

JOURNAL

PROJECT

LINC - Transforming
Urban Planning
Providing Autonomous
Collective mobility
📍 Albertslund, Denmark

TOPIC

Urban mobility

EDIT 31 OCTOBER 2022
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LINC Project Journal 6 - looking back one year after

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In her 6th and concluding journal of LINC, UIA expert Dr. Anna Pernestål describes the final results and takeaways from the project, which include the lessons learned from the trial with autonomous buses and the development of the UIA Challenge over the project time.

Executive Summary

The LINC project received funding from the EU UIA 2nd Call, Urban Mobility theme, in 2018, and ended in November 2021. The project has tested self-driving shuttle buses at the campus of the Technical University of Denmark (DTU) in Copenhagen, with the aim to explore how this new transport mode can contribute to sustainable, shared mobility in suburban municipalities.

The test in LINC was one of the very first operations with self-driving vehicles on public roads in Denmark. Furthermore, the project developed a smartphone sensing platform, including a smartphone sensing platform and an app, to support smart mobility solutions.

In several reports and communications, the project has visualized and exemplified how self-driving shuttles can be part of sustainable urban development. Furthermore, the learnings from the LINC project formed the basis for a report and a SUMP-guide, targeting politicians and officials, on how new, intelligent mobility technologies can become a part of sustainable cities.

The LINC project team has indeed struggled with several challenges, where getting through the legal approval process for self-driving vehicles in Denmark was one of the biggest.

This last journal provides a summary of the main deliverables achieved by the project. It also summarizes the main learnings and insights from running the bold innovation project that LINC has been. In particular, the evolution of the project is described in relation to the operational challenges associated with all UIA projects (as reported in LINC journals 1 to 5). This shows the challenges handled by the project over time, including the actions taken in order to reach the final project outcomes.

Finally, this last LINC journal concludes with my three main takeaways from the project, when looking back at it

one year after it was finished.

Selfdriving busses as a part of a sustainable urban mobility plan

Main achievements in LINC

A new light rail track (Ring 3 Light Rail) is currently built to serve 29 stations in the suburban areas of Copenhagen, and the vision for the LINC project has been to develop a mobility service that supports this high-capacity public transport system. The project aimed at developing and demonstrating a service based on self-driving shuttles that serve as a first/last mile service and expands the utility of the light rail beyond the blocks closest to the stations.

The LINC project started in June 2018, with the objective of letting innovative solutions support a shift from private cars to more sustainable, shared mobility modes. The project ended in November 2021 and summing up the results one year after, the main achievements include:

- The test in the LINC project was one of **Denmark's very first trials** with self-driving buses operating on public streets. See [Journal 5](#) for more details on the tests performed. That fact that self-driving shuttles operated for six months gained a lot of attention. The test **triggered dialogues** about future sustainable mobility among users, operators, politicians, and media. Furthermore, the tests gave **new insights and learnings** that are valuable for other cities, both at technical and operational levels. Furthermore, the tests **gave new insights and learnings** that are valuable for other cities, both at technical and operational levels.
- One of the main achievements of the project was to obtain a **legal permit** to operate the self-driving shuttles. This process appeared to be much more complicated compared to other countries in the Nordics. The LINC project not only obtained the permit to operate, but the project also delivered recommendations for improvement of the Danish approval process to decision-makers. In 2022 the Danish Road Directorate and Danish Road Traffic Authority conducted a final evaluation of the Danish pilot scheme for automated vehicles (AVs). In the authority's evaluation, many of the LINC project recommendations have been heard and have now been taken further for a decision in the Danish parliament's decision to extend the pilot scheme for AVs.
- The LINC project also developed an **app** and a **smartphone sensing platform** that uses Bluetooth beacons to monitor users' mobility patterns and provide smart services to users and operators (see more details in [Journal 4](#)).
- The learnings from the LINC tests have been communicated in several ways, including a **vision and plan for self-driving shuttles** as a complement to the lightrail, and a [report for decision-makers](#), including a SUMP-guide that identifies where in the planning process intelligent public mobility can be useful. Several workshops and seminars have been held with decision-makers, and two articles have been published at "mobility check".
- It has become clear that new technologies like self-driving buses need new business models to contribute to the transformation to sustainable cities. New public-private collaborations need to be established. This can be done by urban planners in terms of revitalizing exciting parts of the city. In particular, in less dense areas, the demand for mobility services is most often not large enough to cover the operational costs. Instead, other values that the improved mobility service brings, e.g. related to property development and improved land use, need to be built on. This is further elaborated on in a [LINC Zoom-in](#).

Activities beyond the LINC project

The full scope of the LINC project, as it was formulated in 2018, has proved to be a bit too futuristic to be implemented already by 2025 when the light rail is intended to open. The concept that LINC is aimed at is not yet ready for upscaling, not on the technical nor the legal side. At the same time, there are many parts of the LINC project that will be directly useful in the near future.

- The operator of the self-driving shuttles is currently searching for other areas for continuing the trials with self-driving shuttles in other contexts, to continue to explore the role of self-driving shuttles as a cost-effective complement to public transport.
- The app and the smartphone sensing platform developed in the project have already been used in two other projects, one at DTU Campus and one bike project in Israel. The app, which handles mobility information to support users, operators, and researchers, will likely be part of future research and innovation projects.
- The exploration of new business models continues beyond the LINC project has started, and a selection of the LINC partners is currently developing a HorizonEurope project to explore opportunities to finance shared mobility services in suburban and other less densely populated areas.
- LINC has performed a potential analysis for a self-driving first-mile and last-mile service connection to the Copenhagen light rail. The analysis shows, despite expectations, that a frequency-based service delivers better in terms of travel time, occupancy rate, operating costs, etc, compared to an on-demand service. The Greater Copenhagen Light Rail and Movia (public transport provider) is now considering enhancing the analysis to include more light rail stations and include externalities like congestion, CO2 emissions, and health in a larger analysis. This way LINC has been a stepping stone for

Summary and reflection of challenges over time

Following UIA Challenges over time

The seven challenges identified by UIA have been monitored and discussed in the journals since the project started, see the figure below. During the first three journals, three project-specific challenges were also followed (Financial sustainability, Technical readiness, and Legislative readiness). However, in the last two journals, these challenges were integrated into the seven standard UIA challenges. In the figure are three important periods mapped: the “legal approval process”, the “Covid-19 impacts”, and the “tests with self-driving shuttles” periods indicated, as these impact the “challenge levels” experienced by the project.

UIA Challenge	Challenge level as reported in LINC Journals				
	Journal 1 November 2018	Journal 2 April 2019	Journal 3 May 2020	Journal 4 May 2021	Journal 5 November 2021
Leadership for innovation	easy	easy	easy	hard	medium
Public procurement	easy	easy	easy	medium	easy
Integrated cross departmental workin	easy	easy	easy	easy	easy
Adopting a participative approach	medium	easy	easy	easy	easy
Monitoring & Evaluation	hard	medium	easy	easy	easy
Communication with target beneficiaries	hard	hard	medium	hard	easy
Upscaling	medium	medium	hard	medium	medium
Project specific challenges, followed in first 3 Journals and later integrated in the evaluation of the challenges above					
Financial Sustainability	medium	medium	hard		
Technical Readiness	hard	hard	easy		
Legislative Readiness	medium	hard	hard		

Legal approval process

Covid-19 impacts

Tests with self-driving shuttles

The UIA challenges monitored offer time. The arrows at the bottom indicate the time duration of three important periods impacting the project.

Reflection on the evolution of the project

November 2018. The project started during the summer of 2018, at a time when the expectations for self-driving technology were high. In Europe, only a few tests had been run, and all of those with a safety driver onboard. The LINC project aimed high: to operate self-driving vehicles on public streets within a first/last mile service and without a safety-driver onboard. The project aimed to operate the vehicles in two tests at different locations and the last one would be a demand-responsive service. At the start, I as the UIA expert, together with the project management identified three specific challenges: Financial sustainability, Technical readiness, and Legislative Readiness. This indicates that already at the start of the project, we were aware that these topics were extra challenging. In particular, since there had been no trials with self-driving vehicles in Denmark.

During the first phase, the project team worked hard to concretize the ambitious scope and boil it down to a tangible plan that was possible to monitor. In focus was also to understand the technical readiness of the vehicles, and to set expectations right in the communication with both politicians and future users.

April 2019. During the winter of 2019, the test and monitoring plans were made more concrete. The vehicles arrived in Denmark but could not be tested due to a delayed process of getting vehicle type approval. At the same time, the project started to realize that getting the legal permit, which besides the vehicle type approval, also required a test approval for the operation at the specific site, could be a very long and cumbersome journey. Legal

readiness was identified as the hardest challenge in the project. Expectations on self-driving buses in general, and the project in particular, were still high. The gap between the actual status, where the vehicles still lacked legal permits, and the expectations of the service, made communication with target beneficiaries challenging.

May 2020. The process to get legal permission was very long. Writing the legal application to run the test was hard work. Then it was a long period of waiting to get the Danish transport minister's approval. The project utilized this waiting time to finalize technical tests with both the vehicles and the app, the plan for tests with users was updated, and the monitoring plan was revised. However, as time went by, the long waiting time for legislative approval became more and more of a barrier. In particular - this long and costly legislative process was identified to be a true barrier to upscaling of services based on self-driving vehicles as a new application is needed for each site. While exploring the service, the project members also identified that finding business models will become a barrier to upscaling shared mobility services.

During the legal approval process, it also became clear that the project could not get the approval to operate without a safety-driver onboard. The costs of the driver constitute a large part of the operational costs, and if these cannot be reduced the service will be far from economically viable. Thus, the financial sustainability of the service was deemed a hard challenge. Moreover, a safety-driver onboard compromised the ambitions of the project for research on user perspectives and interactions on an unmanned service. However, the role of the safety driver proved valuable for the understanding of the maturity and potential of self-driving shuttle technology readiness.

At this time, the project team realized that the legal barriers had made it very challenging to meet the initial ambition of a driverless demand-responsive service. Instead, the team identified other, very related learnings that could be made based on the tests that could actually be run. In particular, they worked by combining real-life tests with simulations and workshops.

May 2021. Finally, after a 30-month-long process, the project obtained legal permission to operate the self-driving shuttles at the DTU campus, and the tests could finally start, significantly delayed. However, at this time the Covid-19 pandemic had hit Europe and led to the closures of many universities, including DTU. The result was a significantly reduced need for mobility services at the campus. These two external factors led to two challenges deemed hard for the LINC project: "Leadership for innovation" and "Communication with target beneficiaries". The shortened test period, with only a limited number of people moving around at the DTU campus, created challenges in collecting the evidence needed for showing how self-driving vehicles can be fully integrated and complement existing public transport. Meaning fewer users respond to surveys and fewer utilized the developed smartphone application.

The project also realized that even if the driverless bus service is not ready to scale up, there are other parts of the project, including the app and the smartphone sensing platform, that could be highly valuable for other mobility services.

November 2021. When the LINC project ended in November 2021, the three self-driving buses had operated at the DTU campus for more than 3.000 hours during a six-month-long period, and around 1.000 persons had shared their expectations and experiences. Even if the project did not fully achieve the ambitions set up at the beginning of the project, with the two test sites and the demand-responsive service, the LINC project has contributed to technological, operational, and legislative learnings about self-driving vehicles. It has also contributed to the dialogue about how smart technology can contribute to sustainable, shared mobility. Maybe even more important, the project has shown the importance of testing new technology with real users in real services to fully understand the barriers when introducing new services. The answer for making sustainable mobility in cities may not be self-driving shuttles in the short term because of technology's immaturity. Instead, cities should focus on existing operational shared mobility services and how they can contribute to sustainable transport.

Final takeaways

Three final takeaways from the LINC project

My interest in the LINC project was triggered by the bold and ambitious plan that comprises two parts: to operate fully driverless (without a safety driver) on public streets AND to explore the role of such smart mobility as part of sustainable city development. Before joining the project as a UIA Expert, I had been engaged in a project in Sweden operating self-driving buses with a safety driver onboard, and I thought that it was time to take the next step in the development.

When summarizing the project, I recognize three main takeaways:

1. **For innovation to have an impact, several perspectives need to be pushed.** For a technical innovation to have an impact, it is not enough to only develop the technology. Also, user behaviour and adoption, business model development, city planning, and legal perspectives need to be developed. The LINC project highlights this, as the main challenge was not the technology, but the legislation.
 2. **Intelligent, shared mobility does have a role in sustainable suburbs**, but to get it rolling, new business models closely connected to city development are needed. Shared first/last mile services as a complement to public transport will play a key role in future sustainable mobility, in particular in less dense areas and suburban regions. However, the fact that these areas are less densely populated compared to city centres means that the incomes from the users of the actual mobility service will most likely not cover the operational costs, even if the vehicles are driverless. Therefore, new business models, where public and private organizations collaborate to explore other values, such as property development and increased land value, are most likely necessary.
 3. **Innovation projects are important but set them up so that they are resilient.** The LINC project has demonstrated the need for testing new technology with real users in real environments in order to identify and overcome barriers. However, when starting complex innovation projects, it is very difficult to predict the actual outcome. It may in the end not be the expected result that proves to be the result in the end. Therefore, projects should be set up so that being “wrong” does not mean “fail”. Having multiple ways to succeed is one way of making projects resilient. *In the LINC project, you can talk about a successful failure as results proved different than originally expected.* The project wanted to test an unmanned demand-responsive shuttle service, but the main results included the smartphone sensing platform, the contribution to the legal process for autonomous vehicles in Denmark, and the dialogue about business models closely connected to city development for shared mobility in suburban development areas.
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Urban mobility

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