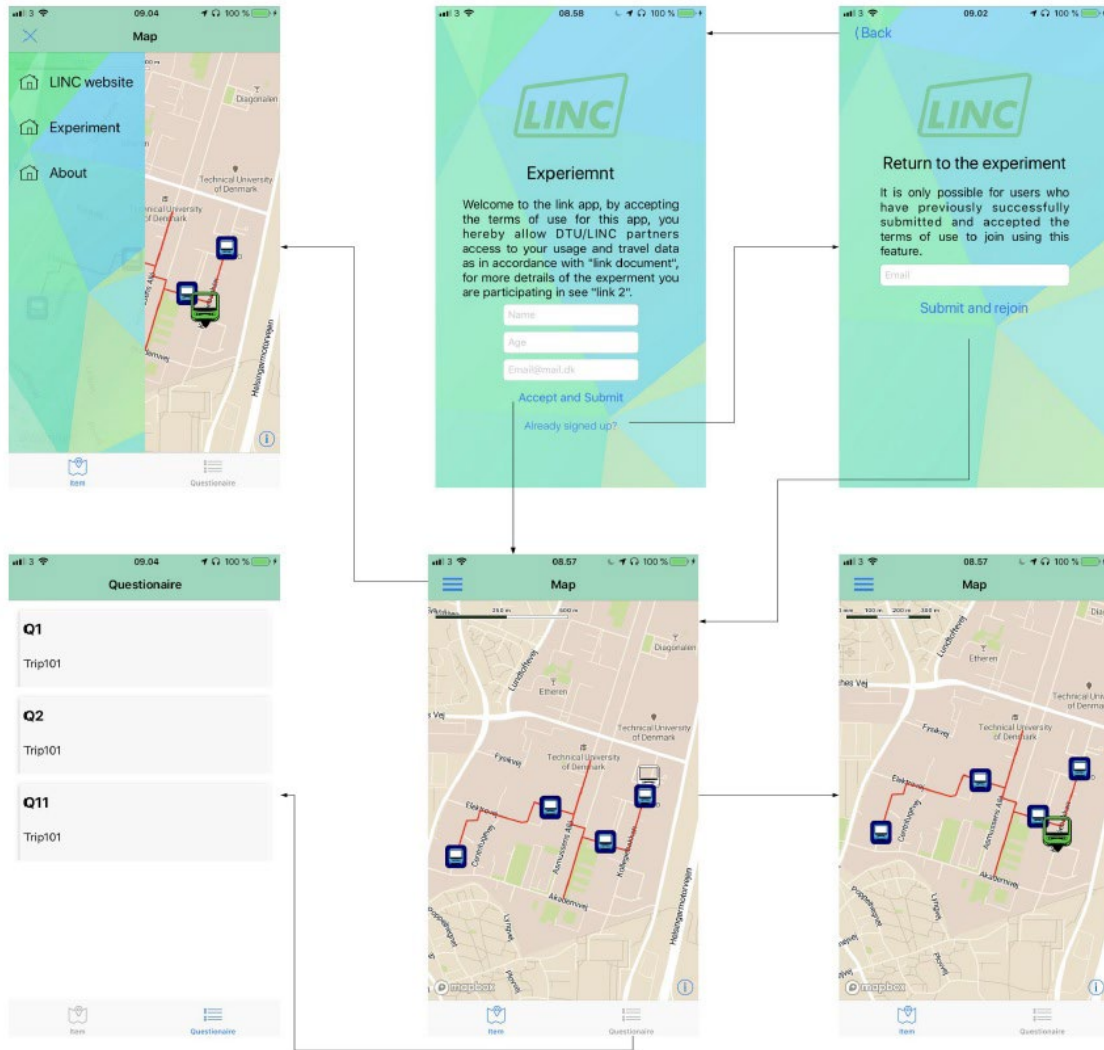
2.2 An app is developed

In the project, a new, collective mobility service will be tested (referred to as the LINC service in this report). To give the users access to the LINC service a smartphone app will be used. This app now developed and tested with users. Screenshots of the app are shown in the figure below. In the app, the users can monitor the movements of the busses in real-time.

The app will also collect data about the users' movement patterns. This will be used to improve the routing of the busses. Furthermore, the

researchers in the project can use the app to push survey questions to users on specific locations or users who have experienced certain events such as emergency stops or being alone on the bus.

In addition to the app, the project utilizes several "state of the art" technologies: IBM cloud, Watson analytics, deep learning, and IBeacons. IBeacons are low energy Bluetooth beacons that will be used for validation of the user's movements and use of the busses at the DTU Campus test.



App screenshots

2.3 The test plan is revised

While working on (and waiting for) the vehicle approval, the project team has gained more insights into the capabilities of the automated busses. At the beginning of the project, the intention was to test on-demand services with driverless busses. However, when getting familiar with the busses it has become obvious to the project team that the busses are not technologically mature enough for being fully driverless. Furthermore, it has become clear to the project that the Danish legislation for trials

with autonomous vehicles is currently not ready for fully driverless operation (SAE Level 4 or 5¹). Instead, it is only possible to run tests with self-driving vehicles that have a responsible driver onboard (SAE level 3). Therefore, the project plan of the LINC – TUPPAC project has been revised, and the focus has shifted from the application of the on-demand mobility service toward the operation of the automated busses, the user acceptance, and incentives for using a last-mile service.

¹ The SAE Levels are described in "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles" published by SAE International in 2016.

The revision of the project plan has also resulted in that project partners have become more aligned in their expectations on the tests, even if they have different aims (e.g. testing operation, doing research, testing routing algorithms).

After the revision of the project plan, I, as the UIA expert, recognize four main goals in the project:

- 1) to operate the self-driving busses on public streets, including getting legal approval;
- 2) to develop and test a collective, demand-responsive mobility service utilizing the autonomous busses;

- 3) to learn how to upscale and run such mobility services based on self-driving busses; and

- 4) to learn how autonomous buses can contribute to sustainable urban development.

To summarize, part of the project is about operating the autonomous busses and the new mobility service, while part of the project is about learning for future implementation.

3. THOUGHTS ABOUT COMPLEX INNOVATION PROJECTS, RISKS, AND DELAYS

This section is based on dialogues with five persons engaged in the project: Hannah Villadsen, RUC, Dan Roland Persson, DTU, Søren Kehr, Albertslund, Rasmus Noes, Nobina, and Morten Wied, DTU.

3.1 Learning instead of failing

From the dialogues it is obvious that the delay of the permission to run the tests with automated buses affects the project – it is what everyone mentions first. As one project member expresses it: *“This overshadows a lot of other things”*.

It is not unusual that complex innovation projects are delayed or not deliver the results that are expected when starting the project. One person who knows this is Morten Wied, a researcher at DTU with a focus on “resilient projects”. He explains that a resilient project is a project that succeeds even if the project encounters unexpected challenges, delays, or if results are not delivered as planned. He explains that even though projects may “go wrong” it is not necessary that they *fail*. One way of avoiding failure is to have multiple potential outcomes in projects, and that this is particularly important for innovation projects like LINC-TUPPAC.

Projects like LINC-TUPPAC are so complex so it is difficult to predict what the outcome will be. At the same time, running this type of complex projects is crucial for innovation and development. One key to success is to have the ambition to learn anything that can be learned from the project.

In the LINC-TUPPAC project, several of the project members reflect that one of the main learnings (so far) is how to get the legal approval to operate the self-driving vehicles in Denmark. The LINC-TUPPAC project is a forerunner in that sense and creates a lot of learnings about the process, both for project partners, the external assessor, and the approving authority. This opens for many others to follow the path and removes one of the main hurdles for the operation of self-driving vehicles in Denmark. To implement mobility services based on self-driving vehicles the legislation is necessary, but it is not enough. All actors also need to know their role in the legislative process. Rasmus Noes from Nobina says:

“I need the approval process to be smooth if I should be able to offer services with driverless vehicles. Otherwise, I will not get the requests for tenders for such services.”

Noes mean that having a smooth process for legislative approval is as important as a reliable technology and attractive service design to make the new mobility services attractive for public transport authorities and other transport buyers.

3.2 Reflections about a testing dilemma

One reflection that is made by several project partners is a dilemma related to the tests.

In the type of mobility services that are envisioned in the LINC-TUPPAC project, technology development (e.g. self-driving vehicles and data-based algorithms) are intertwined with the service development. Therefore, it is necessary to let users test the pre-mature technology in pre-mature services, as is planned in the LINC-TUPPAC project. Engaging users and developing the services and the technology simultaneously is critical to achieving solutions that contribute to the planners' goals of sustainable and liveable cities.

This introduces a dilemma. On the one hand, it is necessary to let users test the technology combined with the service to understand the users' needs and acceptance of the new service. On the other hand, exactly because the technology is under development it will not function as expected. In the LINC-TUPPAC case: the busses will run at very low speed and with a steward on-board. Those are the main functions that affect the users' experience. One project member reflects:

“I have personal experience of the shuttle; I tried them on a fair. I thought it was cool, but I didn't feel that it was very interesting or useful. Mainly due to the speed. So users in the tests might think ‘Wouldn't it just be faster to walk or bike between the buildings?’ “

Another project member discusses the research and learning in complex innovation projects involving both new technology and design of new services:

I have found it interesting to point out that there are two types of research: One that is based on models, where all “stupid” practicalities such as people not showing up, snow, small stones disrupting the doors, etc, are ignored. These models are unrealistic, like superhero movies. Then there is other research based on trials, where there are more or less only those practicalities of testing.

The conclusion is that it is necessary to plan the projects and the research bearing in mind that the technology is not fully functional. LINC-TUPPAC has not had the intention to be a technology development project, but rather to test novel (but existing) technology in new services. However, it is still important to make room for elements of adjustments of the technology to the circumstances.

3.3 Reflections on driverless vehicles and sustainable city development

One of the main goals of the LINC-TUPPAC project is to learn how driverless vehicles can contribute to sustainable urban development. Different project members express different thoughts about this topic:

“My view on that has changed. As I have gained more knowledge, I have become more skeptical”

“We need high capacity public transport in cities. In the outskirts and suburban areas, we need feeder lines, and those could be driverless.”

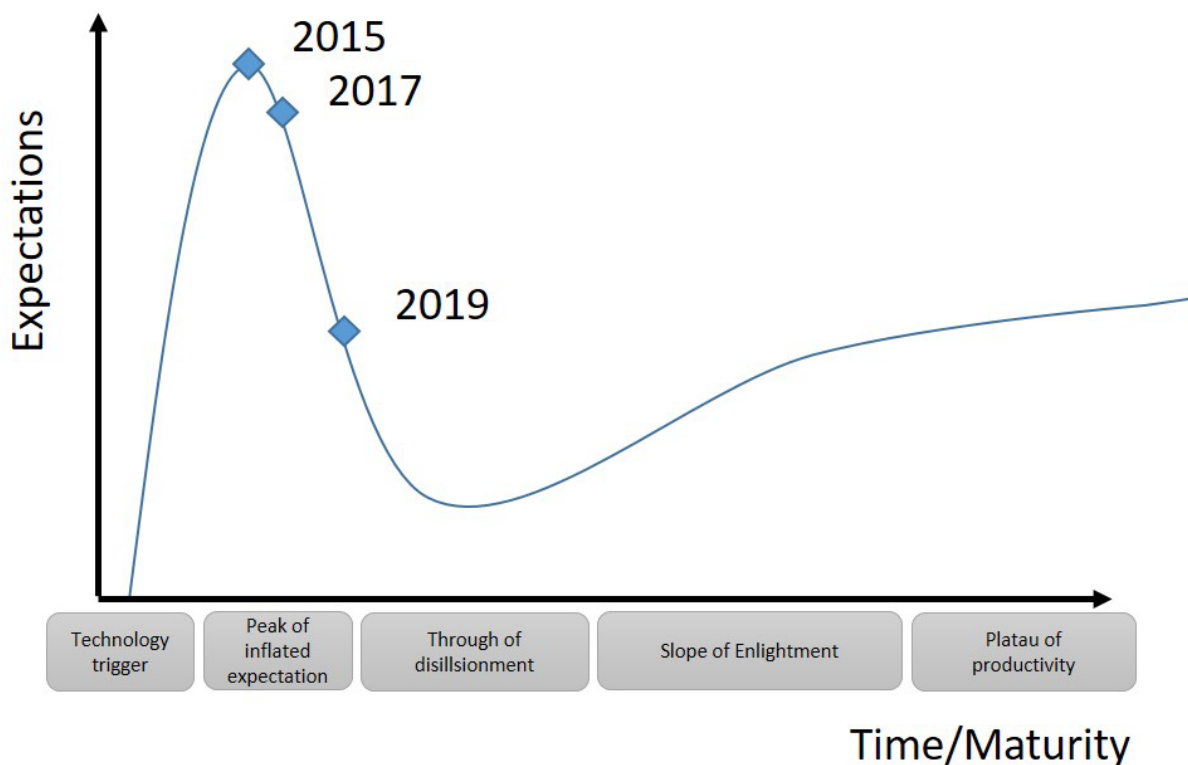
“We run these trials to get a view of the technology, to get the experience. What we have now are gut feelings and clues, but when we take things out into the wild, we get more experience. We have to test it. We don’t know anything until we have got data.”

“I definitely think that driverless vehicles will contribute to sustainable city development, but we don’t know how. But we have integrated this uncertainty in our city master plan”

These comments can be viewed in the light of the Gartner hype cycle, see the figure below. When

the project application was written, autonomous vehicles were at the top of the hype cycle according to Gartner. Now, a few years later, Gartner argues that autonomous vehicles are in the phase of “Through of disillusionment”. Naturally, the capabilities of the driverless vehicles are questioned. The attitude of the LINC-TUPPAC project – to perform trials to collect data but adjust to meet the capabilities of the technology – is sound and will contribute to the understanding of the role of driverless vehicles for sustainable urban development.

Gartner hype cycle for autonomous vehicles



Autonomous vehicles in the Gartner Hype Cycle.

4. CHALLENGES

4.1 Overview of challenges

An overview of the established UIA challenges, as well as three project-specific challenges, are presented in Table 1. Besides the established UIA challenges, three more challenges are identified for the LINC-TUPPAC project: Financial sustainability, Technical readiness, and Legislative readiness. These additional challenges appear as the LINC-TUPPAC project is piloting new technology in a new service.

important issues that are necessary to focus on during the coming six to twelve months. If not resolved, they may impact the project result. Medium-level challenges are important for the success of the project, but the project team has a plan to resolve them. For the Low-level challenges, the project has a clear plan or a platform in place to mitigate them. The High-level challenges are further discussed in sections 4.2-4.4.

In the table below, the levels of the challenges are classified as follows: High-level challenges are

Table 1: Mapping LINC-TUPPAC project against the established UIA Challenges and identified project-specific challenges

UIA Challenges		
Challenge	Level	Observations
Leadership for innovation	Low	<p>Leadership for innovation is relevant for the LINC-TUPPAC project on two main levels: city level and national level.</p> <p>On the city level, it is important to have leadership in the municipality that takes the new mobility solutions into account in planning and decisions. Albertslund municipality has the aim to be a forerunner in sustainable development and has embodied this in a city masterplan where the new mobility modes are taken into account. For example, today there are wide roads with two lanes in each direction. In the masterplan, the aim is to transform one of these lanes to create space for recreation and biking.</p> <p>The challenges with getting approval to operate the driverless vehicles have shown that there is a need for leadership to foster policy development on a national level. The project, and in particular Gate 21 and Albertslund municipality, have taken on this role by utilizing their network for communication and knowledge sharing.</p>

Challenge	Level	Observations
Public Procurement	Low	The vehicles to be used in the project are procured and delivered. The supplier needs to participate in the approval process and they do. The aim of LINC-TUPPAC is also to investigate how public organizations can procure the new service developed. This question is on the table in the project and is planned to be investigated in the test in Hersted business park.
Integrated cross-departmental working	Low	Multiple departments at Albertslund municipality are engaged in the project, including e.g. infrastructure, industry, and business development. Naturally, the departments have different perspectives and roles in the project, but they all share the same vision of the new Light Rail that will enable sustainable mobility and increase the number of citizens and workplaces in the municipality. Working towards this common high-level goal has lowered the barriers for cross-departmental working.
Adopting a participative approach	Low	The clear aim of the project is to engage users in the development of the mobility service. Potential users have been invited to focus group meetings where the app and the service have been discussed. A user test is planned in December, where potential users will be invited to use the service in a laboratory environment. When the vehicles start operating, more activities with users are planned.
Monitoring & evaluation	Low	The project has developed a monitoring plan with KPIs that are related to LINC-TUPPAC goals. The monitoring plan has four main focus areas: operations, user experience, demand-responsive transport, and sustainable city development. For each of these areas two main research questions are identified, as well as the data needed to respond to the research questions, and who is responsible for the data collection. All project partners were engaged in the development of the plan, and efforts were made to ensure that each of the partners' perspectives is met. The data collection will begin when the buses start to operate, but the tools for collecting the data are currently being developed, e.g. in the smartphone app described above.

Challenge	Level	Observations
Communication with target beneficiaries	Medium	<p>The project needs to communicate a vision based on a novel technology that is not previously tested in Denmark. In particular, the challenge is that expectations on the automated vehicle can be too high among target beneficiaries, while at the same time the vehicles are seen as too futuristic to take into account in the urban planning process.</p> <p>Previously, politicians, partners, and potential users had high expectations on the driverless busses and the quality of the service that they could deliver. The delay in the project has given these stakeholders time to get a more nuanced view of the performance of the busses, a fact that has simplified the communication about what can be expected in the project.</p> <p>The fact that the vehicles are not yet tested in Denmark can give the impression that it is still a very long time until driverless vehicles will operate in real services. Thus decision-makers, urban planners, and politicians might not dare to take the new technology into account not even in their long term plans, something that will slow down implementation. However, as described at the challenge “leadership for innovation” this is not the case in Albertslund.</p>
Upscaling	High	<p>For upscaling, the challenges are related to take the service developed and tested in the LINC-TUPPAC project and transform it into other municipalities. There are two main issues to resolve to enable upscaling: the cumbersome legislative approval process (this challenge is further described below) and the challenge to develop sustainable business models. This challenge is further discussed in Section 4.2 below.</p>

Project-specific challenges

Financial sustainability	High	<p>To obtain long-term financial sustainability in the type of mobility services developed in LINC-TUPPAC it is necessary to keep the operational costs of the vehicles low. With driverless vehicles, the operational costs can be significantly reduced compared to traditionally operated vehicles, since no driver is needed onboard.</p> <p>Currently, the Danish legislation requires that a person with full focus on the operation is present onboard. During the LINC-TUPPAC project, this cost is not a problem as personnel is needed on board to supervise the tests. However, if operational costs of the vehicles cannot be cut as expected this can jeopardize long term financial sustainability. This issue is also related to upscaling and is further elaborated on in Section 4.3.</p>
Technical readiness	Low	<p>The technology to be used in the LINC-TUPPAC project is new and innovative, and at the beginning of the project, it was uncertain whether the busses and the smartphone app should be able to meet the requirements in the project. Now, the app is developed, and the busses are delivered and tested. The project team has become familiar with the capabilities of the busses and can make appropriate plans.</p>

Challenge	Level	Observations
Legislative readiness	High	The legal approval of the vehicles is further delayed and operation is not expected to start before June 2020. The LINC - TUPPAC project team has made all measures they can to speed up the process, and this risk is to be considered as an external factor for the project. It has consequences on the project, but also on the potential for upscaling of the service after the project. This is further discussed in Section 4.4.

4.2 Challenge: Upscaling

Two main issues have to be resolved to scale up the mobility services developed and tested in the LINC-TUPPAC project: the process to get approval to operate must be smooth, and there must be sustainable business models.

A long and costly approval process hinders upscaling. After the LINC-TUPPAC project, the next step to scale up the mobility services is to perform more tests and pilots to further develop the mobility service. These tests will require new approvals for automated vehicles. If the approval process is not made smoother, getting these approvals will be both costly and time-consuming and may stop upscaling. The project partners have recognized this potential show-stopper, and use their channels to improve the legislative process and explain the consequences of the time-consuming approval process. For example, the project members have participated in

network meetings and communicated with politicians. Challenges with the legislative process are further discussed in Section 4.4.

Business models need to be developed to enable upscaling. The business models for the type of services are not clear today. Many stakeholders are recognizing the possible value in the solutions, e.g. reduced car traffic in suburban areas, improved public transport, and improved mobility with areas such as campuses or business parks. However, it is still not clear how this value will be captured by different stakeholders. The project has planned to identify the potential users and use cases, the operational costs, and how the service can be used for urban planning. This information will be collected during the tests, and based on these new business models can be developed.

4.3 Challenge: Financial Sustainability

High operational costs if the vehicles cannot operate driverless. One cornerstone in the LINC-TUPPAC service is to use driverless vehicles to provide a mobility service that bridges the gap between taxi and traditional public transport. This is enabled by driverless vehicles – if one operator can handle several busses, it would be

financially sustainable to operate several small buses instead of one large vehicle².

However, according to the current legislative framework in Denmark, it is mandatory to have a driver on-board that has full focus on operating the bus. Thus, with the current legislative

² In traditional public transport operation the driver accounts for approximately 50% of the operational costs.

framework, it will not be possible to operate the service with several small vehicles in a cost-effective way.

Also, the technology needs to be improved to operate the vehicles without a driver on board. Today, the vehicles can operate safely in most situations: they drive slow and stop if they cannot assure safe operation. However, this type of

operation will not give a service level that is acceptable for travelers.

Legislative framework and technology development goes hand-in-hand: vehicles need to be safe enough to be allowed to operate driverless, and the legislation needs to allow tests with driverless vehicles to verify that they are safe enough.

4.4 Challenge: Legislative Readiness

The challenge of getting the legal approval of operation on public streets is at the core of both the other high-level challenges. The project was aware of this challenge when it started, but the time needed to get the approval has turned out to even longer than expected.

There is a legislative framework for operating automated vehicles in place in Denmark, and the challenge for the project is to get through this process. Getting the approval to operate the automated busses on public streets comprises two steps: the type approval of the vehicle, and the approval of operation on the streets in the test site. Currently, the project is at the first of these two steps – getting the type approval of the vehicle. There are a couple of other projects in Denmark that are also in the process of getting type approval for automated vehicles, but LINC-TUPPAC is one of the projects that are “first” in this process. This means that it is the first time the approving authority goes through this process.

The long time needed to get approval is a challenge for the project. The project consortium will most likely get the approval

sooner or later, but there is no guarantee that they will get the approval within the time frame of the LINC-TUPPAC project. Depending on the progress in the legislative process within the next three to four months, the project needs to consider re-planning of the tests.

The long waiting times is also difficult for the people engaged in the project: how should they handle their planning: they need to use their time thoughtfully and partly on other projects/questions while waiting, but at the same time being prepared to start work when the project gets approval.

This challenge is of high-level, but the project is aware of it and continuously discusses the tools they have to be resilient to this risk. Also, one of the most important outputs from the project will likely be the knowledge about how to go through the approval process. This will open the arena for more tests and pilots in Denmark.

5. TAKE-AWAYS FROM LINC - TUPPAC SO FAR

The LINC - TUPPAC tests on how automated vehicles can contribute to sustainable mobility have not started yet, but some learnings can be made from the project.

- **Making projects resilient.** In complex innovation projects like the LINC - TUPPAC project **it is not always the expected result that turns out to be the result in the end.** The project is fully dedicated to having the busses operating in public streets in the two tests that are planned, and this is still possible within the project time frame. During the legislative process, the project has experienced that going through the type approval of new, innovative vehicles is challenging, in particular when it comes to braking performance and EMC. The project has also experienced the importance of having the vehicle manufacturer engaged in the type approval process, as more tests and documentation from them might be needed.

It is also important to try to set up complex innovation projects so that they are resilient, i.e. so that being “wrong” does not mean “fail”, if possible. According to Morten Wied, a researcher with a focus on resilient projects, **having multiple ways to succeed is one way of making projects resilient.**

- **Engage all types of users – also the quiet ones.** In automated vehicles, safety and security are important to users. This has been proven in research and other pilots, e.g. in an

ongoing test in Barkaby, Sweden. When the driver is taken away, the control of the social space is changed. This may lead to that some people feel insecure, something that may be a showstopper for services based on driverless vehicles. However, in workshops held to involve users in service development, the group of people that tends to feel insecure are often not the ones that talk and take a lot of space. Therefore, their experiences of feeling insecure might be forgotten. **Planning workshops and data collection to get all types of users and genders engaged is crucial.**

- When developing complex services based on new technology, there **are two main research approaches.** One is research based on models, where the technology is assumed to function flawless and the service is fully accepted by the users. Those models are unrealistic, but give the targets, or the boundaries, that can potentially be reached with the service. The other approach is based on real trials and tests. In these tests, there are often many practical issues that make them rather poor examples of the service that is targeted. E.g. in the LINC - TUPPAC project, the busses will operate at a very low speed and with a driver on board, and thereby not be able to deliver the service that is envisioned. **Neither of these two research approaches provides the complete answer, and they need to be combined.**

6. NEXT STEPS

Test drive in a laboratory environment from 3rd to 5th December at DTU Campus. In these tests, the smartphone application will be tested together with smart beacons and the first learnings of the users' acceptance of the vehicles will be gained. Around 30 test users will be involved.

The process of getting approval continues, together with efforts to make the process smoother for future applications. For example, discussions within networks of mobility operators and municipalities to improve the legislative process will be held. The project expects the final application sent to the authorities latest December 20th. This depends on solving the last remaining issues related to documenting the vehicle's braking capabilities and documenting the EMC test (Electromagnetic Compatibility test).

The project plans for a local press event at DTU Campus at the beginning of 2020. The event will most likely be held on January 24th at DTU Campus when the final application has been sent to the

authorities. The press is invited to test an Easymile shuttle at a closed test track at DTU Campus without a driver on board. The project will begin the recruitment of test passengers for DTU Campus and will start campaigning for the next months to follow. The goal is to have a minimum of 500 dedicated test users.

When the final application has been sent to the authorities, the project will start their evaluation of the Danish Pilot scheme for autonomous vehicles. As written earlier, the project has experienced considerable legal constraints and on behalf of the evaluation, it will be considered if any steps towards policymakers should be taken to set a less comprehensive policy framework in the future.

Infrastructure will be established at DTU Campus to prepare for the autonomous test when an expected approval in June 2020. This includes signposts, road markings, and removal of some parking spaces.

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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