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A qualitative study of a trial with driverless shuttles in Aalborg East - meeting of city, people and technology

Aalborg University's study of Aalborg Municipality's trial of driverless shuttles in Aalborg East, 2017 - 2022

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A QUALITATIVE STUDY OF A TRIAL WITH DRIVERLESS SHUTTLES IN AALBORG EAST

MEETING OF CITY, PEOPLE AND TECHNOLOGY

AALBORG UNIVERSITY'S STUDY OF
AALBORG MUNICIPALITY'S TRIAL OF
DRIVERLESS SHUTTLES IN AALBORG EAST
2017 - 2022

COLOPHON

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A QUALITATIVE STUDY OF A TRIAL WITH DRIVERLESS SHUTTLES IN AALBORG EAST

MEETING OF CITY, PEOPLE AND TECHNOLOGY

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ASTRUPSTIEN (18.05.2021)

PREFACE

Between 5 March 2020 and 30 November 2021, two green driverless shuttles drove along Astrupstien in Aalborg East from north to south and back again as part of the Smartbus project – Aalborg Municipality's long-awaited test of driverless technology and the first project of its kind in Denmark.

Denmark's first test of driverless vehicles entails an obligation to gather knowledge and reflect on the experience in order to better understand the possibilities of this new mobility technology. The need to document the experience is further reinforced by the fact that the driverless shuttle trial in Aalborg East was conceived as part of the area's urban planning development, thereby creating a unique opportunity to examine how the concrete urban and transport context interacts with the driverless shuttles and how people use and experience them as part of their city and everyday life.

Against this background, Aalborg Municipality and the Centre for Mobility and Urban Studies (C-MUS), Aalborg University (AAU), entered into a collaboration in 2017. Aalborg University was to follow, document and analyse the experiment via qualitative studies of the encounters between city, people and technology.

The results of this multi-year study are presented in this report.

THANKS TO ALL STAKEHOLDERS AND CONTRIBUTORS

AAU's investigation has involved a large number of project actors and local contributors, whom we would like to thank. Thanks to all citizens of Aalborg East who shared their experiences. Thanks to Holo and the local shuttle operators for sharing data and information. And thanks to Aalborg Municipality for the positive cooperation throughout the project period.

SUMMARY

The introduction of the driverless buses took place in the suburb of Aalborg East, which houses approx. 16.000 inhabitants. The area where the buses ran has for a number of years been the focus of social housing interventions and radical transformations of the building mass and functionalist urban plan in an attempt to redevelop this part of the city, and counteract the accumulation of social problems and rundown housing conditions.

Between 5 March 2020 and 30 November 2021, two driverless buses drove along the 2.1 km test stretch on a public path accessible to pedestrians, cyclists and people on scooters, electric wheelchairs and mopeds. To make room for the buses, the path was widened and the underpasses under automobile roads were redesigned. On the extended path, buses and bicycles shared a paved lane. Pedestrians had a separate pavement.

The path - Astrupstien - had been identified as a potential backbone in the area, that could connect otherwise segregated housing enclaves and help create a cohesive urban district. The driverless buses were also intended to make Astrupstien accessible to citizens who, in the absence of access to public transport, were restricted from travelling.

Along the route 10 stops were set up with step-free access. All stops were located on the west side of the pathway. The buses used in the project were designed to carry up to 15 passengers, but due to Covid-19, there was a passenger limit of between two and four people on the bus at different periods. The busses were free to use.

The buses were operated on the extended path in automated mode, but there was always an operator present in the bus who took control of the vehicle when necessary (SAE level 3). It took an average of 13 minutes and 12 seconds to drive from the first to the last stop. The bus had a maximum speed of 18 km/h. The average speed on the route was 8.6 km/h.

It was planned that the two buses would run approximately every 15 minutes for 14 hours a day between 7 am and 9 pm, 365 days a year for two years. Due to the effects of the Covid-19 lockdown, operations were suspended between 11 March 2020 and 10 August 2020. In addition, there were periods when only a single bus or on rare occasions, no bus was in operation. The reasons were primarily staff shortages related to the Covid-19 pandemic and technical challenges with the operations.

The bus was running on a pre-programmed track - a kind of digital rail. The bus' sensors cover a 360 degree radius, and brake immediately if an object is within 3 metres of the front of the bus or within 30 cm of the side of the bus.



LEARNING POINTS AND EXPERIENCES

The driverless buses, which ran at relatively low speeds, ran on the shared space of Astrupstien without increasing the risk or significantly restricting the freedom of movement on the path for children and people with reduced mobility. However, the buses were not used to a great extent as a means of transport as many potential users of the pathway perceived them as too slow and the waiting time as too long. The average commercial speed could be optimized by placing stops in both sides of the path, which would simplify operations considerably. A higher maximum speed is not advisable at this time due to recurrent occurrences of harsh unexpected emergency stops triggered by sensors and environmental factors like heavy rain or low flying birds. At a higher maximum velocity this would have posed a serious risk of injury to persons in the buses.

The elderly and people with walking difficulties did not use the buses to any great extent, a result which may, however, have been exacerbated by the fact that the same groups of citizens were at the time advised to reduce their social interactions due to the risk of serious illness caused by Covid19 infection. The operators of the buses experienced that this group of passengers completely stopped using the buses, as a second partial shutdown was imposed in late 2020.

Children and young people make up a large proportion of the people who use Astrupstien on a daily basis. This group used the buses as a convenient alternative to walking and as entertainment. The operators were thus placed in a social role and worked to build a positive dialogue regarding the use of the buses and in relation to ensuring that everyone felt safe to use them. The operators' presence on the path, not least in the evening, is described by some users of Astrupstien as promoting safety on parts of the path that may otherwise appear deserted and unsafe.

The operation of the driverless buses on the existing path necessitated a broadening of the path to ensure better space for the buses alongside other existing forms of mobility and inhabitation. This refurbishment has been completed, and the path has been upgraded from a central, albeit relatively narrow and partially worn-down pathway for vulnerable road users to an accentuated mobility axis running through the area. The transformation of the buildings and areas around the path has significantly contributed to this and has ensured more 'eyes on the path' and a more diverse environment than before, where simple and uniform functionalist design was consistent. The southern part of the route has an urban appearance and is busier than the northern part, which means that the path in the south clearly forms a connecting element in the urban space that ties in the spaces, functions and activities of the area. In the northern part of the route, there is still potential to create a clearer functional and spatial connection between the surrounding areas and the path.

PHOTO FROM THE PROJECT'S OPENING DAY (05.03.2020)

1. INTRODUCTION AND MAIN CONCLUSIONS

This chapter presents the main conclusions of AAU's study of the Smartbus project in Aalborg East. It also introduces the background of the project.

Although AAU's study constitutes an independent report and description of local experiences, the study was preceded by a long process in which urban development, social housing efforts and interest in new mobility technology formed the basis for Aalborg Municipality's framing of the project and embarking on the extensive work of adapting the infrastructure and applying for the necessary permits.

1.1 INTRODUCTION

Driverless vehicles are being investigated in various ways and are of interest to many. Studies from various places around the world have revealed that there are important unresolved questions about where, how and with what benefits the technology can be used. The Aalborg East trial has in several ways proven to be ahead of its time in terms of providing early answers to some of these questions. The Aalborg East Smartbus project was a proposal regarding how to work with innovative mobility technology by introducing the technology as part of an urban strategic vision, rather than as a test of the technology itself or its traffic functionality. The trial was set up to investigate the technology as a means of pursuing practical and social purposes in a concrete urban context and as part of the ongoing social transformation of an existing urban area.

In line with this broad intention, the task description for AAU's study has not been bound by special hypotheses or fixed boundaries in relation to what knowledge the study specifically could or should produce. Because the use of driverless technology is a new field, it has been a research goal in itself to collect the richest and most nuanced material possible about the concrete encounters between technology, city and people. This will give us insights into the route's specific spatial characteristics and design, the ways the shuttles were used and who used them, and the narratives about place and identity in which the shuttles were embedded.

The driverless shuttles at Astrupstien in Aalborg East have been the occasion and starting point for the many conversations and observations that form the basis of the study. However, in meetings with users, technology has not always been in the foreground. How quickly and how often the shuttles can get you from A to B has of course been important, but many other conditions that directly affect the users have also proven to be of decisive importance: Is it easy to get in with a wheelchair? Can you relax in soft seats along the way? Can you overtake the shuttle when riding a bicycle? Do you feel safe? Is the operator nice to talk to? Is a driverless shuttle what the district needs? And who is it really for?

The overarching objectives, which are the foundation for the study and for the results presented in the following, can be summarized as follows:

1. To gain knowledge about how the shuttle connection and driverless technology became incorporated into the district's development, urban space and everyday life

2. To obtain knowledge about the encounters of users and citizens with the shuttle and the technology

3. To share this knowledge with both practitioners and academia, in Denmark and internationally

In addition to AAU's study, Aalborg Municipality carried out an evaluation of the operation, including passenger counts and passenger surveys. These data are not included in this report.

THE PROJECT AT A GLANCE

- The two driverless shuttles drove on a section of two public paths, Jerupstien and Astrupstien, on a 2.1-km-long test route. As part of the project, these sections of the paths were widened so that shuttles and bicycles shared a paved lane, while the pedestrians had a separate pavement.
- The route had 10 stops with step-free access, all located on the western side of the route.
- Use of the shuttle was free.
- It was planned that the two shuttles would run approximately every 15 minutes throughout the day for approximately 14 hours a day, between 7 am and 9 pm, 365 days a year for two years. Due to Covid-19 restrictions, operations were suspended between 11 March 2020 and 10 August 2020. For the same reason, the number of passengers was limited to between two and four people during the subsequent operating period.
- Occasionally, only a single or no shuttle was in operation. The primary reasons for this were staff shortages resulting from the Covid-19 pandemic and operational or technical challenges.
- The shuttles were self-driving, but an operator was always present to take over when necessary (SAE level 3)[1]. The trip from the first to the last stop took an average of 13 minutes and 12 seconds. Shuttles ran at a maximum of 18 km/h, and the average speed, including stops, was 8.6 km/h.
- The shuttles travelled on a pre-programmed track – a kind of digital train track. The shuttles' sensors covered a 360-degree radius and braked immediately if an object was detected within 3 metres of the front of the shuttle or within 30 cm of its side.

1 SAE International (2021)

1.2 BACKGROUND

In order to understand how driverless shuttles came to drive back and forth on Astrupstien, it is helpful to know something about some of the previous analyses and initiatives.

In the years leading up to the trial, substantial investments were made in Aalborg East, with certain parts of the area being classified as either 'ghetto areas' or 'particularly vulnerable residential areas' between 2008 and 2016. The approach taken in the development of these areas during this period has since been called the Aalborg model and consists of a combination of transformations of the physical housing stock and other social housing initiatives. The Aalborg model is also characterized by a high degree of transversal cooperation between various public and private actors[2].

In 2010, it was decided that the new Aalborg University Hospital would be located in eastern Aalborg . As large investments in new transport infrastructure and extensive housing renovations were planned at the same time, a city plan competition – City in Between – was launched to ensure that the many investments would be seen as benefiting the citizens and the environment. As a consequence of this process, Astrupstien was designated as a possible future focal point for better internal mobility and as the key to connecting Aalborg East to the planned future BRT line[3] called +Bus, Aalborg University's campus and – via the BRT connection – the new university hospital.

ASTRUPSTIEN AS THE MAIN STREET AND NEW PUBLIC TRANSPORT CONNECTION

In the original winning proposal for the City in Between competition, a conventional bus connection was introduced at Astrupstien. The idea was judged to be economically unsustainable, but it shows that the rationale for a bus connection existed prior to the driverless shuttle test project. The need was described as follows:

"In the past, public transport in Aalborg East moved largely along an east-west axis, which made north-south movement within the area impossible. The less mobile population groups had thus been cut off from even very nearby activities and could generally become very segregated from the society they lived in. The Astrupstien bus connection became the possible missing link between northern and southern Aalborg East."
(Smartbus.dk)

OPPORTUNITY TO REALIZE THE VISION FOR ASTRUPSTIEN

In Aalborg Municipality, the idea of a collective transport solution for Astrupstien lived on, so when self-driving mobility began to emerge as a possible future scenario, the idea arose to deploy an electric driverless shuttle on the route as a possible cheaper and ecologically sustainable alternative. In 2015, Aalborg Municipality was the first in Denmark to contact the national authorities, and permission was obtained for a trial in 2019.

In addition to the mobility purposes already described in the original vision for Astrupstien, the great interest in driverless vehicles, both in and outside of Aalborg, has meant that the project has had some special communicative opportunities. On the project's website, this effect is mentioned as a possible benefit of a trial in the Aalborg East context:

"Contributing to an improved image of the district can also help to strengthen the positive development the area is undergoing and in this way help attract investment to the area [...]

At the same time, the testing and evaluation of driverless buses in a Danish context could make Aalborg East a 'first mover' on driverless vehicles, thereby using innovative technology as a lever to boost the image of Aalborg East."
(Smartbus.dk)

Overall, the establishment of the Smartbus project was thus based on three overarching visions that were not primarily about technology but rather about urban development.

First, the shuttles must help mobilize citizens and users within the district as well as between the district and the rest of Aalborg. This was seen as part of the vision to create a more coherent city, wherein increased mobility serves as a tool to prevent segregation and strengthen social capital.

Second, the test route was identified as an important urban space in the structure of the district. The shuttles reverse the functionalist logic of traffic segregation with which the district was designed in the 1960s. Furthermore, the transformation of the path and its nearby surroundings is expected to increase the quality of life for some citizens.

Third, the use of innovative technology is regarded as an opportunity to influence the public narrative concerning Aalborg East – the district's image – in a positive direction.

2 BL Danmarks Almene Boliger (2019): De første resultater af Aalborg-Modellen
3 BRT - Bus Rapid Transit, high class busconnection

1.3 ENVISIONED ROUTE AND TEST ROUTE

The map shows the envisioned route and trial routes respectively.

In the specific implementation of the test, the shuttles ran on a shorter test route of approximately 2.1 km

AALBORG C

BRT - LINJEFØRING

AALBORG ØST

TESTSTRÆKNING
2,1 km på
Astrupstien

VISIONSTRÆKNING
Forbindelse til AAU
og den kommende
BRT-linje

AAU

NAU
(Nyt Aalborg
Universitetshospital)

CITY OF AALBORG 1:25.000
THE TEST ROUTE AND THE ENVISIONED ROUTE FOR THE DRIVERLESS SHUTTLES IN THEIR URBAN CONTEXT

1.4 CONCLUSIONS: EIGHT LESSONS LEARNED FROM THE STUDY OF THE SMARTBUS PROJECT

1.

CITY AND PATH REDEVELOPMENT

The deployment of the driverless shuttles on the existing path required a widening of the path to provide more space for the shuttles. This widening was completed, and the path was improved from its original character as a central, albeit relatively narrow and partly run-down, path for vulnerable road users to the status of an accentuated transport axis in the district.

The transformation of the buildings and areas around the path, along with its new functions, have contributed significantly to this improvement as well as to ensuring more eyes on the path and a more varied environment than before.

The southern part of the test route has a square-like urban appearance and is busier than the northern part, which means that the path in the south clearly presents itself as a linking element in the urban space tying in the functions of the area. In the northern part of the test route, there is still potential to create a clearer functional connection between the surrounding areas and the path.

2.

IMPROVED MOBILITY

The driverless shuttles on the test route had the potential to open up the upgraded path and urban space for citizens in the district who could not cycle, walk or use assistive devices such as electric wheelchairs and were therefore dependent on public transport to use Astrupstien.

However, the shuttles were only used by this population to a limited extent, just as only a minority of other passengers used the shuttles as an actual transport service.

To a greater extent, the shuttles were used as an additional activity on the path, and children in particular used them as entertainment, as a convenient supplement to walking and as a social meeting place.

It is most likely that this picture was reinforced by the Covid-19 restrictions, which were in effect during virtually the entire test period and which affected the everyday life of both children and the elderly and limited many people's outward-oriented activities.

In the final feedback from users and citizens, some expressed annoyance that the experiment stopped just as the Covid-19 restrictions were being lifted and more people might have found their way onto the shuttles.

3.

PERCEIVED SAFETY ON ASTRUPSTIEN

Both before and after the transformation, there were users of the path who felt unsafe walking on the path in the evening and in the dark. The better-lit tunnels under roads and the presence of operators and shuttles on the path in the evening had some effect in enhancing the perception of safety.

Before the shuttles were put into operation, there was a concern among some locals about whether their introduction would make it less traffic-safe for children and others to stay on and near the path. We estimate that the driverless shuttles, at the speeds at which they drove in Aalborg East, did not significantly limit the carefree movement that characterizes the traffic on the test route.

4.

TRAFFIC INTERACTIONS ON THE PATH

The need to interact with the driverless shuttles on the path meant that path users had to get used to the shuttles' driving patterns, which sometimes seemed difficult to predict. For their part, the operators occasionally chose to hold the shuttle back manually until there was a clear lane so that ambiguous right-of-way situations would not arise. Generally, the low speed of the shuttles meant that these situations were only experienced as traffic hazards in isolated cases. In these cases, the operators stopped the shuttles manually rather than waiting for them to stop by themselves.

In some cases, the shuttles were obstructed by road users who used the shuttles' defensive programming to gain the right of way. The shuttles' programming meant that they always held back if an object was detected in their immediate path. Despite this, the assessment is that the shuttles in the current implementation functioned well in a physical environment that has many of the same characteristics as a 'shared space' design.

CONCLUSIONS: CONTINUED

5.

LOW SPEED AND ABRUPT HARD BRAKING

The shuttles ran at a maximum speed of 18 km/h. The realised average speed was 8.6 km/h, which is slightly faster than walking but slower than cycling. Many path users indicated this speed as the reason the shuttles were not a practical means of transport for them. With waiting time included, the travel time was in many cases greater than the time it would take to walk.

It is estimated that a higher average speed could be achieved by not stopping at stops when there are no passengers getting on or off and by placing stops on both sides so that the path does not have to be crossed at stops, as such crossing delayed the shuttle.

Given the study's findings, it would be inadvisable to increase the maximum speed at the current level of technological maturity, as unexpected hard braking occurred when fellow road users moved into the safety zone of the shuttles and when arbitrary external disturbances of the sensors occurred (e.g., birds or snow). The hard braking led to scares, falls and a few cases of physical injuries to people who were inside the shuttles.

6.

THE SOCIAL ROLE OF THE OPERATORS

The presence of operators in the shuttles and on the path was decisive for the function of the shuttles, local ownership of the project, and path users' experience of safety and security.

The operators reported that a large part of their work consisted of acting as hosts, conversational partners and moderators in the small, 'intimate' space inside the shuttle – not least in relation to children and young people, who used the shuttles a lot.

Some operators reported conflicts and the need to deny people use of the shuttles due to transgressive behaviour. Similarly, both children and adults reported that interaction with the operators was an important part of the Smartbus project's importance for the district and for the increased sense of security that some described.

7.

NEW NARRATIVES IN AALBORG EAST

The users of the path generally embraced the shuttles, although there were also some who found them disruptive to the general flow of the path. There was initially a concern among some residents that vandalism would be committed on the shuttles or that the artwork in the tunnel and on the shuttles' garage would be destroyed. Many ultimately reported finding it positive and uplifting that the furnishings and decoration were allowed to remain undisturbed .

Several expressed their view of the Smartbus project as a positive contribution to the district's development because it meant that Aalborg East was associated with innovation and solutions for the future rather than social problems or vandalism. Others questioned whether the money would have been better spent on other initiatives in the district.

All in all, the trial has added a new chapter to the compilation of narratives about social problems and strong counter-narratives about unity, colour and diversity that exist in and around Aalborg East.

8.

DEVELOPING A COMMUNITY APPROACH

The richness of the interactions that took place in and around the shuttles, between shuttle users, path users and operators, warrants continued curiosity about how driverless mobility can be brought into play as an element in sustainable mobility development and urban development.

It is possible that the experience could be used to investigate whether a community approach to driverless technology can be further developed, one that integrates mobility, local community development, social work and the quality of public spaces to follow new model , e.g. in the form of a collaborative project where local actors, such as businesses, leisure facilities, transport companies, housing associations and nursing homes, join together in implementing a local citizen-oriented driverless service bus.

STREET ART IN THE NORTHERN TUNNEL (29.09.2021)

2. RESEARCH DESIGN AND METHODS

AAU's study of how the driverless shuttles and the transformation of Astrupstien affected life on and around the path took place over a number of years, from the initial studies in 2017 to the end of the project in 2021. Throughout this period, the shuttles gave rise to interviews, informal conversations, workshops and observations about driverless technology, the district's qualities and challenges, and the path's many uses. This chapter describes the methodological considerations and the qualitative methods used.

2.1 RESEARCH CONTEXT AND CASE STUDY METHOD

Research on driverless vehicles is relatively well developed within the technological field, while social science research on the likes of users' experiences with driverless vehicles and the societal opportunities and risks of the technology are limited[1]. Existing studies that investigate user perspectives often focus on 'user acceptance'[2]. Several studies find that among potential users there is an overall positive attitude towards driverless vehicles[3], but it is also emphasized that "[...] a positive attitude does not imply that people will be willing to adopt them".[4]

The specific and often quantified focus on the positive and negative experiences of driverless technology may indicate broad support for driverless vehicles, but it often remains unclear in these studies what nuances exist in informants' answers and what factors are actually measured. For example, studies have found that users' 'positive attitude' to driverless vehicles may be due to the anticipation of what these technologies will be able to contribute in the future[5], not least because only a very few have actual experience with the technology.

There is also a potential discrepancy between users' ideas about, enthusiasm for and expectations of driverless vehicles and the real technological development and limitations that the vehicles have[6]. Studies point out, for example, that despite a positive attitude towards driverless shuttles, several informants do not find them practical in their current form[7].

The research in the area also faces criticism for being based on an assumption that technological breakthroughs unilaterally determine people's reality, with people reduced to passive recipients of driverless technology[8].

CASE STUDY RESEARCH

In the investigation of the driverless shuttles on Astrupstien, it was Aalborg Municipality's and AAU's wish to place particular emphasis on knowledge of how driverless technology, physical infrastructure and the reality of people and traffic work together. This is a form of knowledge that, in principle, cannot be encapsulated in a formula as too many actors and specific circumstances come into play. That is why we chose to approach the trial in Aalborg East as a case study. A case study is a detailed study of a concrete single case and has particular strength when it is necessary to understand the studied phenomenon in its context.

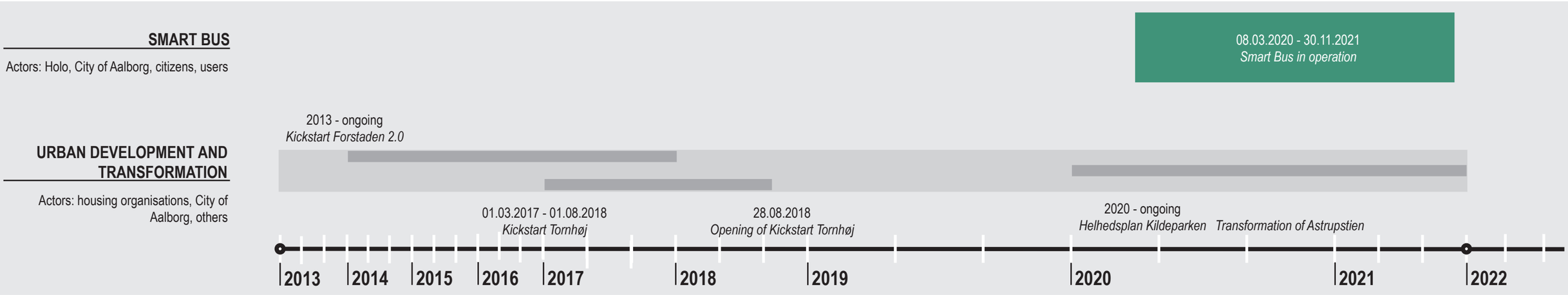
Research is often associated with the search for answers that are universally applicable across locations and social contexts and that are easily transferable to projects or applications elsewhere. In the study of people and society, however, this type of transferable knowledge has often been shown to be illusory. As one of the method's proponents, Bent Flyvbjerg, notes in an article about case studies, this is not because no attempts have been made: "*Despite persistent attempts to develop context-independent and predictive theory as in the natural sciences, in the social sciences you always end up with context-dependent knowledge.*"[9]

At the same time, the fact that the knowledge we obtain by studying the driverless shuttles in this project is linked to its context does not mean that it does not contribute to the collective building of knowledge about how new technologies can work and possibly be put to use. The idea is precisely to contribute to the accumulated knowledge, but without assuming that driverless technology will be the same everywhere and for everyone who encounters it. In order to be able to say something substantiated about what driverless technology can contribute more generally, in Aalborg East as well as elsewhere, we must first and last actually know something about its use and impact. Put more directly in the words of Hans Eysenck as quoted in Flyvbjerg's article: "*sometimes we simply have to keep our eyes open and look carefully at individual cases – not in the hope of proving something, but rather in the hope of learning something*"[10].

A consequence of studying phenomena in their social and spatial context is that the descriptions that emerge can rarely be summed up unambiguously in a single unified argument. The case presentation consists of perspectives and experiences which are characterized by the complexity of lived life and people's mutually contradictory perceptions. Our goal has been to piece these different perspectives together into a fair and meaningful presentation that enables conversation about the experiences, opportunities and dilemmas that the project made visible.

1 Heikoop et al. 2020; Yeo and Lin 2020a
2 see Nordhoff et al., 2017
3 e.g. Mouratidis and Cobeña Serrano, 2021; Nordhoff et al., 2018; Rehrl and Zankl, 2018; Salonen and Haavisto, 2019
4 Roche-Cerasi 2019, p. 172
5 Sadiq and Khan 2018; López-Lambas and Alonso 2019
6 Nordhoff et al. 2017; 2019; Mouratidis and Cobeña Serrano, 2021
7 Roche-Cerasi 2019; Mouratidis and Cobeña Serrano 2021; Nordhoff et al. 2019
8 Yeo and Lin 2020a
9 Flyvbjerg 2010, p. 466
10 Hans Eysenck quoted in Flyvbjerg 2010, p. 468

2.2 THE ORGANIZATIONAL CONTEXT OF THE SMARTBUS PROJECT



Timeline showing the Smartbus project's preparatory phase and operating period seen in interaction with local social housing and urban development efforts. The diagram also shows stakeholders who have played a role in the Smartbus project.

In 2017, as AAU began the work of mapping the experimental route and the various local players' expectations of the bus, it became clear that the shuttle was being deployed in a context with a strong tradition of social engagement and where consistent work was being done to cultivate various forms of dialogue between different municipal departments and local actors. These included the public housing associations Lejerbo, Alabu Bolig and Himmerland Boligforening, which own and manage the majority of the building mass, and which entered into the collaboration as significant players in the local area of Aalborg East.

For the technical task of making the driverless shuttles a success, Aalborg Municipality entered into a collaboration with the company Holo, which is a private actor specializing in testing driverless mobility. The task of recruiting local operators – operational security staff – was carried out in dialogue with people from the local area. Holo was the employer of the operators, who had a major role in staffing the shuttles and keeping them running even when the technology presented challenges.



As part of the process of developing the project, a local stakeholder group was set up, bus stops were offered for sponsorship by, e.g., housing associations, and local street art artists were responsible for decorating the shuttles' charging facilities and – in collaboration with one of the area's youth clubs –decorating several of the public spaces and surfaces along the shuttles' route.

2.3 THE REPORT'S CHAPTERS AND DATA

In order to create a representation of the many experiences, observations and viewpoints that together make up the Aalborg East case, we combined a number of interdisciplinary approaches and qualitative methods for data collection.

The analysis of how the introduction of the driverless shuttles and the physical transformation of Astrupstien developed together and separately is based on site analytical methods, wherein field observations, map material and publicly available information are included and combined. The methods for site analysis are detailed in the introduction to Chapter 3, *Buildings, path and shuttle*.

Mobility, community, safety and everyday life on Astrupstien – with and without the driverless shuttle – are examined partly by mapping how the driverless shuttles changed access to public transport and partly through workshops, focus group interviews and ethnographic interviews with citizens and users of the bus. This can be read about in Chapter 4, *The driverless shuttles on Astrupstien.*

This two-step analysis of the spatial and social context forms the background for an analysis of the concrete effects of driverless technology on traffic along the path. Descriptions of risks, accessibility and how the driverless shuttles' driving pattern was incorporated into life on Astrupstien are detailed in Chapter 5, *Flow and friction on the path.*

Finally, the many conversations with children and adults, users, non-users and institutional actors gave insight into how identity, social housing transformations and the driverless shuttles are part of a renegotiation of what Aalborg East is and should be. These insights are described in Chapter 6, *The driverless shuttles as a formative narrative in Aalborg East.*

As part of AAU's work on the Smartbus project, intersections with other projects and studies of driverless technology were also explored. In Chapter 7, *Experiences from other studies of driverless transport*, a number of areas are reviewed where experiences from other trials can help to substantiate, contrast with or put into perspective the experiences from the Smartbus project.

Finally, in Chapter 8, *Discussion of the results and perspectives*, we tie together the central points that the case study supports as a whole – in relation both to the redevelopment of Astrupstien in Aalborg East and to empirical knowledge about the implementation and development of driverless mobility more broadly.

An overview of the Smartbus trial's many interconnected timelines, including the phases and scope of the data collection, can be found in the Appendix.

2.4 THE METHODS USED FOR DATA COLLECTION

In the study, 10 different qualitative methods were used for data collection. The 10 methods and their use in AAU's study are described individually on the following pages. Throughout the report, we quote from interviews, workshops, field notes and logbooks. Interview recordings, interview notes and field notes were translated from Danish by the authors. Logbooks were kept in English and are quoted verbatim or very lightly edited for clarity.

FIELD OBSERVATIONS

Observations were made on 10 days, before and during the operation of the driverless shuttles. The 10 observation days covered both weekdays and weekends, spanning different times of the day from 7:30 am to 8:30 pm. During the observations, two observers were present; they alternated between being visible observers (taking pictures and standing clearly visible, holding a pad) and taking more neutral roles in order to reduce their influence on the informants' behaviour. Observations were documented with notes, photos, videos and sketches of users and interactions.

FOCUS GROUP INTERVIEWS

In 2018, before the shuttles were put into operation, two focus group interviews were held with people who lived in the area and people who worked in the area respectively . After the operation of the shuttles began, a focus group interview was held with four children. The advantage of gathering several informants for one interview is that the informants may know each other or may have something in common that they have more knowledge about than the interviewer. In such cases, they can complement each other and lead the conversation in a way that the interviewer cannot.

GO-ALONG INTERVIEWS

Go-along interviews are in-depth interviews, focused on a shared experience, in which the informant and researcher walk or drive in an area that is central to what the research is about. In this case, interviews were conducted along Astrupstien, where the informants could see the test route and shuttles. Go-along interviews are suitable for investigating informants' understanding of surroundings and social practices in a physical environment. Four go-along interviews were conducted, two with residents in the area and two with operators on the bus.

WORKSHOPS

Workshops were held with fourth-grade students in 2018 and with the same students again in 2020, when they were in the sixth grade. In 2018, the children drew the path and things that were important to them. In 2020, they filled in worksheets about their use of the shuttles and the path. In 2021, an outdoor workshop was held with children in the first grade, who answered questions by standing next to a red, yellow or green circle. They then drew with chalk what they thought about the bus.

METHODS: CONTINUED

COLLABORATIVE EXHIBITION

From 26 November to 10 December 2021, AAU held a small exhibition in the local cultural centre, Trekanten, in Aalborg East. The exhibition was intended, at the end of the project, to invite citizens and path and shuttle users to share their experience of the shuttles and their effect on Astrupstien and Aalborg East. At the exhibition, visitors could mark places along the route that they liked as well as places that they didn't like. Also, visitors could write postcards about the shuttles and Astrupstien.

OPERATORS' LOGS

The operators filled in logbooks after each shift detailing problems at the various stops, technical challenges and the behaviour of other road users and passengers. Comments from passengers and the operators' experiences of various situations were also recorded here in the form of notes. AAU had access to the logs from the launch in March 2020 until May 2021. Notably, there are only a few logs in March 2020, while there are almost daily logs from August 2020 onwards.

CARTOGRAPHIC ANALYSES

The cartographic analyses are based on data from Kortforsyningen, Google Maps and Aalborg Municipality, supported and validated by field observations. The purpose of the data collection was to gain an understanding of the spatial, structural and functional conditions along the test route. Data were collected that related to topographical conditions, public services, housing typologies, housing stock ownership types and links to public transport.

INPUT FROM LOCAL EXPERTS

During the project, regular meetings were held with the project's 'large group', set up by Aalborg Municipality, consisting of local actors and experts, such as housing associations, community centres, youth clubs and primary schools. At the meetings, local social and cultural intersections with the trial were repeatedly highlighted. As a follow-up to these meetings, AAU conducted an interview in December 2021 with an after-school club director who had been following the pilot project from the first fledgling ideas and had special knowledge of the young people along Astrupstien.

INFORMAL (ETHNOGRAPHIC) INTERVIEWS

Ethnographic interviews, also called 'informal interviews', resemble informal conversations. The ethnographic interviews in the study lasted between two and five minutes, during which the researchers initially stopped citizens and asked for permission to walk with them and ask them questions. The questions varied from interview to interview and from situation to situation. During fieldwork between March 2020 and May 2021, ethnographic interviews were conducted with a total of 142 people on Astrupstien.

SERIAL VISION

The term 'Serial Vision' originates from British architect Gordon Cullen's 1961 book Townscape and describes a way in which visual and other sensory impressions can be mapped along a route, usually based on a pedestrian's experience. There is a particular focus on mapping transitions and contrasts, i.e. where changes occur in the urban space. These are marked on a map and supplemented with photos or hand sketches, which are displayed in the form of cinematic sequences.

PHOTO OF THE NEW TUNNEL AT TORNHØJ AND THE SHUTTLE (08.05.2021)

3. BUILDINGS, PATH AND SHUTTLE

This chapter analyses the specific landscape and built-up context that the test route runs through and the concrete transformations of the path and its surroundings that took place before the shuttles were put into operation. The purpose of the analysis is to present the contextual starting point for the operation of the driverless shuttles and the residents' use of them. The end of the chapter presents the views expressed by the study's informants regarding the redeveloped path.

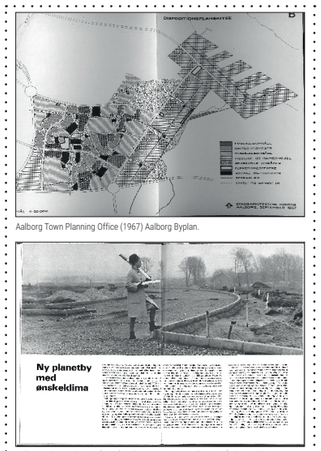
3.1 AALBORG EAST: THE DISTRICT'S HISTORY AND DEVELOPMENT IN BRIEF

Aalborg East is a dynamic suburb that was originally planned and built in the 1960s as a satellite city to Aalborg – called "Planetbyen" – based on functionalist planning principles. It had a sharp division between areas designated for housing and for business, as well as between areas for soft and hard traffic. The district is thus still characterized by a divided structure.

In recent years, the district has been the subject of major renovations and the addition of various new forms of housing in addition to the original public housing blocks and detached houses.

Beyond the new buildings and redevelopments, the district's social profile has also been the subject of social interventions and restrictions, as the district has historically had a higher proportion than the municipal average of citizens with low incomes, citizens from minority backgrounds and citizens with social problems[1].

In other words, since its establishment, the district has been subject to interventions from outside and social upheavals from within. This has manifested in a high degree of awareness among the district's residents about the district's external reputation as a burdened residential area and the town's internal identity as a special and colourful place to live – for better or for worse. Some of these ongoing battles between change and preservation can be read in texts written about Aalborg East[2] and can also be seen in the selection of social housing action plans and reports listed on the timeline on the right.

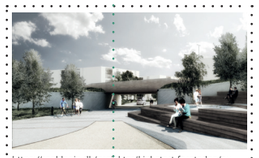


Planlagt og bygget
Aalborg Øst - satellitby/byvækst areal



https://realdania.dk/projekter/fremtidens-forstaeder





https://realdania.dk/projekter/kickstart-forstaden/nyheder/aalborg-oest-udbed-310516

VI SKABER OS

KONKURRENCE: CITY IN BETWEEN

Kickstarter
Nyt bydelscenter ved Tornhøj

Helhedsplan: Astrupstien, CIB

STRATEGISK UDVIKLING

Fremtidens Forstæder
Realdania



https://www.effekt.dk/news/2014/8/13/kildeparken-2-bedre-titel-

ALMEN BOLIG RENOVERINGER

Kildeparken 2020
Færdig plan

Kildeparken 2020
Boligrenovering for 1,5 mia.

Øst i Centrum, Boligsocial helhedsplan

BOLIGSOCIALE HELHEDSPLANER

Projekt 9220, Boligsocial helhedsplan

Center for Samskabelse, Boligsocial helhedsplan

KVARTERSLØFT

1960 | 1970 | 1989 | 2005 | 2010 | 2015 | 2020 | 2025

1989 - BIK Projektet
1993 - Lokalt byudvalg
1996 - 2002 - Kvarterløft

AAK pressemeddelelse
Projektet offentliggøres

Planlægning af forsøgsprojekt

BUSSER IMPLEMENTERES

ARMA
Bussen lanceres

Opstart AAK
Interessen etableres

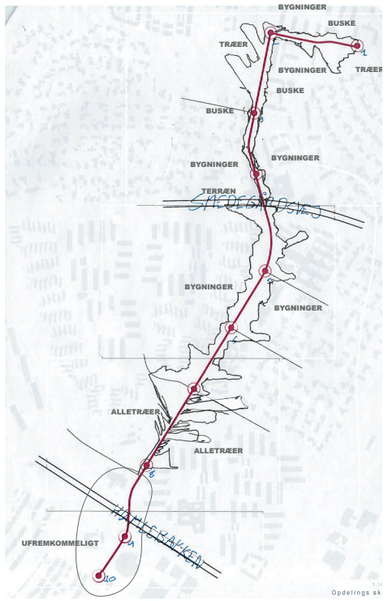
Samarbejde AAK + AAU
Opstart

1 BL - Danmarks almene boliger (2019): De første resultater af Aalborg-modelen
2 E.g. the city district magazine "Det sker i 9220" from 2010 and forward forward

3.2 TOPOGRAPHY AND LANDSCAPE

The landscape along the route is soft and undulating and falls predominantly from NW to SE. The landscape is predominantly open and gives a feeling of airiness and horizontality as one moves along the test route. Especially in the middle of the route, the path is high in the landscape with good views on all sides, and along most of the route there are green lawns and vegetation that create distance from the surrounding buildings.

In some places, buildings, trees and bushes gather closely around the path and frame the view. Especially in the two urban areas – that is, at the Planetcentret Smartbus stop and at the Trekanten, Humlebakken and Tornhøjhave Smartbus stops – the feeling of the open landscape is replaced by denser urban design, with more public services, and two underpasses of the path under major roads.



Field sketch of the view from the test route (17.12.17)



Photo 1 (29.09.21)
At Planetcentret, the shuttle passes through a section where the buildings are very close to the path



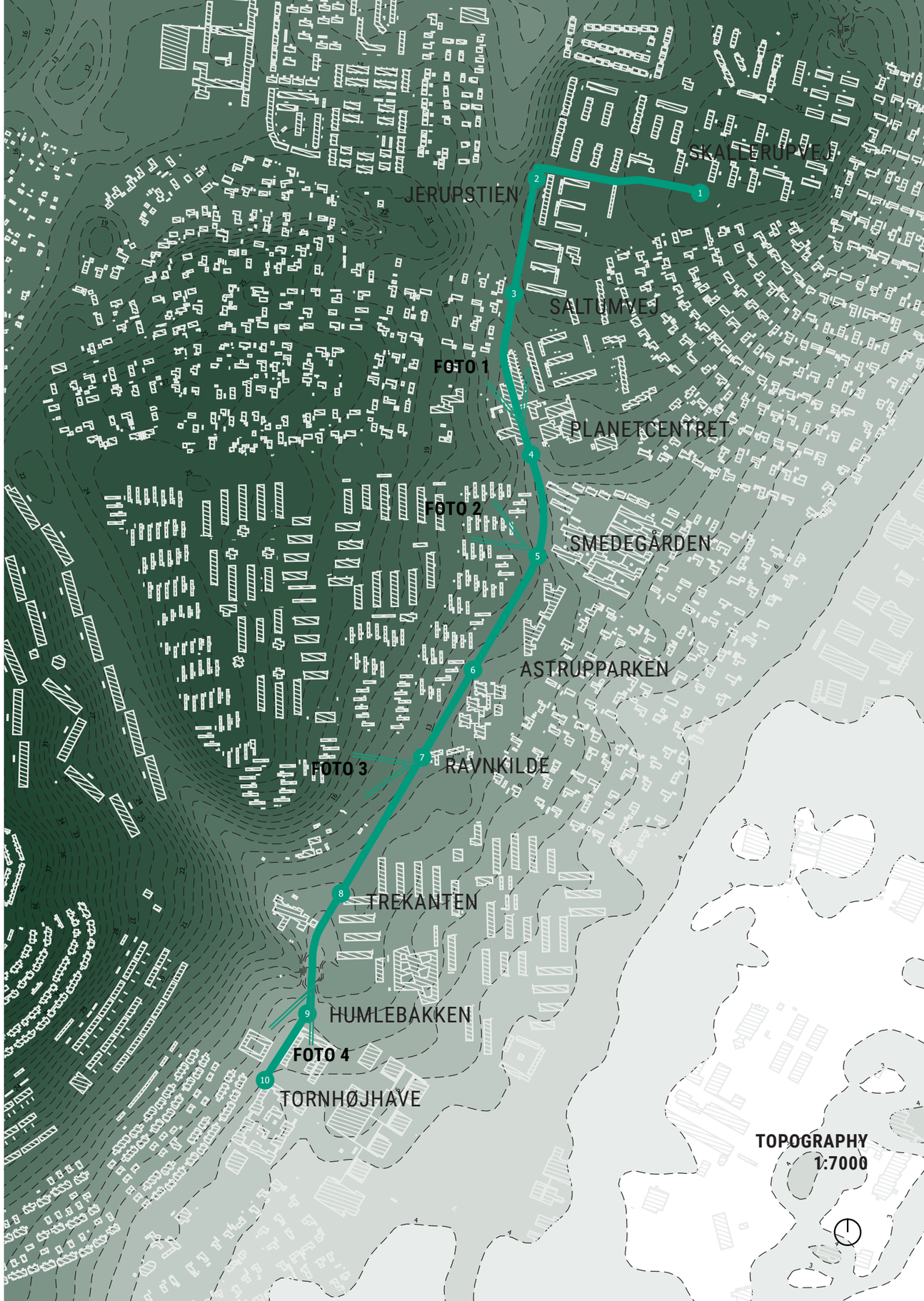
Photo 2 (29.09.21)
The middle of the route is high up in the landscape, with low residential buildings located at a slight distance from the path



Photo 3 (29.09.21)
From the test route, there is a view of open countryside near a large playground south of the Ravnkilde stop; the avenue trees along the path can be seen to the left



Photo 4 (29.09.21)
In the southernmost part, the viewer is located low in the landscape in the transformed centre of the district



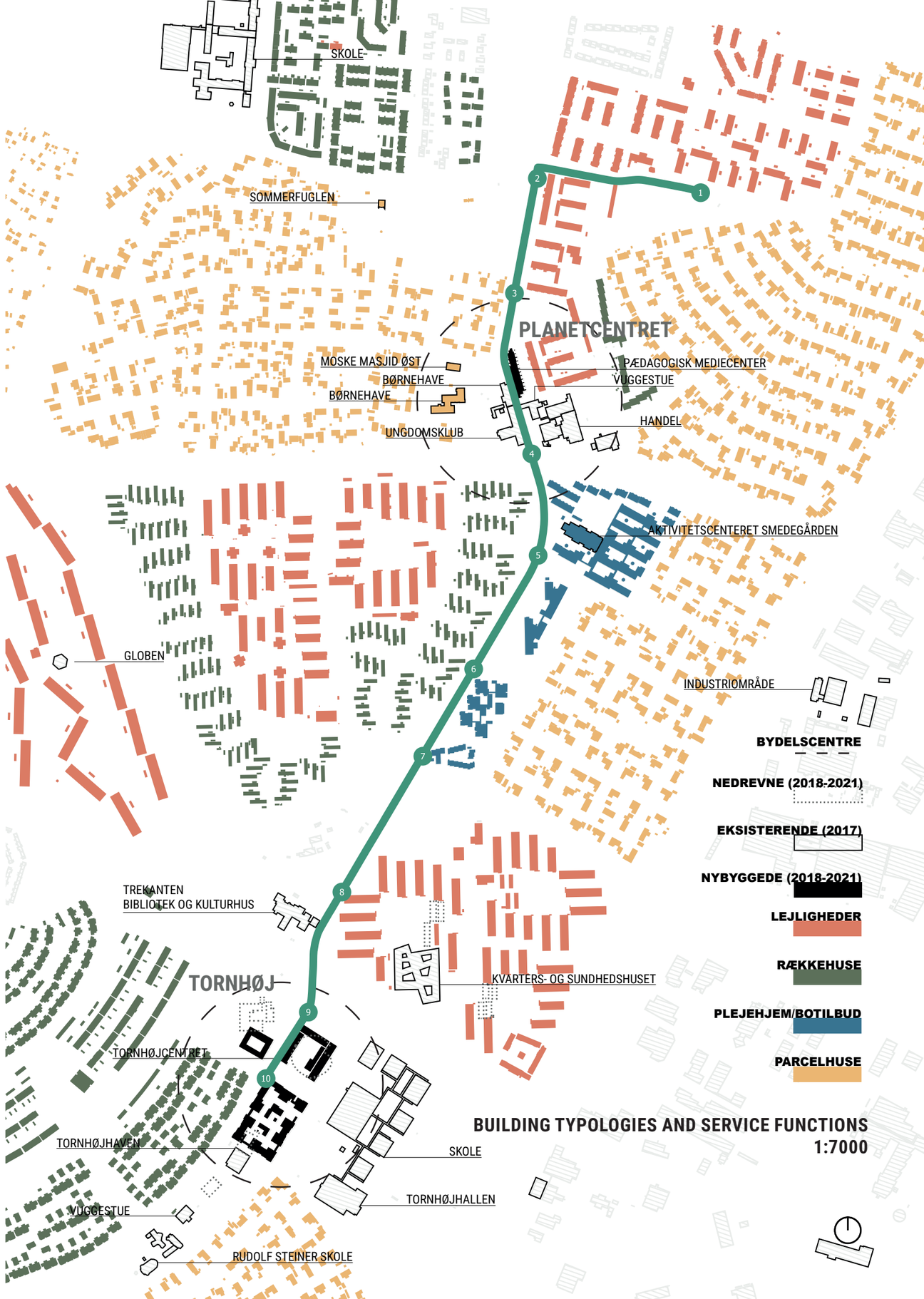
3.3 BUILDING STOCK AND URBAN TRANSFORMATION

The buildings around the test route are predominantly residential and organized in enclaves with different housing typologies and forms of ownership, with a large proportion of public housing. In addition, to the north is the Planetcentret, with shops and institutions, and to the south is the district centre at Tornhøj, which contains shops and buildings with a wide range of public functions, such as a school, a cultural centre and a health centre.
As previously mentioned, the district has undergone an extensive transformation and urban renewal of the relatively run-down building stock and other facilities from the original modernist town plan. The development was also driven forward by a number of national partnerships with a focus on sustainable principles for the renewal of suburban areas – ideas that are articulated, e.g., in reports from recent urban development projects such as 'Suburbs of the Future' and 'City in Balance'[3].

The area's public housing, originally from the 1970s, has undergone major changes with the comprehensive Kildeparken 2020' plan[4], where recommendations from 'Suburbs of the Future' have been translated into concrete measures: Small apartments have been renovated and merged into larger ones; individual buildings have undergone additions and alterations, allowing new homes (e.g. penthouses) and types of housing (e.g. senior housing community) to be added; and new buildings have been erected with different types of housing and forms of ownership.

The transformation has also included the areas between the buildings and the connection between residences and outdoor spaces. Work has been done to create a more varied and experience-rich landscape, where, among other things, new plantings and rainwater reservoirs have been established, where before there were only large open lawns. Streets have been created with pavements and direct access from homes to both street spaces and recreational areas. Finally, diverse urban spaces with common functions have been established in the individual residential enclaves where there used to be parking areas.

When one is travelling along the test route, one experiences the biggest transformation at Tornhøj in the south, where newly constructed buildings and urban spaces contain shops, cafes, homes and institutions. The Trekanten cultural centre and library is also located in this area, along, as well as a community and health centre, and the local elementary school . The original tunnel, which led the path under a major road, has been transformed into a bridge-like, airy structure. The transformation was carried out under the auspices of the 'Kickstart Tornhøj' project, which aimed to establish a functional and social centre of gravity at this location in the district and thereby create the foundation for a revitalized, coherent urban centre[5].



3 realdania.dk/projekter/fremtidens-forstaeder/nyheder/fremtidensforstaeder_151112 ; https://realdania.dk/projekter/byibalance
4 kildeparken2020.dk
5 www.aalborg.dk/om-kommunen/byplanlaegning/byudvikling/kickstart-tornhoej

3.4 PATH AND SHUTTLE

In line with the philosophy behind the original urban plan, car traffic – and thus public bus transport – is routed around the district's residential areas. Astrupstien, which until the Smartbus trial was reserved for pedestrians, cyclists and mopeds, therefore forms the central north-south transport route within the district. It connects residential areas, service functions, institutions and shops and acts as a backbone for active traffic and city life, as well as being a central urban space for recreational activities: People run, cycle, walk and roller skate here, and local outdoor events such as the district's children's carnival are held on and around the path.

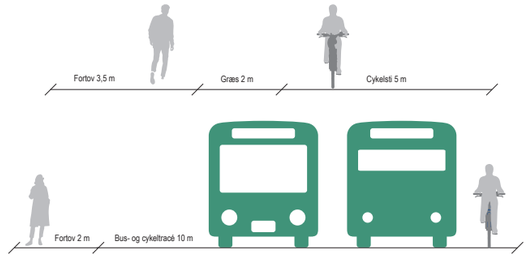
A disadvantage of public transport being routed around Astrupstien is that this can make it difficult for citizens with limited physical mobility to access the central service functions that the path connects.

In the vision for the district, which is outlined in the latest comprehensive plan for the area[6], Astrupstien is articulated as the district's new main street – i.e. as a continuous urban space towards which housing and recreational areas are oriented. Increased accessibility within the district for citizens with reduced mobility was therefore identified as a sub-goal for the urban transformations. The Smartbus project must thus be understood in the context of the site-specific social and urban context, where various projects, initiatives, discourses, understandings and development goals have shaped the planning over time.

TRANSFORMATION OF THE PATH

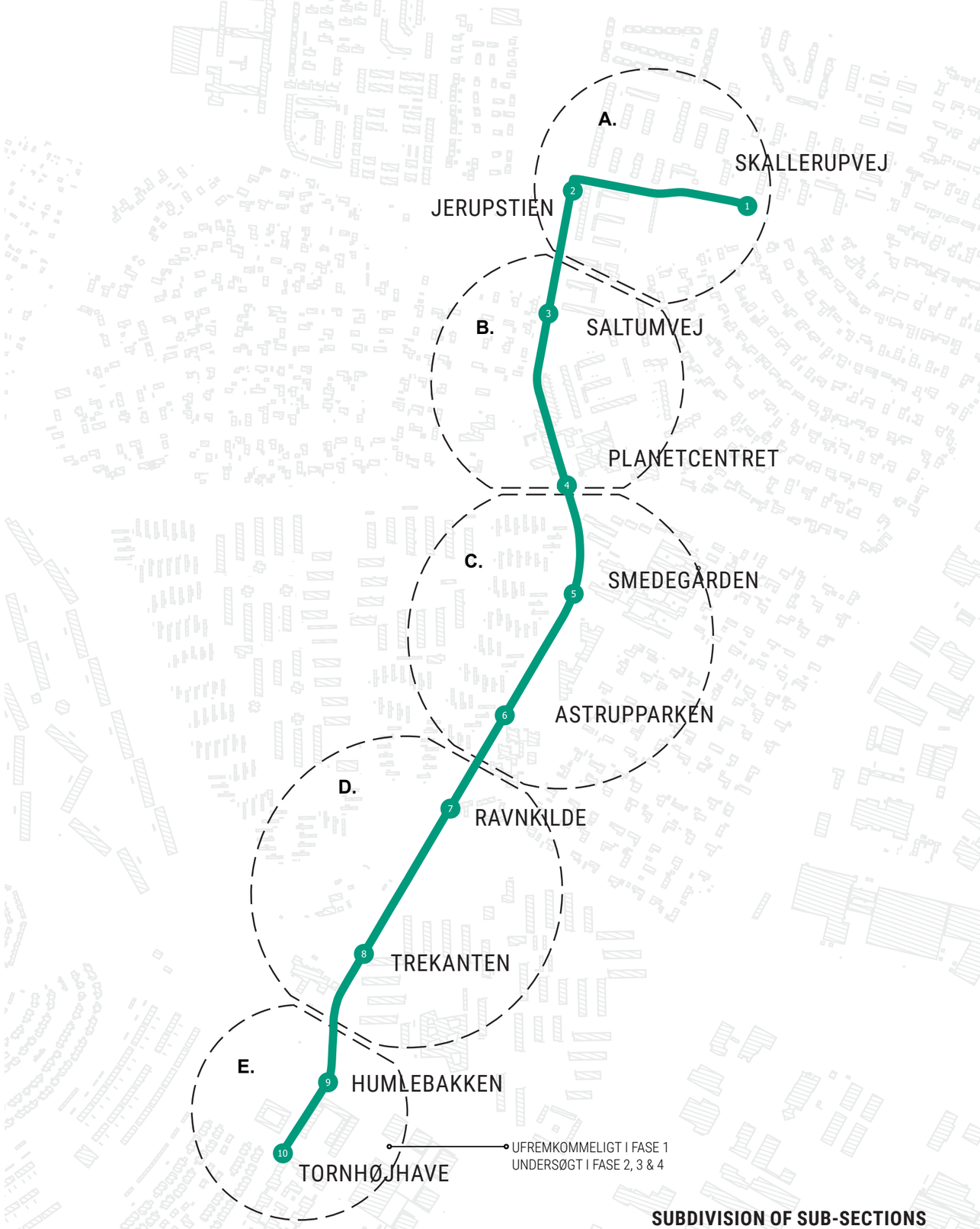
The test route is 2.1 km long and runs briefly along Jerupstien in the north and then along Astrupstien to the south. Before the Smartbus project, the path was reserved for vulnerable road users and mopeds. With the exception of a short stretch at the Planetcentret in the northern part, the path has been made wider so that two shuttles, cyclists and pedestrians can pass each other. The route was laid out with a wide asphalt surface for the driverless shuttles and cyclists, along with a concrete pavement for pedestrians.

The following sections describe the transformed path and the adjacent surroundings in more detail. The description follows the course of the path through five sections from north to south, which together create an overview of the variations in the context that the test route cut through and connected.



Before and after construction work on Astrupstien; section showing the redevelopment principle.

6 Kildeparken 2020 - en del af de nye Aalborg, Himmerland Boligforening. (Kildeparken2020.dk)



SUBDIVISION OF SUB-SECTIONS
1:7000

The test route from north to south with a total of 10 stops; in the AAU study, it was subdivided into five sub-sections for the purpose of site analysis – see the next pages.

3.5.1 SECTION A



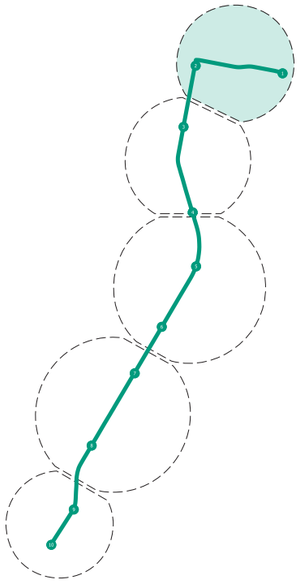
CHARACTERISTICS

The northern part of the test route runs on Jerupstien and the first part of Astrupstien. There is a clear view along the course of the path, up to the point where the path turns south.

There are housing developments along the path to the north, while the southern side consists variously of dense vegetation, an open green area with space for play and ball games, and housing developments.

This part of the test route is usually peaceful and quiet, with few people on or near the path. The hum of cars from the busy roads further away is barely perceptible. The breeze that touches the trees can be felt, and there is the sound of birdsong. These sounds contribute to the atmosphere of the place, giving the impression of a space that is quiet and secluded, where things take place slowly and calmly. Occasionally you can hear the sound of a moped, children playing behind a hedge, a dog barking or the chatter of passers-by.

Encounters with other people on the path are sporadic. People might be walking, cycling or walking a dog, mostly at a slow pace. Although the path is divided into a bus/cycle lane and pavement, in the use of the path there is often no distinction between cycle and pedestrian paths.



BEFORE AND AFTER URBAN TRANSFORMATION

As part of the extensive conversions and renovations of the housing stock in Aalborg East, the low, two-storey residential buildings along the northern side of Jerupstien underwent extensive renovation (below right) from the former yellow brick buildings (below left).

The width of the path was increased, and the route was laid out with a wide asphalt surface intended for the driverless shuttles and cyclists alongside a concrete pavement for pedestrians.

The new materials have given the path a more contemporary and well-maintained look, which is supported by upgraded lighting. Where the path was previously characterized by worn surfaces and fixtures, the new materials give an impression of an area in which both attention and resources have recently been invested to create a more attractive outdoor environment.

2018

2021

Section A before transformation



(14.03.2018)



(14.03.2018)

Section A after transformation



(29.09.2021)

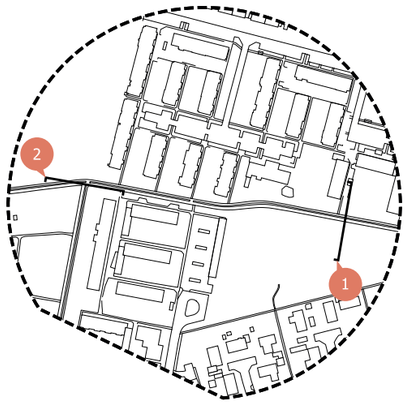


(29.09.2021)

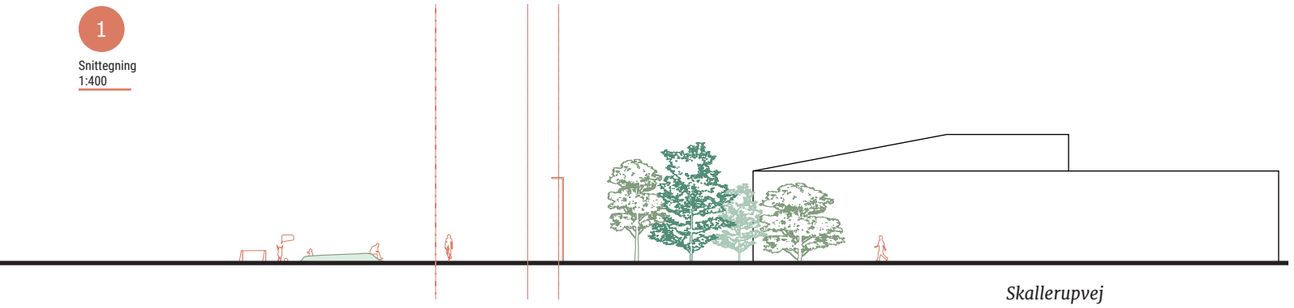
STOPS AND SPATIAL DESIGN

Along section A, two stops were established. The stops form a break in the path, where the pavement widens and creates a flat area – or a small urban space – around the bus stop. Here passers-by can sit on a bench, with newly established lighting and varied planting right beside the stop.

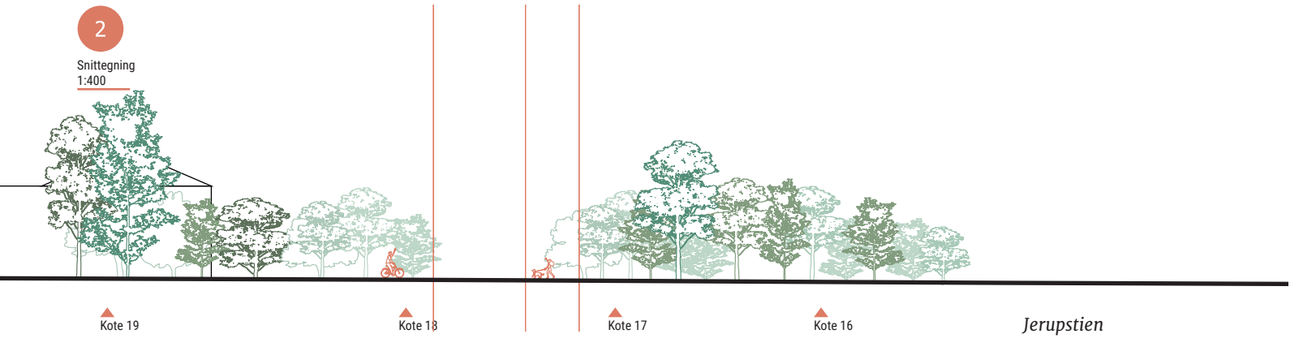
The markers that mark the bus stop itself have the same green colour at all 10 stops and contribute to a coherent communication of the route as well as to the experience of a well-designed urban layout.



1
Snittegning
1:400



2
Snittegning
1:400





Jerupstien (14.03.2018)



Bus shelter at Skallerupvej (29.09.21)



Skallerupvej (29.09.2021)



Jerupstien (29.09.2021)

During the test period, some users requested that a covered waiting area be established. As part of the ongoing dialogue between users and Aalborg municipality, such areas were established at the route's first stop, Skallerupvej, and at the last stop, Tornhøjhave.

3.5.2 SECTION B

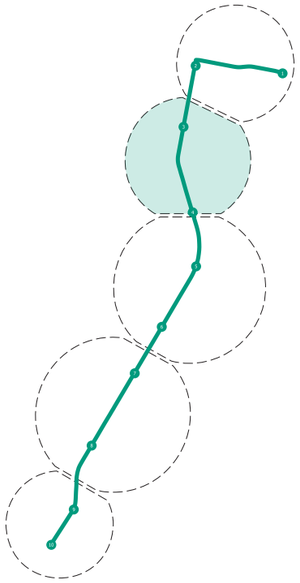


CHARACTERISTICS

This section consists of a straight, open stretch to the north, with housing developments to the east and a partly open, partly planted area to the west. In the southern part of the section, the path runs through a more densely built-up area at Planetcentret, which is a local centre with shopping opportunities and bus connections to the city. There are buildings very close to the path, and they form its boundary on both sides in a relatively narrow, street-like course, which is experienced as far more urban than the open spaces to the north, with their more extensive vegetation and greater distance from buildings. Next to the path are housing, a kindergarten and a youth club. A connecting path leads into the Planetcentret's shops and service functions.

The section narrows and ends at the entrance to a tunnel, which leads Astrupstien under the automobile road, Smedegårdsvej, from which minor traffic noise emanates.

The presence of children and young people is a characteristic feature of this section, and passers-by regularly meet other people. In addition to children and young people, other pedestrians, cyclists, electric scooters, mopeds, prams and dogs are often seen.



BEFORE AND AFTER URBAN TRANSFORMATION

The reconstruction of the path, with a wide asphalt surface for the driverless shuttles and bicycles and a concrete pavement, continues into section B and is a consistent characteristic of the entire test route.

However, it was not possible to widen the path in the southern part of the section as the buildings here are close to the path and the width of the tunnel imposes a limitation. This means that the shuttles cannot pass each other in the tunnel and must therefore hold back from each other.

2017-18

Section B before transformation



(06.12.2017)



14.03.2018)

2021

Section B after transformation



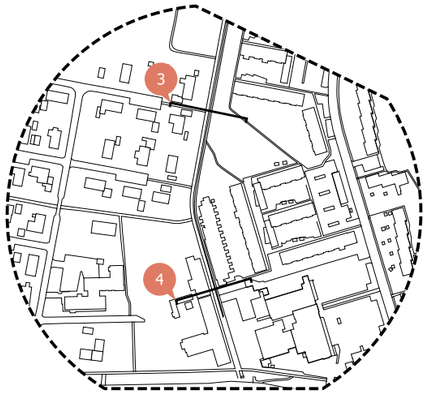
(29.09.2021)



(29.09.2021)

STOPS AND SPATIAL DESIGN

Section B also has two stops. The first stop, at Saltumvej, is spacious, with a fairly large paved area around the stop itself and a bench. At the Planetcentret, the space is more limited, and the marking of the stop is less developed, with a small wooden platform for step-free entry to the shuttle placed on top of the concrete pavement.



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Snittegning
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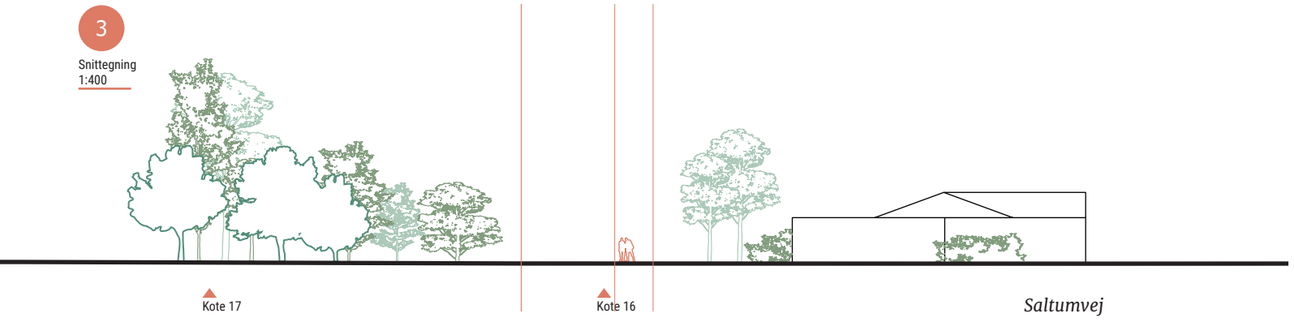

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Snittegning
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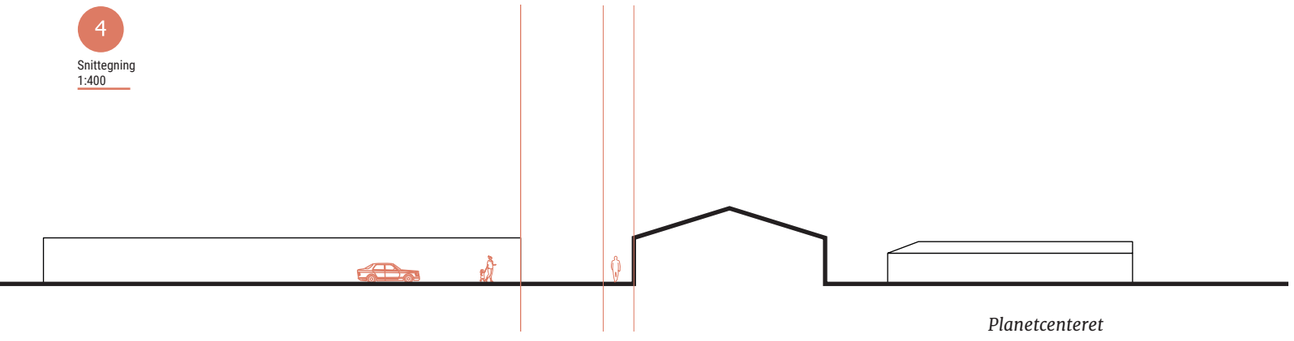
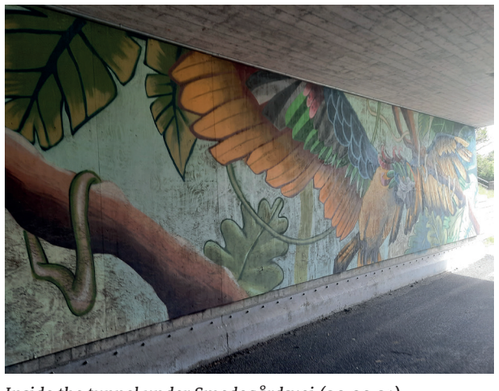




The tunnel under Smedegårdsvej (24.10.2020)



Inside the tunnel under Smedegårdsvej (29.09.21)

The tunnel is the narrowest point of the test route. Before the test route upgrade, it appeared dark and battered. There have been no plans to rebuild the tunnel; instead, it was decorated with graffiti art painted by local artists.

The artwork was part of the ongoing dialogue between the project and its local partners about how to support a sense of local ownership of the shuttles and the surrounding infrastructure.



Saltumvej (29.09.2021)



Planetcentret (29.09.2021)

3.5.3 SECTION C



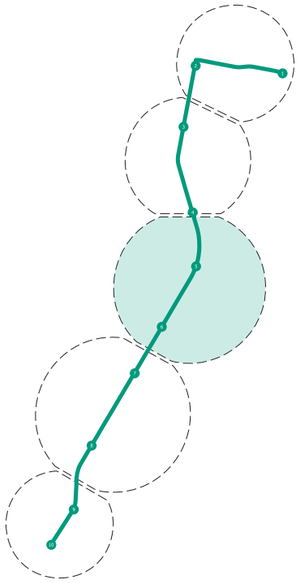
CHARACTERISTICS

Section C is open and long. From the beginning of the section just south of the tunnel under Smedegårdsvej, the terrain rises evenly, while the path curves gently. From here, the terrain levels out, and there is a view of the rest of the section.

The buildings are generally located some distance from the path on both sides, and the path thus appears to be open and embedded in the landscape.

Along the entire section, there is housing that consists of linear buildings arranged in straight rows to the east, including a nursing home that is located relatively low in the landscape, while terraced houses spread out on the higher ground to the west. Extensive building renovations have been carried out here, just as the landscape has been changed with plantings, rainwater collection, etc.

Most people on this part of the stretch move at a slow pace. As there is no shelter on the path, it can feel a bit windy along this stretch.



BEFORE AND AFTER URBAN TRANSFORMATION

To the west along the open part of Astrupstien on section C, there was densification during the trial period involving new detached, relatively small high-rise buildings. The existing housing stock has been renovated, and the existing green lawns have been partially transformed with rainwater lakes and new planting.

Small paths have been established across the residential enclaves to the west, creating connections between the outdoor areas between the houses and Astrupstien.

2017-18

Section C before transformation



(06.12.2017)



(14.03.2018)

2021

Section C after transformation



(29.09.2021)

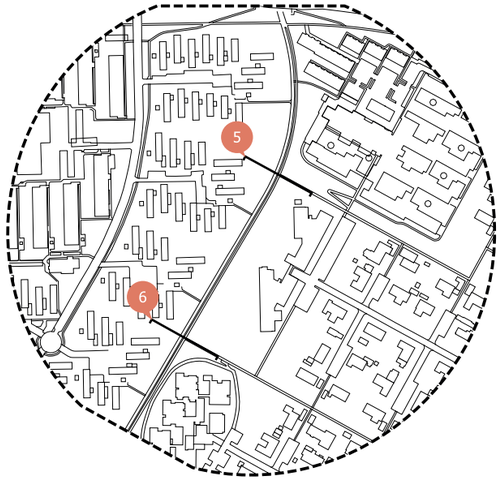


(29.09.2021)

STOPS AND SPATIAL DESIGN

Along section C, two further stops have been established. The stops are not exactly the same but are shaped according to the same basic design principle. Both are constructed by extending the pavement to a wider area, which is broken by a central island of vegetation that encircles and provides shelter for a bench at the stop. Rubbish bins and signage contribute to furnishing the outdoor space.

The stops help to give Astrupstien a design identity, but at the same time, the consistent distance to the other urban spaces means that despite the established connecting paths, they form their own slightly exposed open spaces, with few incentives to stay other than waiting for the shuttle.



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Snittegning
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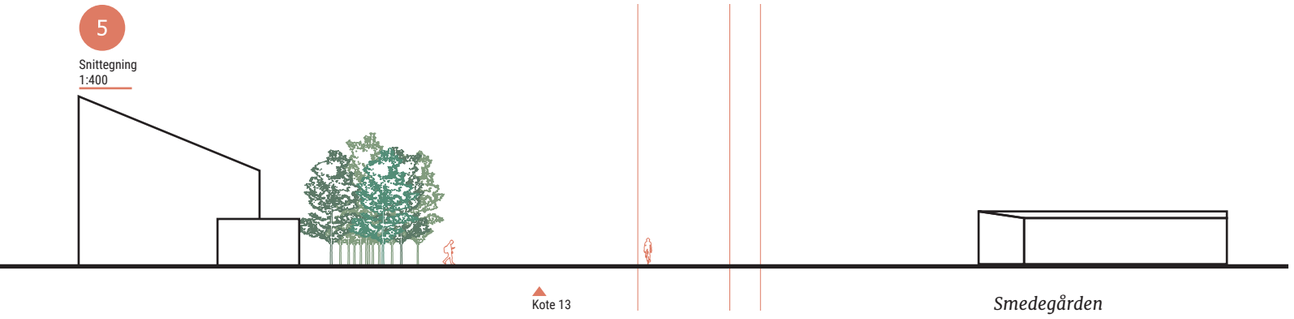

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Snittegning
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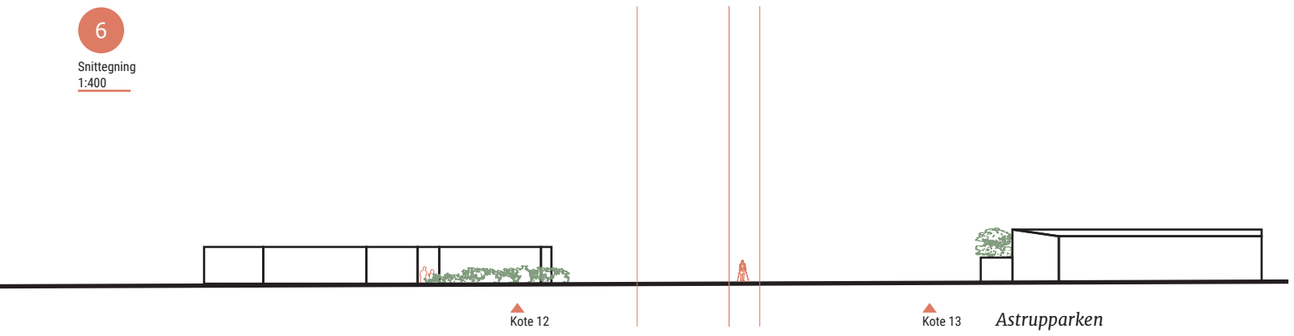




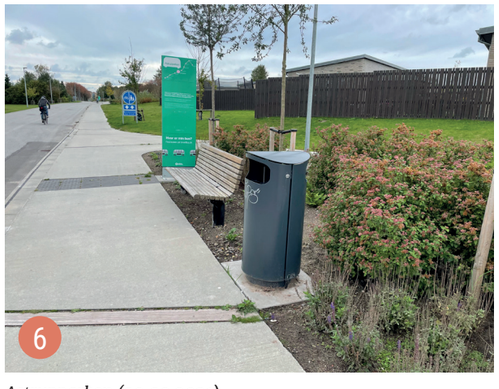
Nursing home and shielded residential facilities (12.12.2017)



Homes along Astrupstien (12.12.2017)

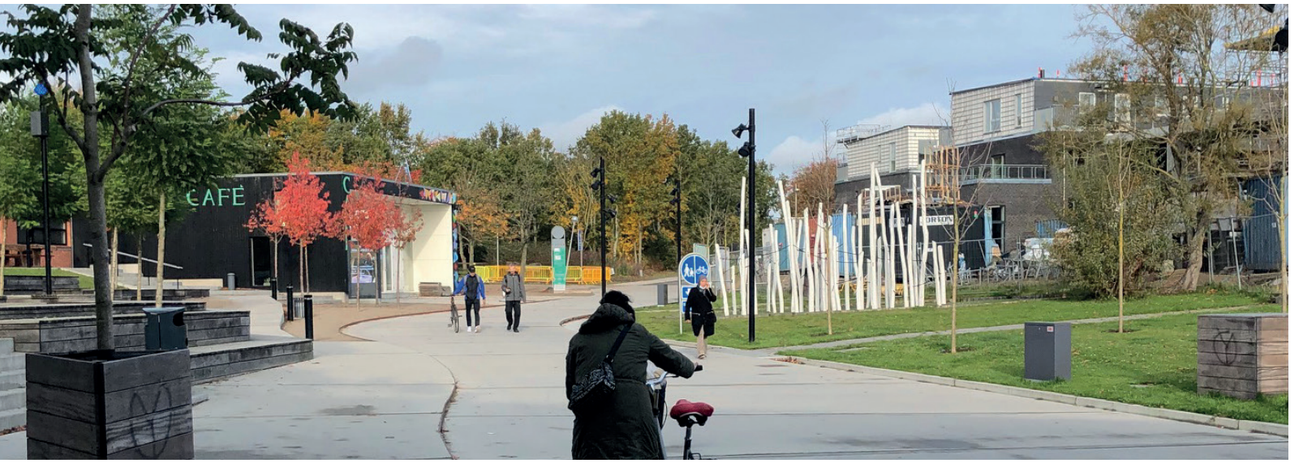


Smedegården (29.09.2021)



Astrupparken (29.09.2021)

3.5.4 SECTION D

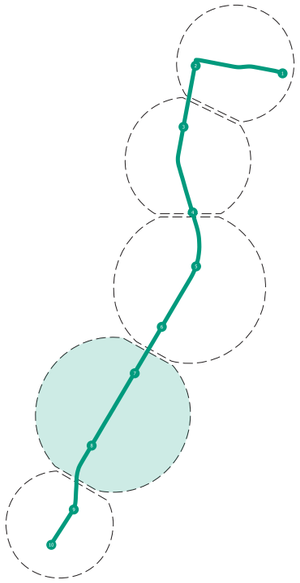


CHARACTERISTICS

Section D forms a transition between the open section C, where there are relatively low-rise residential buildings with a view over the countryside, and the more densely built-up urban section to the south. Along the northernmost part of section D, an older, well-established hedgerow to the east has been preserved, giving shape and character to the section. A ball field and a playground have been added to a green area to the west.

Along the southernmost part of the section, the housing developments become significantly higher and denser. In this area, many of the district's common and public functions are found, such as a health centre and the Trekanten neighbourhood centre.

The transition to the more urban part of the test route is reflected in the fact that far more people travel on this part of the path, and at a slightly increased pace. In particular, there are many children and young people here.



BEFORE AND AFTER URBAN TRANSFORMATION

At the transition to the more densely built-up area, the spatial character around the path is changed by the preserved hedgerow to the east. The path has also been widened in this section, so that it consists of a wide asphalt surface for shuttles and cyclists and a pavement made of light-coloured concrete.

The area around Trekanten has undergone an extensive transformation, and both buildings and outdoor spaces have been renovated. The apartments close to Trekanten have also been renovated, and parts of some buildings have been demolished or extended.

2017-18

Section D before transformation



(06.12.2017)



(06.12.2017)

2021

Section D after transformation



(18.05.2021)

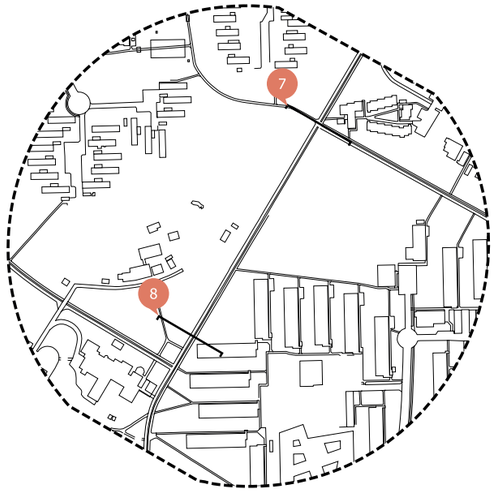


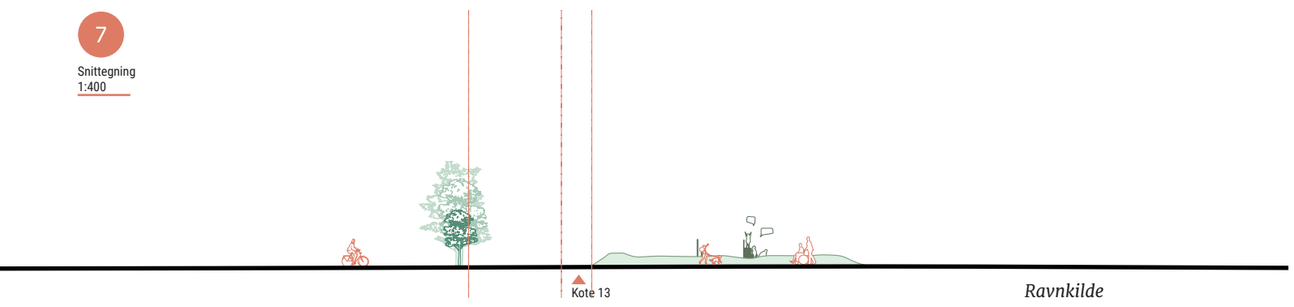
(29.09.2021)

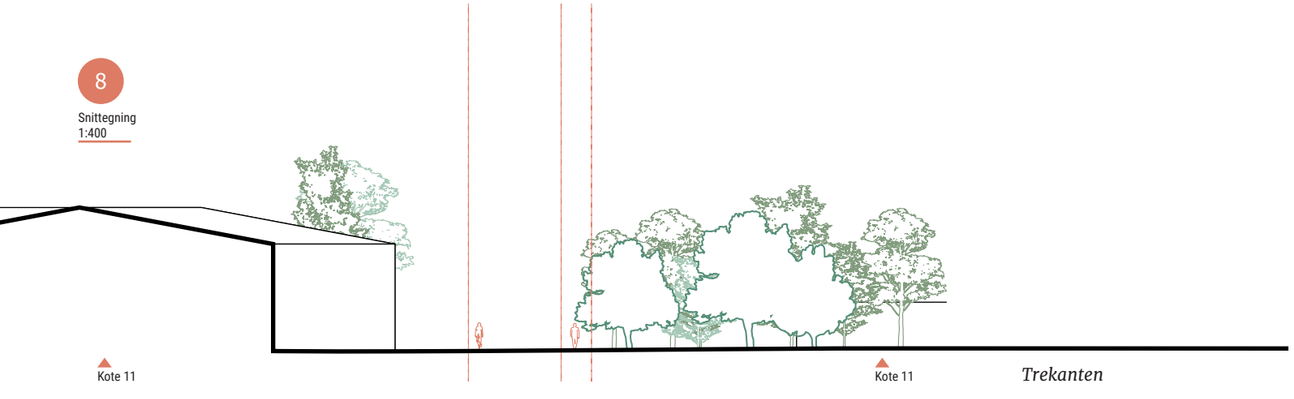
STOPS AND SPATIAL DESIGN

The Ravnkilde stop follows the same design principles as the previous stops, while the bus stop at Trekanten is simpler (similar to the stop at Planetcentret in section B) and is located in a newly established urban space, where a cafe area inside Trekanten faces the path and enables active interaction with life on the path.

At the transition to the urban space in front of Trekanten, the surface of the path changes from asphalt to concrete elements, and the path forms part of a larger paved area. Several types of pavement are used here, edged with concrete elements at points of steep elevation change, with wooden beams across the path between the concrete elements. New vegetation has also been established, and trees have been planted, breaking up the paved areas.









Café Trekanten (29.09.2012)



Southern view of the transformed urban space (08.05.2021)



Ravnkilde (29.092021)



Trekanten (29.092021)

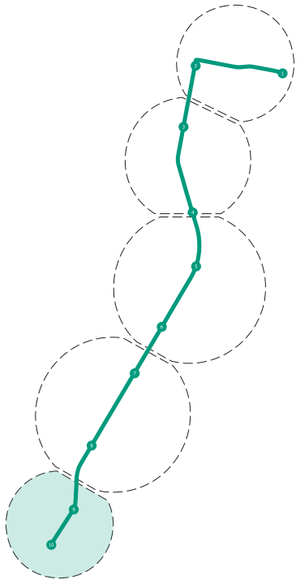
Whereas the bus stops on the northern part of the test route form island-like opportunities to stop and rest, the stops along the southern segment form less prominent elements in the larger urban landscape.

The area in front of Trekanten, which is on the western side of the path, has the character of a small square. To the east of the path, another playground has been established as well as several crossing paths that reach into the areas between the newly renovated buildings and over to the health centre to the east. To the south, section D is bounded by a bridge, which carries the busy Humlebakken road across the carless area. The space created by the difference in heights between the road and the path has been shaped into a terraced area with an integrated stage that forms a meeting place and a possible setting for events.

At the transition to the last section, paths and urban spaces in several directions and at several heights intersect with the path, which forms a unifying and continuous line. On this busy and feature-rich part of the test route, the driverless shuttles appear to have a less defining role in shaping the path and its surroundings.

3.5.5 SECTION E





CHARACTERISTICS

The entire area around section E appears to be newly built, with the exception of a few apartment blocks at the edge of the area. In addition, there are new buildings with convenience stores and cafes.

The area appears as an open urban space with views in four directions: north along Astrupstien under the new bridge that carries Humlebakken over the path; south along Astrupstien towards lower buildings, with a large playground and a green area on the right; west up the hill towards newly built, sand-coloured apartment blocks; and east towards new, white apartment blocks with public-oriented businesses on the ground floor that have replaced the former shopping centre (Tornhøjcentret).

There are parking options at shops and a pedestrian pathway to Tornhøjskolen, where many of the children and young people who use Astrupstien go to school. Compared to the rest of the test route, this section is particularly active and urban, with people moving around for school, shopping, recreation, etc., and spending time at the playground, cafes, benches, etc.

BEFORE AND AFTER URBAN TRANSFORMATION

Section E and the immediate surroundings have undergone an extensive transformation. The former narrow concrete tunnel, which led Astrupstien under the Humlebakken road, has been transformed into a much more airy and bridge-like construction, with a wide and open path underneath. The path's materials are continued from the section around Trekanten (section D – southern), and in the same way as north of the bridge, the urban space expands south of the bridge.

The surrounding areas have also been extensively transformed. New urban spaces, buildings and functions have created a district centre with an urban appearance that is markedly different from before the transformation. At this location, Astrupstien has acquired the character of an urban space that brings together functions and buildings on the west and east sides of the path.

2011

Section E before transformation



(September 2011)

2021

Section E after transformation



(29.09.2021)

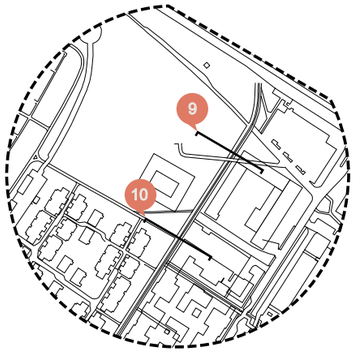


(08.05.2021)

STOPS AND SPATIAL DESIGN

The two stops on section E, Humlebakken and Tornhøjhave, like the stop in front of Trekanten, have the character of “city stops” that are kept simple and consist only of the green marking and the platform at which the shuttles stop.

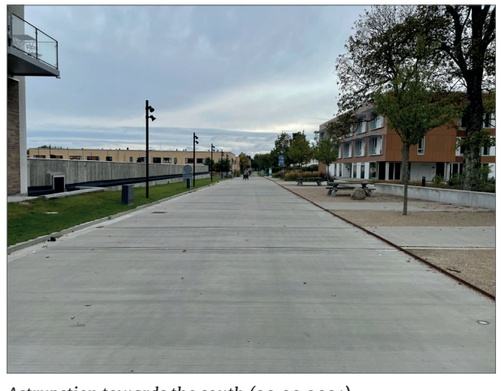
Since several users requested shelters at the stops, these were set up at the first and last stops of the route, i.e. (along this section) at the Tornhøjhave stop.







Housing and the playground around the spider (29.09.2021)



Astrupstien towards the south (29.09.2021)

In the area around Tornhøj town centre, cars drive from the road network to the local service functions. An integrated barrier has been established to prevent cars from the nearby car parks and access roads from straying onto the path.

To the east of the path, opposite the new shop fronts, a green area has been established with a playground built around a large old tree. A striking play sculpture depicting a large black spider stands in the middle of the playground.

The test route ends with a long, straight stretch. The widened path ends at the last stop. From here, Astrupstien continues south along the route that formed the Smartbus project’s ‘envisioned route’, which would potentially create a connection to Aalborg University’s campus and allow passengers to change to the BRT bus towards Aalborg city centre and the new university hospital.



Humlebakken (29.09.2021)



Tornhøjhave (18.05.2021)

3.6 THE RESIDENTS' EXPERIENCE OF THE TRANSFORMED PATH AND ITS SURROUNDINGS

In the previous sections, we described the path's physical appearance and the many changes that the areas around Astrupstien have undergone. To investigate this further, we relied particularly on methods for site analysis based on observations and cartographic data. Alongside the site analyses, we collected statements from users of the path in the form of focus group interviews and conversations with users of the path who agreed to be informants for the Smartbus project study. The informants were both children and adults, all having some association with Astrupstien. Some of the collected statements relate to the many different experiences of children and adults concerning the transformations in the district and of the path. These various statements are described below.

WHAT DO CHILDREN AND ADULTS WHO USE THE PATH SAY ABOUT THE TRANSFORMATION?

The renovations and conversions were referred to positively by many informants on the path. Several described it as "something happening", and words like "fine", "nice", "lovely", "enriching" and "cool" were used when we asked informants about the new path and its surroundings. One mentioned that the renovations were a large part of the reason he stayed there. Some appreciated that there were fewer holes in the asphalt, and others found the path better to walk on now – in particular due to the separation of the path from the pavement.

Two new supermarkets, Netto and Lidl, opened in 2019 and 2020 on the southern part of the path at the Tornhøj centre and were described by many as valued shopping opportunities. The health centre with its facilities was also praised by many.

Some were considering the significance of the transformation for Aalborg East and its "identity".

A 7th-grade student reflected in 2021 on the transformation of the district:

> *Student:*
> *"Actually, I think it was a bit nicer before. Because now it's just such a fancy city we live in. Before it was more cosy. All these new apartments, everything has just been renovated, there are more and more buildings here in Aalborg. [...] it will be very similar to a Copenhagen number two. They have removed all the trees and all the landscapes. It was much nicer before."*

A similar observation was made by a resident in 2021, who described the new construction as a change in Aalborg East's identity:

> *Resident:*
> *"In this way, it has become a much more inviting district. It certainly is. But maybe also... a bit more middle-class Denmark than it was before; it may have lost a bit of the identity that it may have had because it was very multi-ethnic and perhaps also with slightly more residents who also had different challenges."*

Despite a predominantly positive assessment of the urban transformation, we also met several people who were not impressed and described it with words like "It's ugly!" as well as those who missed the graffiti in the old tunnel and found that the new southern tunnel does not offer the same shelter from the rain as the old one. An informant aged about 70 described the path as having become boring and needing "to be cheered up a bit".



CYCLISTS AND PEDESTRIANS ALONG ASTRUPSTIEN (08.05.2021)

Some did not regard the new construction work as anything special, although they called it "okay". A resident also exclaimed that "they shouldn't build more now!" A few children were surprised in 2021 that no new graffiti had appeared on the new tunnels: "It's really strange. I figured after a week there would be graffiti on it."A resident also reported that she had expected vandalism:

Resident:
"when they started making those beautiful murals with those animals, I thought... But there has been no one who has destroyed it. I think that's great."

Both the children and the resident believed that the absence of vandalism may be due to the fact that the new building looks nice and that people therefore respect it.

WISHES FOR THE PATH AND THE BUS STOPS

Various wishes were expressed for the path in 2021, including more rubbish bins (especially in sections A and B) and more bus shelters at bus stops. Three older informants specifically requested a bus shelter at the "Smedegården" stop on section C so that they could shelter from the rain. A 7th-grade girl reflected on the lack of shelters in 2021:

Girl:
"Actually, in terms of rain, it's a bit silly, because if you have to stand outside at the bus stop and wait, you'll get wet. But if there was a small half-roof over it, you wouldn't get wet, or if it was really, really hot and you couldn't stand the sun."

At the bus shelter set up at the southern stop, some of the glass panels had been broken, which the local children described as expected pranks. A consideration that takes up a lot of space in the inputs from users of the path is criticism of the transverse wooden beams between the concrete elements on the route. These stripes repeat on the pavement along the northern parts of the path and on the urban parts of the path in sections D and E. As early as a 2018 workshop with a 4th-grade class, the beams were drawn and mentioned several times by the students. A boy, for example, thought that it was dangerous with the "holes" in the road. An informant explained that the grooves were "something bad", as she has seen "really many" elderly people tripping over them when they walk. Another informant also criticized the beams, saying the many bumps were uncomfortable when she drove along the path in an electric wheelchair. Another informant observed that the new path has "ruined" it for skaters and roller skaters. A cyclist offered the uninvited explanation in 2021 that she was tired of the beams:

Cyclist:
"It hurts like hell to ride a bike! [...] It is due to those trees – something in the path. So, it does... Did you notice the guy who came on a scooter? He also jumped over them every time. [...] – I get up from the bicycle seat because it hurts."

We observed children having difficulty keeping their balance when riding a scooter across the beams, and three children in the 7th grade reported in 2021 that "they are annoying". Two of them elaborated on the problem:

Girl:
"Can you see that line? The road is changing. Over there, I think I fell like 10 times. On a scooter or bicycle."

Boy:
"It's [expletive] annoying to drive on. [...] You almost fall. What's the point of that?! Why not just lay new, nice asphalt? Why make grooves?"

Girl:
"Yes, just like over there by the rounder [playground]. It's smooth there."

3.7 SUMMARY – BUILDINGS, PATH AND BUS

The transformation of the test route and the residential and urban areas through which it runs was extensive and was carried out with social, maintenance, architectural and safety-promoting purposes in mind. In the bigger picture, the renovation and widening of the path itself to accommodate the experiment with the driverless shuttles is thus just one purpose among many.

The transformation of the path has made it more visually significant. It signals that the path constitutes prioritized access and a connecting road, as well as a spatial backbone, in the district, as was proposed in Vandkunsten's original winning proposal for the development of the district. The test section runs through areas with a highly varied appearance, where some sections are open and part of the landscape, while other areas have an urban character.

With the transformation, it seems that an attempt was made to overcome some of the problems with the original layout of the area. The attempt took two main approaches. The first was to create connecting paths into the nearby built-up areas, which previously faced inwards and away from the path, thereby creating a connection between the different built-up areas along the stretch. The second was to establish a more varied, better lit and more viewable environment along the path. The time-limited Smartbus project's need for temporary bus stops was addressed by creating small, delimited outdoor spaces with shielding vegetation, which can be used as meeting places along the path following the completion of the trial.

The residents we spoke to were generally happy with the transformation of the path, not least the fact that the stretch is now perceived as brighter, friendlier and more populated. At the same time, however, some felt that the limit has been reached for how much can be changed without residents no longer experiencing the district as theirs, with its somewhat raw characteristics and the diversity that the users of the path described as being part of Aalborg East's attractiveness and distinctiveness.

THE SOUTHERNMOST PART OF THE TEST ROUTE AT TORNHØJHAVE (08.05.2021)

4. THE DRIVERLESS SHUTTLES ON ASTRUPSTIEN

In the years leading up to and during the trial, AAU was in dialogue with children and adults who use the path. This chapter contains an analysis of Astrupstien's role in the everyday life of those who travel on the path. Here, we investigate how the driverless shuttles were used, interpreted and experienced as part of life on and around Astrupstien.

4.1 SHUTTLE OPERATION ON THE TEST ROUTE

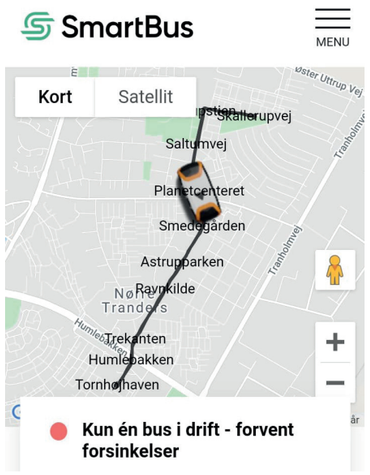
The driverless shuttles used in the Smartbus trial were manufactured by the French company NEAA and were of the NAVYA type, model Arma DL4. The shuttles were equipped with 11 seats and four standing places. However, for most of the test period, due to Covid-19, the shuttles could only take five passengers, and in some periods a maximum of two people were allowed on the bus. In the period from 11 March to 10 August 2020, operations were completely suspended as part of the general restrictions on social activity during the pandemic.

The operation was organized so that two shuttles were in operation at the same time while a third shuttle was being charged. When operations proceeded according to plan, the shuttles ran approximately 14 hours a day between 7 am and 9 pm. Due to illness among the operators, operator absence in connection with Covid-19 (isolation, close contact, etc.) and technical challenges with the vehicle and its software, on some days only a single shuttle was in operation.

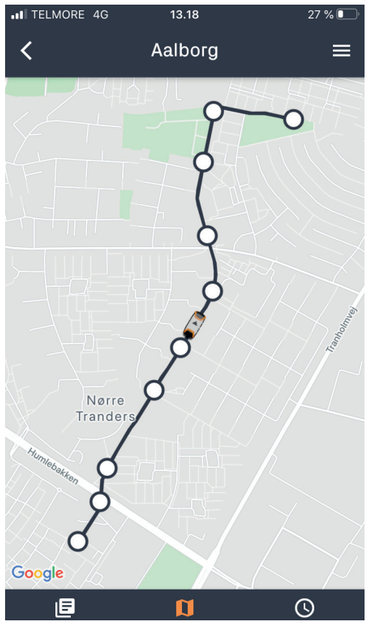
The shuttles operated at SAE level 3, which meant that there was an operator present on the shuttle who could take control by switching to manual operation and who was tasked with monitoring safety. The operator would also answer passengers' questions. The shuttles were authorized to travel up to 25 km/h, but during the test they were programmed for a maximum speed of 18 km/h. The average speed during operation was 8.6 km/h, and the frequency in normal operation with two shuttles was approximately 15 minutes.

The ramps at the stops were designed for step-free access to the shuttles, which were equipped with a ramp for wheelchair users.

Information about the shuttles was available via a smartphone app or Smartbus.dk.



Smartbus.dk website (20.10.2020).



Let's Holo app screenshot.

SAE-LEVELS

The SAE levels, which refer to the levels of automation for self-driving cars, span levels 0 to 5:

Level 0: No automation
Level 1: Driver assistance
Level 2: Partial automation
Level 3: Conditional automation
Level 4: High automation
Level 5: Full automation (SAE International 2021)

The Smartbus operates on Conditional automation – Level 3. This entails that the bus is self-driving, but that an operator is always onboard to take over driving when required by the system or the traffic situation.





The driverless bus, Navia Arma, on display in Sundhedshuset, Aalborg East, in late summer 2018 (Aalborg Municipality).

4.2 ASTRUPSTIEN'S MANY USES

ASTRUPSTIEN IN EVERYDAY LIFE

In 2018, we investigated the informants' use and experience of Astrupstien and the Aalborg East district before the shuttles were implemented. In the following, these early accounts are compared with corresponding experiences during the test period in 2020 and 2021.

Astrupstien fulfils many purposes, is used in many ways and has multiple meanings to the informants we spoke to. A resident said:

"[...] both my wife and I use the path a lot when we go to the gym, to the doctor or to the library. So, we use it almost every day."

The path is used for more than just getting from A to B, and it creates a connection between north and south. This was also the case before the conversion, as one resident explained in a focus group interview in 2018:

"[...] the path is simply a lifeline through the area, I mean – it connects from one end of the area to the other, and all areas are connected all the way down the path. So it is simply a corridor that can really be used for... Yes, of course, to arrive at places, but also just to stay and be."

The descriptions of the versatile uses of Astrupstien and of the path as a local lifeline are clearly seen both before and after the transformation of the path. In 2018, 2020 and 2021, many different users were observed on the path, from children on scooters to electric wheelchairs and people on horseback. Two informants who went for a walk on the redeveloped path called it "cosy" and "lovely" with playgrounds and no traffic – they only use it for pleasant walks. We observed several path users strolling along the path or walking their dogs.

Some use the path for exercise, and children meet other children for play. No clear difference was described between use before the conversion and after it (or before and after the shuttle was introduced). However, new traffic situations arose in encounters between the shuttle and other road users. Despite the short length of the test route, there was a remarkable difference between the northern and southern parts of Astrupstien, and several informants commented on this difference, e.g. a resident during a go-along interview in 2020:

"I find it to be two different... Here [at Trekanten] there is a lot of activity – but on the other side of Saltumvej [sections A and B] I don't think there is as much going on."



INVITATION TIL DELTAGELSE I FOKUSGRUPPE
EVALUERING AF FORSØGET MED FØRERLØSE BUSSER PÅ ASTRUPSTIEN

Vi vil gerne høre din mening

– invitation til en aften med mad og drikke

I sommeren 2018 indsætter Aalborg Kommune en førerløs bus på en 2,1 km lang teststrækning på Astrupstien. Den nye teknologi skal være med til at mobilisere borgere og brugere, både internt i bydelen og mellem bydelen og resten af Aalborg.

Aalborg Universitet udfører en evaluering af forsøget med førerløse busser på Astrupstien.

HVAD

Du inviteres til at deltage i fokusgruppe-interviews, der vil bestå af stillingtagen til en række udsagn og spørgsmål samt en diskussion.

Vi søger indsigt i:
- Din brug og oplevelse af Astrupstien – før og efter bussen kører
- Dine holdninger til de udfordringer og muligheder for dit hverdagsliv og for bydelen, som bussen medfører

Dine input vil bidrage til evalueringen af forsøget med de førerløse busser samt til den fremtidige udvikling af bussen på Astrupstien.

HVEM

Vi vil samle tre hold på hver ca. 10 personer, som repræsenterer forskellige typer af brugere af Astrupstien:
Måske arbejder du i området og bruger stien (på cykel, til fods eller andet). Måske bor du i nærheden og forventer, at du vil bruge bussen, når den kommer til at køre. Måske regner du ikke med at bruge bussen, men bruge Astrupstien på anden vis.

HVORNÅR

Der planlægges to møder:
- Ét i april/maj 2018, før bussen kører
- Ét i efteråret 2018, når bussen er sat i drift

Begge møder vil holdes en hverdag kl. 16:30 – 18:30.
Der vil serveres aftensmad og drikke.

Hvordan melder jeg min interesse?
Inden 15. februar 2018
Kontakt Ditte Bendix Lønng, Center for Mobilitet & Urbane Studier, Aalborg Universitet
e-mail **dbla@create.aau.dk**
eller telefon **9940 3646**

Fokusgrupperne sammensættes af projektets forskere. Du får besked om din deltagelse omkring den 1. marts.

Open invitation to participate in focus group interviews in phase 1 (2018).



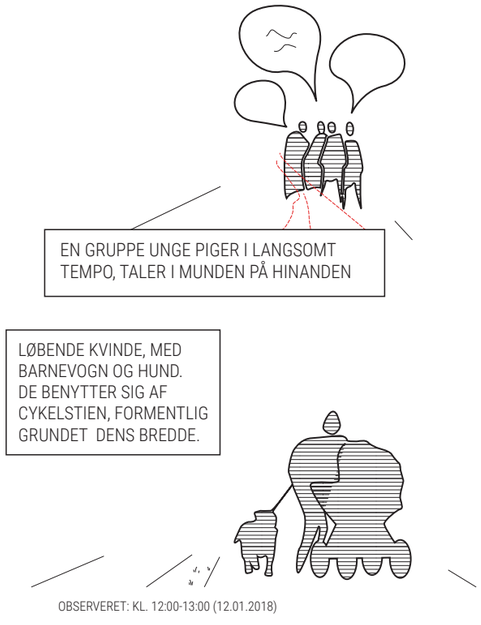
AT TREKANTEN ON THE OPENING DAY OF THE DRIVERLESS SHUTTLE OPERATION (05.03.2020)

Another resident explained in the interview that the new construction has a positive effect on the southern part of the path compared to the northern part:

"So now I can feel that there is a little more life here, a little more security, a little more modern, a little newer. "

Both residents described the northern part as "boring", while other informants explained that they could feel unsafe in the evening on the northern part of the path. The lack of perceived security on the northern stretch was also described in 2018 by users who missed lighting on the path.

A lack of security can also be linked to the fact that the landscape and layout of the urban space are different in the different sections. The visual overview is more blocked to the north as there are buildings and passageways with bushes and trees that wrap around the path.



Field notes from observations on Astrupstien before the operation of the shuttles.

4.3 COMMUNITY ON AND ALONG ASTRUPSTIEN

Several informants in the focus group interviews in 2018 mentioned social activities in Aalborg East, e.g. the May Festival, a children's carnival, a marathon, football, Mardi Gras, Midsummer and a roller skating club. It was described how, for example, the May Festival gathers many people on Astrupstien and how children from near and far sledge here when there is snow on the toboggan hill. Trekanten was also referred to as a "meeting point", where the staff have their "finger on the pulse". Several children mentioned it as a place where you can "get warm".

The descriptions reflect the experience that the area is characterized by community and that many people know each other: The children know each other, and neighbours talk to each other outside their homes. One resident explained:

"[A]lmost everyone here knows each other. All my kids know everyone else's kids. We know each other! If there is someone who gets lost, for example, we know who it is."

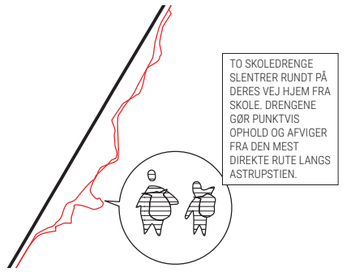
This resident also talked about local Facebook groups where residents post pictures and help each other. Two residents described the various initiatives for women from minority backgrounds that they are involved in. They participate, among other things, in an association primarily for Arabic women, which works to create a community in Aalborg East. Under these auspices, they hold Eid parties and other cultural gatherings. Aalborg East was consistently described as a community with words such as: "There is a good unity out here" and "We are a big family in Aalborg East". Children also talked about the community in Aalborg East in 2021:

"Everyone knows each other and such... [...] I don't think I've ever gone outside without meeting 10 people I know."

In both 2018 and 2020, we observed many children who maintain various friendships both on and around the path, e.g. on the 'Runderen' playground on section C and on the way home from school. In 2020, we saw the children gathering on the path and at the sandwich bar in Tornhøj district centre, where several children hung out for several hours on Saturdays.

In a focus group interview from 2018, parents and others emphasized the importance of their children being able to use the path for play and community. They mentioned a concern that the urban transformation would prevent some of this, and they expressed a concern that the shuttle should not be dangerous for the children, who must be able to move around freely.

Data from 2020 and 2021 do not indicate that the transformation of the area and the path or the operation of the shuttles hindered the children's activities. During fieldwork, we observed children during all the hours of observation, except during school hours, playing on the playground, riding scooters in the middle of the path, playing ball, hanging out on the path, etc.



Field notes from observations on Astrupstien before the shuttles were put into operation.



FOCUS GROUP INTERVIEW WITH CHILDREN ON ASTRUPSTIEN (08.06.2021)

4.4 THE DRIVERLESS SHUTTLES ARE NOT LIKE ORDINARY PUBLIC TRANSPORT



CONNECTION BETWEEN ASTRUPSTIEN AND THE CITY BUS STOP SOUTH OF HUMLEBAKKEN (29.09.21)

"NOT JUST A TRADITIONAL FLEX-TRAFFIC TAXI"[1]

One of the purposes of the driverless shuttles was to ensure better internal mobility between north and south. As Aalborg East is built according to functionalist principles, the road infrastructure and city functions are separated. Furthermore, the area's internal path systems for pedestrians and cyclists are separated from motorized traffic. In Aalborg East, citizens who, e.g., have limitations in their mobility need to use buses that run on the road network that is routed around the district. Consequently, it is time-consuming and cumbersome to access functions in the middle of the district, and the driverless shuttles were therefore intended as a local supplement to the existing public transport. In our interviews with citizens in Aalborg East, the driverless shuttles were not primarily referred to as a means of public transport. When the shuttles were described, much emphasis was placed on the fact that they were driverless and not just ordinary vehicles. One resident explained:

"It is not because it is decisive [that it is self-driving], I just think it is cool that it is. And I think it's great that they have been allowed to do it out here in Aalborg East to get some positive development in the area."

We asked the resident what he would have thought had the shuttle not been self-driving and instead been an ordinary small motorized means of transport on the path:

"Then it would probably lose some of its charm; there is something charming about the fact that it is a new means of transport. And if only a traditional NT flex-traffic taxi with a driver came along, chugging around down here... No, I probably wouldn't be so excited about that. Then the meaning would kind of go up in smoke... Because then you could just as well take it up on an ordinary road and say that this is a system of paths for pedestrians and cyclists."

Some gave the shuttle a special status and role, which was partly a symbolic response to its being self-driving: It is "something other" than a means of public transport on Astrupstien. From Astrupstien, there is access to bus stops for regular buses that run on the regular road network, and in connection with the renovation of Astrupstien, better access to the city buses has been established.



Photo of the bus stop close to Planetcentret (område B/C, 29.09.21)



Photo of the bus stop at Tornhøjparken (område E, 29.09.21)

1 Flex-traffic is flexible shared taxi rides at a reduced price

4.5 REQUESTS FOR EXTENSION OF THE SHUTTLES' ROUTE

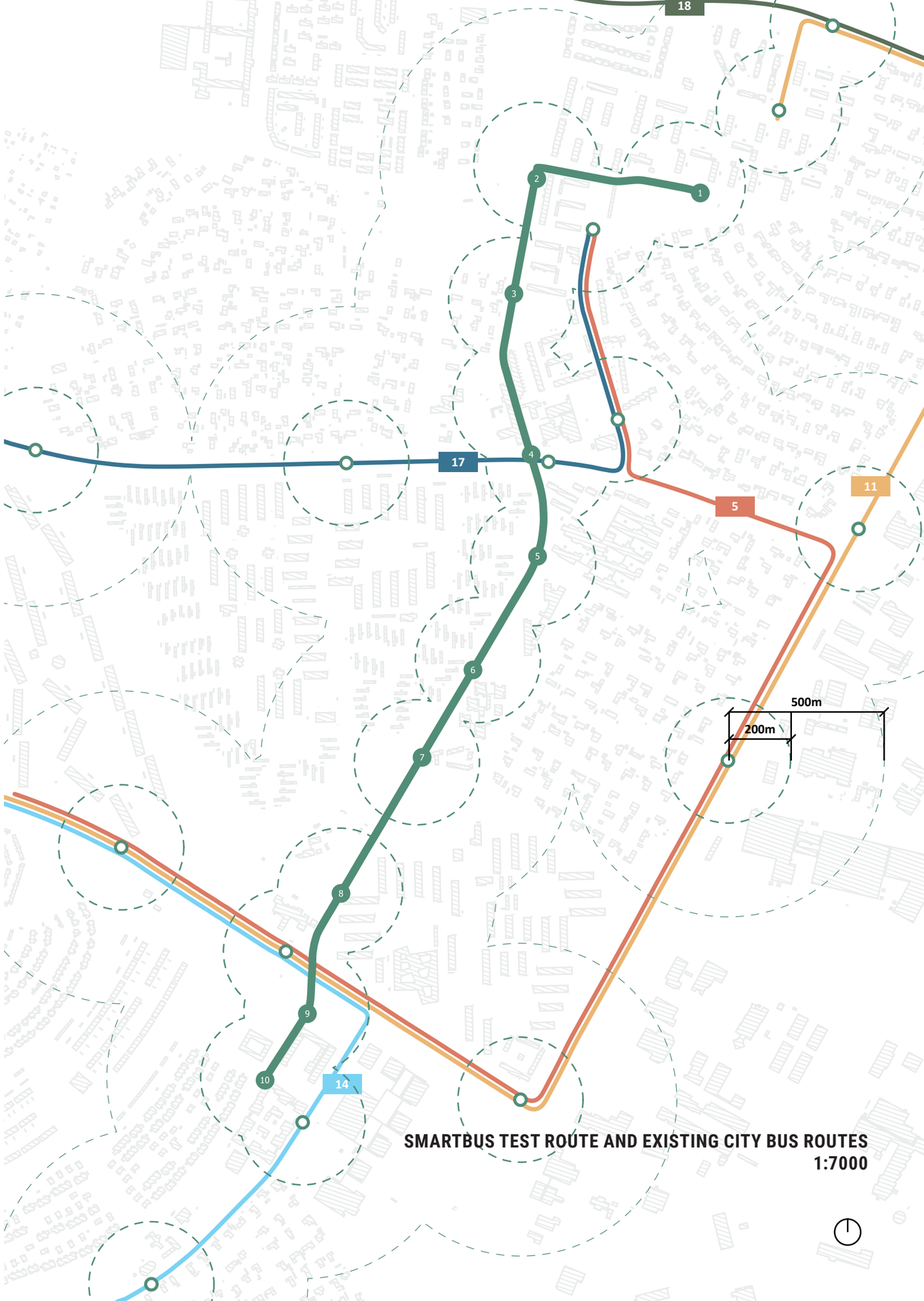
Despite the improved public transport coverage within Aalborg East provided by the driverless shuttles, several informants early on pointed to the need for a longer route. During the focus group interviews in 2018, several people mentioned that the shuttle would have greater potential as a transport service if the route extended towards the university, which is further south, and became connected to Aalborg's new BRT system, called Plusbus:

"When it hooks up with Plusbus [...] then it makes real sense, I would say. In other words, before that happens, it will almost be a bit like this. [...] A bit of internal fun, we'll make it a bit easier and fun with a robo-bus and stuff like that, right? But then, when it hooks up to the other, it starts to fulfil needs."

Informants from 2018 also suggested that the driverless shuttles could run to Gigantium and the new hospital. Overall, there was broad agreement that the test route is very short. Informants we spoke to in 2020 and 2021 said something similar; in particular, there were repeated proposals to extend the route to the large convenience store Føtex, which is 1.5 km further to the south, and the university, which is 2 km to the south.

Resident:
"But I don't think I would use it as a means of transport as such – well, it would have to be if it were to run longer. Because if you could get down to the university or Føtex or something, then you might well want to take it."

Operator:
"If it drove all the way to Føtex, it would simply make so much sense. We hear it almost every day: Drive to Føtex."



SMARTBUS TEST ROUTE AND EXISTING CITY BUS ROUTES
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4.6 USERS OF THE SHUTTLES – "JOYRIDERS" AND "UTILITY PASSENGERS"

USERS AND NON-USERS OF THE BUS

Most of the people we talked to on the path did not use the shuttle themselves, and the logbooks, observations and interviews indicated that the majority of shuttle users were children. This surprised many informants, since they were of the opinion that the shuttle was intended for the elderly and people with walking difficulties.
We asked all informants about their use of the bus. We define 'users' as informants who had been on the shuttle several times, whereas informants who had only tried it once or twice are not considered users.

The shuttles were not in operation between 11 March 2020 and 10 August 2020 due to Covid-19 restrictions, and therefore we focus on interviews conducted after that period, with informants who had the opportunity to become users. Forty-four of the 107 informants we spoke to in this period were users of the shuttle, and the majority of these shuttle users were children. Overall, we spoke to more children than adults, as they travelled in larger groups on the path. Only a few of the adults we spoke to had used the shuttles.

The following reviews the different types of use of the bus, the elderly's reasons for using or not using the shuttle, and the reflections of various informants on the shuttle as a means of transport. The data only represents a picture of the path users with whom we spoke and is therefore not necessarily accurate in relation to all users of the path or the shuttles throughout the period.

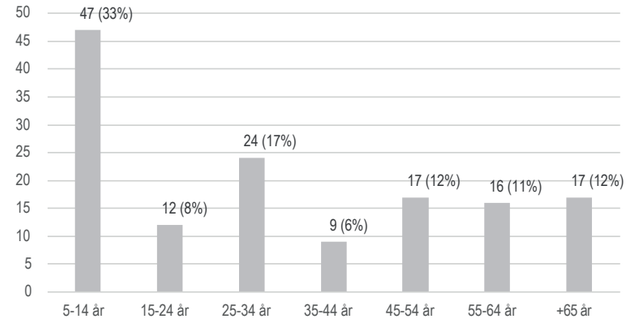
THE SHUTTLE AS ENTERTAINMENT AND AN ATTRACTION

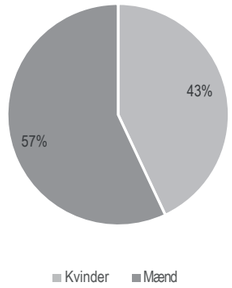
Both children and adults were observed using the shuttle for the sake of the experience, and some parents took the shuttle primarily "for the sake of the children" to give them a fun experience: "it's somehow an attraction." The operators said that they had many passengers who wanted to "try out" the bus, especially when the weather was good.

During fieldwork, we met quite a few people who were trying the shuttle for the first time. Several informants said in 2021 that they used the shuttles to a lesser extent than at the beginning as it was not practical for them, and that they had now "tried it". Several informants described the shuttle as something you ride "for fun" and "if it happens to be there" and mentioned that it was mostly children who used the bus. One operator estimated in 2020 that only 15% of the passengers might have actually been what he called "utility passengers", while the rest were so-called "joyriders", including many children.

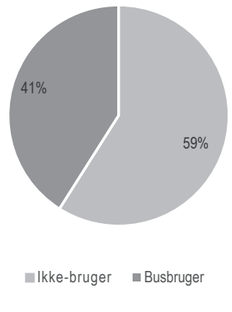


The shuttle is used as relocation transport (18.05.21)

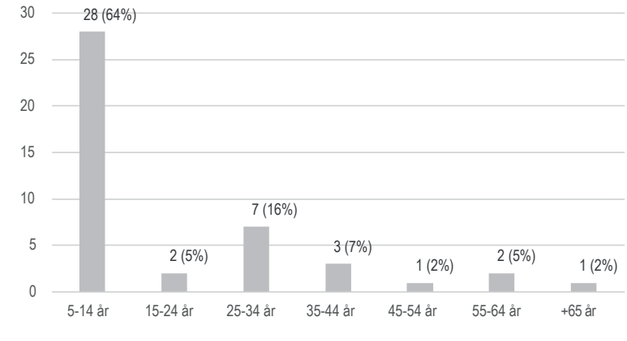




All informants, divided by age and gender (2020-2021)



Share of shuttle users among informants (2020-2021)



Shuttle users in the informant group by age (2020-2021)

UTILITY PASSENGERS

Among the "utility passengers" were some children who talked about the shuttle as a practical means of transport, i.e. when going to and from school, carrying a lot of things or shopping for their parents. Two of the 12 children we talked to in a 6th-grade class used the shuttle for a practical purpose.

Some adults used the shuttle to shop at Netto or Lidl, and some would have liked the shuttle to go to Føtex further south. The operators reported on a few "regular customers" who used the shuttle in the morning to go to the nearest bus stop for ordinary city buses or to drop off children at day care or school .

We also met individuals with carrier bags in tow, scooters that had run out of power, and a single resident who had a moving box as she was relocating to the other end of Astrupstien. These informants described the shuttle as practical when carrying heavy things. However, we met many informants on Astrupstien who did not see the shuttle as a practical means of transport, primarily due to the speed of the shuttle and the many stops it made. This is elaborated on in Chapter 5.

4.7 CHILDREN'S USE OF THE BUS

FUN, PLAY AND SPONTANEOUS TRANSPORTATION

Accounts and observations of children's use of the shuttle were a recurring theme in the interviews. It was very clearly recorded that many children used the shuttle for its entertainment value or as a place to stay rather than for purely practical purposes. The operators' logbooks from the days on board the shuttle show that children were a large part of their customer base. Children who got on and off several times – apparently primarily for fun – were dubbed "joyriders" by an operator. Operators noted in 2020 that children took turns being on the bus, as in this log note:

LOG:
"I had joyriding kids that had had funny pattern. For a whole roundtrip they were 4 kids with 3 bikes, switching places on who got to ride the bus. This of course gave a lot of registered passengers in the app, as I had a new kid for every stop."

An operator claimed that "The young people use the shuttles as a warm shelter". Three children explained in 2021 that they also saw groups of friends "hanging out" on the bus. They believed that this was because the groups wanted to warm up and might "think it's cool". Many adult informants also noticed the many children on the shuttle, and of the 44 shuttle users we spoke to, more than half were children. During the fieldwork, many children were observed either waiting for the shuttle or sitting inside the bus. Their enthusiasm is described in a field note from 2020:

Field note:
The children line up in a perfect row – very nicely, as if they have been told. I lose their attention as soon as the shuttle arrives. [The operator] drives past them and stops in the middle of the road, opens the door and explains that she needs to restart the bus. They can either wait where they are or go down to the next stop to the south. The children sprint down to the next stop as fast as they can. Unnecessary, but they do. I think to myself that if they had left right away, they would probably be home by now.

Several of the children we talked to explained that the shuttle is good "when they don't feel like walking", to get warm or "for the sake of cosiness", and because it is "nice with friends". A boy used the shuttle occasionally with the words "it's quite fun". In addition, half of the 6th-grade children who attended the workshop in 2020 used the shuttle "for the sake of fun". A 12-year-old girl said on the opening day:

> *"I'm not going to take the shuttle because I live so close to the school, so it would only be for fun."*

Several times we met children on the shuttle playing Pokémon GO – the game counts how far they have walked, and the shuttle here serves as easy access to more points on the odometer.



CHILDREN GETTING ON THE BUS (20.10.21)

Field note:
They play Pokémon GO on the shuttle – in dialogue with the operator, joking, talking [...] They communicate loudly and excitedly with a boy who appears on an electric scooter outside the shuttle – out the back window – a friend. [One] shows him the phone (with Pokémon GO on, I assume). He gets to the next stop, where the operator opens the door, and they talk through it.

LOG:
"They used the bus as a warm and dry place to play Pokémon GO."

An operator reported that the children took the shuttle as a quick way to "get a lift" home, and the operators explained that they occasionally asked the children how far they were going, so that they did not drive back and forth. According to the operators themselves, they did this so that the children would not take away seats from other passengers, "take over the bus" and "make it theirs". Three children in 7th grade said in 2021 that they believed the shuttle is for the elderly and for people with disabilities, but they primarily saw children and young "groups of friends" using the bus. They offered the following reflections:

Boy:
"I'm thinking of people, that is, parents with small children, and the disabled or whatever it's called, the elderly. I think they should actually be the only ones allowed."

Girl:
"Yes, I think children can easily walk."

Boy:
"They are healthy enough."

Interviewer:
"Should it be so that children were not allowed to use it?"

Girl:
"Well, I don't think that's a good idea. Because then I think they would be upset. But I think it's a bit of a shame that there are so many children who use it that the elderly can't get to it. That is why sometimes, if I see some old people who want to enter, I just choose to walk away and then just walk. Because they need it more than we do."



Workshop with a 4th-grade class (26.09.2018)



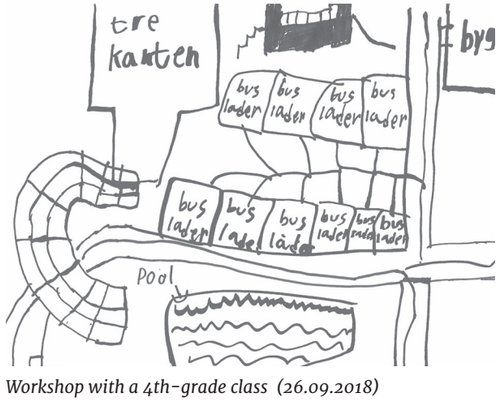
Workshop with a 1st-grade class (18.06.2021)



Workshop with a 4th-grade class (26.09.2018)



Workshop with a 1st-grade class (18.06.21)



Workshop with a 4th-grade class (26.09.2018)



Workshop with a 1st-grade class (18.06.21)

4.8 THE SHUTTLE AND EXERCISE

"IT'S HEALTHY TO MOVE"

During a focus group interview in 2018, an informant who worked in the area was surprised that the shuttle was being introduced in Aalborg East, which, according to her, is an area with health problems:

"[...] so I thought it seemed a bit wrong that you want people to move more, but then you put a shuttle on a very short stretch where most people are able to walk. Because then it's easy to jump on that bus, instead of just getting five hundred or a thousand steps out of it. I thought it didn't seem well thought out. [...] unless you have some kind of illness, you can walk those distances."

In another interview in 2018, this was also mentioned by a resident from the area:

"[...] when you think about that broadcast about Aalborg East, that we are actually the ones who live the worst and have the worst health of all in Denmark, and you just have to walk six kilometres, and then we deliver a shuttle to make it even more comfortable. [...] It seems to me to be contradictory in this case."

The topic of exercise and fresh air was brought up by several people in 2020 and 2021, including people with walking difficulties, such as an informant aged about 75 who did not use the shuttle because she needed to "move her legs" and "keep moving". The same informant generally expressed a negative attitude towards the bus. Several others mentioned that they preferred to walk and also referred to the fact that they were perfectly capable of moving on their own and that was why they did so. Many people commented on the many children on the bus. One said: "I think that's wrong", and another wondered why they didn't walk and get some exercise, since "the bus is not for them".

A young girl mentioned on the opening day: "I also think it's healthier to walk or cycle". A student in the 6th grade also believed that technology can make people lazy: "soon you won't have to do anything at all". Two students aged around 7 said that their mother does not want them to ride the bus: "Our mother wants us to walk, so we get exercise".



Young pedestrian on Astrupstien (18.05.21)

4.9 PEOPLE WITH WALKING DIFFICULTIES AND THE ELDERLY



ELDERLY PERSON WITH A WALKER ON THE PATH (24.10.2020)

USERS WHO OTHERS THINK SHOULD HAVE PRIORITY USE OF THE SHUTTLE

A large proportion of informants, including those who did not use the shuttle themselves, believed that the shuttle was really good "for the elderly", "disabled citizens" and "vulnerable citizens". In general, younger and mobile informants described the shuttle as useful for these groups of citizens, which did not include them. At a workshop with 1st-grade students, one of the children explained that the shuttle was for people who couldn't walk very well. However, disabled and elderly citizens were not seen on the shuttle to the extent that several informants had expected, and it surprised them that they primarily saw children and young people on the bus. Several speculated that elderly people might have found it difficult to get to a stop, and one informant also mentioned that she knew an elderly woman who could not walk all the way down to the path to catch the bus. On the opening day in March 2020, this was also a consideration an informant had:

"I'm a bit sceptical about people who are unable to walk, whether they can get to the stop from their home – it may well be a hard trip. But it is a good opportunity to visit all the new shops that are opening here in the area."

Others pointed out that the abrupt braking that occasionally occurred could be problematic for frail citizens[2].

The operators reported that they observed fewer elderly people and people with walking difficulties using the shuttle from December 2020 until the summer of 2021. One guessed: "now I'm not an expert on this, but I could also imagine that if you walk with a walker, then snowy weather might not be the best". Some of the operators believed it may have been related to Covid-19. One of them explained in an interview in 2021:

Operator:
"So it was a bit interesting, they really disappeared when we shut down the second time. There was really... They had started coming over the summer. They were getting used to us being here, that they could use us. And then they really disappeared."

In 2020, we spoke to a small number of informants with walking difficulties related to illness, old age or pregnancy who appreciated the transport, but only a few of these used the shuttle. In 2021, we spoke to 16 people who had walking difficulties and/or used a wheelchair. Only one of them used the bus. The reasons for not using the shuttle varied. The majority mentioned that they preferred to walk and move, whereas those in electric wheelchairs explained that they did not feel that there was room for them on the bus, that access was too difficult or that they could drive faster themselves. In an interview, we asked an operator about wheelchair users and received this response:

Operator:
"I have never had a wheelchair user on the bus. NEVER! [...] I know we had someone on opening day. And I mean we've also had one or two since, but that's about it. [...] I believe that the municipality assumed that there were more of them, but that is how it is. It is difficult to predict, after all."

Other informants with walking difficulties mentioned challenges such as a lack of shelter at stops, no smartphone to check timetables, and long waiting times. In addition, some seemed completely uninterested in driverless technology. Only a few mentioned Covid-19 and the risk of infection, and it remains unclear what role the pandemic played for this user group.

2 The abrupt braking will be unfolded further in chapter 5

4.10 THE OPERATOR'S SOCIAL ROLE

AN EXTRA ADULT ON THE PATH

An operator explained that while the primary task for "normal bus drivers" is driving the bus, his job as an operator was very much about the social side, with the driving itself being secondary; in describing the operators' role, he said: "we humanize the bus". Several children said that it was nice to talk to the operators when they rode the shuttle, and among both children and adults there were several who knew the names of the operators or could describe their appearance. The operators' logbooks also indicate that they were familiar with many of the locals, especially the children. This could be observed when the shuttle was en route, when the operators were seen, for example, greeting people, helping them, making small talk, answering questions and waving to people on the path.

The extent of waving between people on the path and the operators was remarkable. In 2021, we asked an operator about this in an interview:

Interviewer:
"There are many people waving at you?"

Operator:
"Yes, there is. [...] I think it's the culture here that we just wave at everyone. People also just get a little happy when they see [the bus] I think. It's kind of funny, it runs in their local area."

Interviewer:
"Do you think they are waving to you or to the bus?"

Operator:
"So it's probably me, at least I'm waving to them. But I also think they are just used to the fact that when the shuttle comes, you wave. Because I have experienced as a new operator that everyone waves to you."

We also asked three children about this in 2021:

Interviewer:
"When you wave, are you waving to the shuttle or the driver?"

Three children in unison:
"The driver!"

Boy:
"It would be a bit silly to wave at a piece of technology."

Interviewer:
"So it has nothing to do with it being driverless?"

Boy:
*"No, that would be equivalent to doing this:" *takes out his mobile and waves at it**

A resident who always waved to the operators explained that "you just do it" and "it does something to make it a bit... local". We asked about a scenario where the operators were not on the bus, to which she laughingly said: "You probably wouldn't go and wave at the shuttle like that. I don't think so". She saw the operators as an additional relationship that comes with the bus: "In the long run, it should drive itself, regardless of whether there is a person in it or not. So that's the relational thing you get.".



THE SHUTTLE AT THE UNDERPASS UNDER HUMLEBAKKEN (08.05.2021)



EVENING VIEW OF THE SHUTTLE ON THE PATH WITH STREET LIGHTING (24.10.2020)

4.11 SENSE OF SAFETY ON ASTRUPSTIEN

INSECURITY, MOPED THUGS AND "SASSY YOUNG PEOPLE WHO HANG OUT"

Several informants mentioned insecurity and frustration over various trends they experienced in the area. In the focus group interviews in 2018, several people talked about the "infamous mopeds", which were "chiselling off"[3] and "driving like death and hell". The mopeds were also noted during our own observations, in the operators' logbooks and by the people we spoke to. A few pedestrians commented in 2021 that the path had become better for cyclists after the reconstruction, but that "the new path attracts those mopeds, which make a lot of noise". Likewise, a resident found it a pity in 2021 that the road bumps that stopped mopeds from driving too fast on the old path had been removed:

Resident:
"The thing about those road bumps – we miss them, because the mopeds just go really fast and... it's mostly about safety... our boys find it uncomfortable to ride roller skates now when those mopeds come in fast."



Field notes from observations on Astrupstien before the shuttles were put into operation.

One resident mentioned that she has had five break-ins in 10 years, and in a 2018 focus group interview with people employed in the area, several women explained that they felt unsafe walking in some areas of Astrupstien. They associated this insecurity with "sassy" young people who "hang out" when it is dark, and who may sometimes call out to them – especially at Planetcentret. This was also mentioned in the second focus group interview with residents in 2018, where a woman described how "unfortunate types" can sit and shout at the Planetcentret, which is one of the areas she finds "kind of scary". Three children also stated in 2021 that they had seen crime and violence in Aalborg East; they came up with several stories accompanied by comments such as "it happens every day" and "it's normal out here".

Primarily, however, the informants we met described Aalborg East as safe, pleasant and a place of unity and development.

THE SHUTTLE AS A "CREATOR OF SECURITY"

In 2018, a man speculated that the shuttle could help to create more safety: "there is a bus there, so you are not quite so afraid to travel in the evening, because there is a bus and maybe someone on it". This was also mentioned on the opening day in March 2020 by two girls aged around 12: "then you don't feel so alone when you go home and it's dark". A woman described in 2021 how the shuttle created greater security for her:

Woman:
"I think it has made it much safer. That the bus is running. It is as if there is some life – even in the evening. [...] So it provides a kind of security."

3 Danish slang for speeding without consideration for others

Some informants therefore referred to the shuttle as a "creator of security", and as an extension of this it was mentioned that the bus, as well as the transformation of the path and its surroundings, had created more light on Astrupstien, something that was lacking before the conversion. A resident explained in 2018:

Resident:
"[...] it is an old theme in Aalborg East, precisely the lighting on the paths. There have been citizen meetings about this in the past, among other things, because typically the slightly older people don't like to walk or travel on the paths after dark."

THE OPERATORS AS CREATORS OF SECURITY AND AUTHORITY

The operators reported that they undertook social tasks related to maintaining order by, for example, reprimanding teasing or provocative children both inside and outside the shuttle and ensuring that they did not "joyride" and thereby take up all the seats on the shuttles. Operators noted in their logbooks that some joyriders were "up to no good", or that they had had to ask children to leave the shuttle because they were acting too wild or were a nuisance.

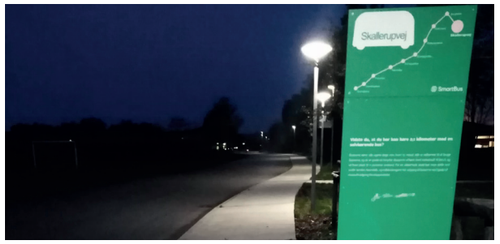
In such cases, the operators acted as an authority over the children, maintaining a friendly tone and calm behaviour on the bus. Some of the operators noted that they believed that their role was important, e.g. it was noted that young people would probably party on the shuttle if there were no operator present.

Adult informants also mentioned the importance of an authoritative role that could create security. Two women independently mentioned that they would feel unsafe being "alone" on the shuttle and that they appreciated the operators. One of the women, a resident, explained:

Resident:
"[The operators make it] more safe and secure – what if some young people jump on the shuttle and start fooling around with other, old people? ... you can't do without – It is safer for people that there is someone present, so that if something happens, that there is someone who can help."



The renovated tunnel (24.10.20)



Light on the path (24.10.20)



The path in the dark (24.10.20)



The new tunnel (20.10.20)

4.12 SUMMARY: THE DRIVERLESS SHUTTLES ON ASTRUPSTIEN – ACCESS, MOBILITY AND COMMUNITY

The shuttle was originally intended as a contribution to internal mobility and as part of the collective transport system. When we consider the public transport in the area, the shuttle covered an area that is otherwise not very well provided with public mobility options.

In the study, however, we found that during the Smartbus trial the driverless shuttles were only used as a transport solution by a fairly small number of users, and often in situations where the passenger had a lot of things to carry. Most users perceived the shuttles as an entertaining element in the buzzing common everyday life that takes place on the path in the form of traffic, exercise, play and social events. The path was described as a lifeline in Aalborg East, and for most people, the upgrading of the path had made a positive contribution to the experience of it.

It was largely children who used the bus. They mainly used it as an element of their social life and as a way to entertain themselves. However, there were also some users of the shuttles who had incorporated them into their everyday routines and were returning passengers. Both children and adults were aware of the potential for citizens with reduced mobility to use the driverless shuttles to get around better, and there was general agreement that a special space should be made for these potential users. However, residents with walking difficulties in the area did not use the shuttles to a particularly great extent, since for various reasons – i.e. a lack of space in the shuttle and the low speed – they did not find this practical for them.

The operators were present along the path for many hours and took on a social role, both in that path users often waved to them and thereby acknowledged their presence as part of life on the path and by virtue of the social relationships they entered into with users of the shuttle – including the many children who walked on the path in their spare time. The operators were given or assumed a regulatory role in relation to the children's behaviour and use of the shuttle. Users of the path and the shuttles observed that the reconstruction of the path and the upgrading of the lighting on the path and in the tunnels had a beneficial effect on the experience of safety. The operation of the shuttles contributed to activity and presence along the path – including in the evening, which was experienced as positive for safety. The operators played a special role in relation to this and were seen by some as crucial to the safety of the bus. It is thus not clear that the shuttles themselves – without an operator – would provide the same experience of more life and safety on the path.

Two conditions in particular may have had a limiting effect on the use of the driverless shuttles as a transport solution. First, it is unclear what the changing degrees of pandemic-related social lockdown meant, not least for groups at particular risk of becoming seriously ill. Second, several people requested that the test stretch be longer and create a connection to, e.g., the large convenience store, Føtex, to the south.

PHOTO OF A SHUTTLE ON JERUPSTIEN ON THE NORTHERNMOST PART OF THE ROUTE (08.05.2021)

5. FLOW AND FRICTION ON THE PATH

The Smartbus trial was the first example of driverless vehicles on public roads in Denmark. In addition to the importance that the shuttles have had for Aalborg East, the trial has contributed knowledge about how driverless shuttles can possibly be implemented in the transport system in the long term and contribute to solving transport issues. This chapter analyses the characteristics of the shuttles, the traffic experiences they encountered and the interactions between the shuttles and other road users on Astrupstien.

5.1 THE OPERATIONAL SIDE OF THE SMARTBUS TRIAL – THE SHUTTLES' DRIVING PATTERN AND SAFETY

The shuttles ran on a pre-programmed route – a kind of digital rail. If an object was blocking a shuttle's route, the operator had to manually drive around it as the shuttles could not deviate from their programmed route when operating in driverless mode. The speed was also coded into the digital map that the shuttle followed and was adapted to the conditions along the route. For instance, the shuttles were programmed to slow down as they approached each stop. In addition, different 'priority zones' were programmed, for example when the shuttle was obliged to give way and at playgrounds, where the shuttles drove more slowly.

The shuttles automatically stopped immediately if they detected an object within 3 metres in the direction of travel, and they were programmed to brake for all types of obstacles. The shuttles oriented themselves using sensors and positioning data, which were integrated using the shuttles' software:

- 3D mapping using sensors called LiDAR, which registered and mapped surroundings in 3D in real time
- Cameras, used to estimate the distance to objects and register road signs, etc.
- GPS, used to locate the shuttle accurately in relation to the route
- Sensors, which registered the movements and speed of the bus

As stops were only built on the west side of the route, the shuttles, when travelling in a northerly direction, had to cross the southbound track to enter and exit the stops. It took some time for the driverless shuttles to complete this operation, which meant that the northbound trip took about 3-4 minutes longer than the southbound. On average, a round trip from south to north and back again took 26 minutes and 24 seconds.

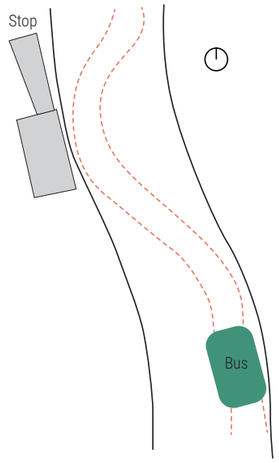


Illustration of the shuttle's path as it travelled north and had to stop at the bus stops on the west side of the path.

THE SHUTTLES RAN ON ELECTRICITY AND WERE CHARGED IN GARAGES DECORATED BY LOCAL ARTISTS (29.09.2021)

5.2 THE OPERATOR AS A DRIVER AND A ROAD SAFETY GUARANTOR

Several of the children were quick to reprimand us when we said "driverless shuttle". They justified this with the observation that there was, after all, "someone who presses the button". It was mentioned by several informants, especially in 2021, that the shuttle was not "driverless", with comments such as: "There is also someone who controls the bus" and "I thought it was driverless?". A boy said in 2021 that he was disappointed that the shuttle was not driverless, as had been planned for the opening day: "so I feel the opening [indicated] that now you have finished testing [the shuttle] and that they must be fully developed. And I feel like they really aren't." He stated – in a humorous tone: "You cannot have a driverless bus that is not driverless, it is simply not good enough!" It might have been more accurate to describe the shuttle as "automated" rather than "driverless".

However, the shuttle was generally described as acting autonomously: "the shuttle brakes", "the shuttle stops behind", etc. Here, the informants did not seem to notice that there was an operator. However, this might have been due to a general linguistic reference to vehicles as autonomous: "the car drove that way", "the train stops", etc.



View from inside the shuttle (08.05.2021)

The operators of the shuttle had several roles, including operating the shuttle manually from time to time. Several operators reported that rain, leaves and birds could interfere with autonomous driving and result in the shuttle braking hard or coming to a complete stop, with the software apparently interpreting the sensors' readings in these situations as solid objects in the bus's path. The operators explained that this could fluctuate greatly from day to day. One operator referred to the shuttle as a "teenager", susceptible to "bad days" on which it did a lot of braking and often had to be driven manually. Operators wrote in their logbooks that most manual operations involved driving the shuttle all the way to stops. A few times in 2020, it was also reported that the shuttle scraped against the platform at a stop. On a few occasions, the operators reported that they were unsure in specific situations whether the shuttle would brake in time and therefore braked manually when, for example, children and cyclists appeared in front of it.

One operator explained that they often manually held back the shuttle at stops until cyclists had passed, something we also observed other operators doing. The operators explained that they did this to avoid "confusion" and hard braking and believed that it was easier for all parties if the shuttle waited. All turns towards stops in the northbound direction had to be approved manually by the operator, as the shuttle headed against the normal direction of travel at these stops. Likewise, in certain cases the system required manual approval from the operator before the shuttle could leave a stop or continue after an unplanned braking.

5.3 TEASING AND HARASSMENT OF THE SHUTTLE

In both 2018 focus group interviews, there were already concerns before the bus's implementation that children and young people would tease or harass the bus. Two informants who work in the area reflect:

Participant 1:
"My own private first thought was like this: God knows what with vandalism and attempts to put it out of action and stuff like that? [...] how could it be secured against something or other happening?"

Participant 2:
"It's Aalborg East"

Participant 1:
"Yes, we are in Aalborg East. It can happen. As such, people are very inventive with things, so I think: hmm..."

The informants in the interview gave various hypothetical examples: throwing a ball in front of the bus, running close to the bus, hanging onto the side of the shuttle or climbing onto the roof while it was moving.

In the second 2018 interview with residents in the area, the expectation of teasing was justified with the thoughts that there are many curious children and that "it would be too tempting". Several informants in 2020 also either expected that children would tease the bus or had seen it actually happen themselves.The operators have noted some episodes of harassment, e.g. a group of young people were kicked off the shuttle due to noise and swearing, after which they repeatedly pressed the outside door button so that the operator could not drive on. The operators wrote about children and young people whom they had rejected due to inappropriate behaviour, including provocative and rough behaviour towards the operators. A couple of young people were described as aggressive and threatening. However, there were only a small number of episodes with this degree of severity. Typically, it was more good-natured "teasing" that was noted by the operators.

Especially in 2020, the operators reported objects being placed on the path in front of the bus, children and young people who "played" with the doors despite being reprimanded, and children as young as 5 who repeatedly drove or walked out in front of the shuttle to see if it would stop. An operator explained that it was most often children aged 10–14 who teased the shuttle or were silly, wild and loud on the bus. He referred to it as a "grey area": "when does it go from silly remarks to harassment?" He described most episodes as "stupid curiosity" and said he was unsure whether it could be linked to Aalborg East specifically. At a 2020 workshop with a 6th-grade class, some of the children explained that it was fun to tease when their friends were on the bus, but they also mentioned that sometimes it was the operator whom they teased. A boy explained in an interview in 2021 that he became unfriendly with an operator and therefore walked close to the shuttle's sensors:

Boy:
"So instead of him getting mad at me without me doing anything, I just walked in front of the bus again and again and again. Just to annoy him."

The children also spoke of how other children walked in front of the shuttle and danced to make it stop. One informant believed that the shuttle caused troublemakers to focus on it rather than on other children:

"[...] I think they tease the bus instead of teasing others."

5.4 TRUST IN THE TECHNOLOGY AND USE OF 'RIGHT OF WAY'

In 2021, fewer such episodes of teasing were recorded in the logbooks, and one operator explained that they no longer experienced it as often: "it's typical when something is new that people just have to test it". The operators instead noted situations where people did not move out of the way of the shuttle when it was driving behind them – something we observed in both 2020 and 2021. As one operator put it:

Operator:
"What we see instead is that people just don't care. Because people know we'll stop if they just walk out in front of it. So they don't do it deliberately with the aim of teasing it, it's probably deliberate in the sense that they know they don't have to wait for it. But it's actually very normal because people get used to how the shuttle reacts. When they know it stops, people know they will get the right of way . [...] then they are assured that the technology is safe."

Such an episode was described by an operator in a 2020 log note as follows:

LOG:
"Had a near accident at Bogø Sandwich. A guy on a bike (not a kid) rode directly in front of the bus. It stopped hard and was about 20 cm from the guy. He smiled. I think it was on purpose."

Once again in 2021, a log note described a cyclist as making use of this pre-programmed 'right of way':

LOG:
"Had a bicycle cross right in front of the shuttle when it was docking, and he was well aware of what he was doing. I stopped the shuttle manually."

The above-mentioned episodes can be interpreted as harassment but also as an expression of cyclists' having great confidence that the shuttles' programming would ensure that they stopped. This is what the children in 6th grade told us when we asked why some of them walked out in front of the bus. They said that they "know it will stop" and that "it is not dangerous when it drives so slowly".

We observed quite a few pedestrians who remained standing or walked in the shuttle's path and only pulled to the side when the shuttle slowed down and rang a bell. One such case was observed during the fieldwork, where a woman strolled at a slow pace on the shuttle's route with the shuttle behind her. The shuttle automatically rang the bell and waited for her to move, but the woman continued apparently undisturbed for approximately 40 metres. The operator subsequently believed that "she had seen the bus", and said that it was something they experienced from time to time. The operators also reported on young people who refused to move out of the way, requiring the operators to drive around them manually.



CYCLIST ON CARGO BIKE 'EXPLOITS' THE FACT THAT THE SHUTTLE WILL STOP (18.05.2021)

5.5 HARD BRAKING – FALLS, SCARES AND CONFIDENCE THAT THE SHUTTLE IS SAFE

The operators regularly noted problems with the bus's sensors and the system's detection of objects, primarily in the form of hard braking for no apparent relevant reason. This could have been caused by leaves, precipitation or birds. Hard braking was also seen when, for example, cyclists or mopeds drove close to the bus. Operators noted in 2020 that the bushes along the path had to be trimmed as the shuttle detected them as obstacles. Furthermore, in the days following New Year's Eve 2021, operators noted that fireworks debris and broken glass on the trail resulted in problems. Informants described how technical problems meant that the shuttle had to be driven manually by the operator and that it "stuttered" in its movements or braked hard.

EMERGENCY STOPS – FALLS AND SCARES INSIDE THE BUS

Abrupt braking was mentioned by many informants who tried the bus, both in 2020 and in 2021. The operators noted in both years that passengers had been jerked out of their seats or fallen completely. This was also observed during the fieldwork. The operators noted that some children were hurt by falling out of their seats or hitting their heads when the shuttle braked. Several children reported that they had fallen inside the bus. Finally, the operators noted an episode in which an adult passenger fell while on the shuttle and had to be sent to hospital.

In total, the operators noted 41 braking episodes from March 2020 to May 2021 in their logbooks. Twenty-seven passengers fell and/or were pulled out of their seats, of whom 14 were described as children. Fourteen times the operators noted that they themselves had fallen. In relation to this, we see that the operators in both 2020 and 2021 noted that more passengers wanted seat belts on the bus, which may indicate that they had also experienced hard braking.

In 2021, we inquired about what shuttle users thought about the braking. Several commented that it did not bother them or that they had gotten used to it. A woman we interviewed in 2021 had heard from other residents that small children had fallen on the bus; she said that this was one of the reasons she had not yet tried it with her own children. She tried the shuttle during the interview and said:

Woman:
"It's not at all as bad as I expected, because we had heard that the children fall down the seats!"

The operators themselves were required to stand during operation to have sufficient visibility, and they reported in their logbooks that they themselves had fallen when the shuttle braked unexpectedly. The hard braking led to some of the operators' arms and shoulders being twisted when they were holding onto handles, and some operators reported wrist or shoulder injuries after falling.

The hard braking also led to scares described by passengers and noted by operators. For example, an operator wrote in the logbook in March 2020:

LOG:
"A passenger got a few mental shocks from sudden braking. […] It made her uncomfortable."

An 11-year-old boy explained: "Sometimes the bus brakes hard. It can be a bit dangerous." And a girl of about 7 years old explained that she got scared when it braked. An informant experienced the shuttle slowing down when boys and teenagers drove in front of it and said this caused problems, especially for older people, whose bodies were jerked inside the bus.

HARD BRAKING – RISKS AND TRUST

Several residents said they were worried when they first heard about the driverless bus:

Resident:
"When we heard it was going to be driverless… because you've heard those horror stories."

Resident:
"When I heard "driverless bus", I pictured a lot of accidents happening."

The concern was particularly pronounced in 2018, before the shuttles are introduced on Astrupstien, as expressed by a local daycare provider who worked in the area:

Daycare provider:
"[…] for these little ones I go with… I have control over my children, but all of a sudden you have one who lets go of you and runs. So, what is… how quickly does it stop?"

In 2020 and 2021, however, several informants said that they were no longer worried and were reassured that the shuttle would stop immediately if someone or something was in front of it:

Informant:
"Den anden dag så jeg en cykel, der kørte ind foran. Det var en hård opbremsning, så det var ret ubehageligt som passager, men det er da trygt at vide, at den stopper, for jeg kunne være lidt bekymret for mine børn."

Children and adults said that they had great confidence in the shuttle stopping. Therefore, they were not afraid to walk or cycle in front of the bus, as they "know it will stop".

In other words, the fact that the shuttle braked consistently and hard when the sensors detected obstacles may have been reassuring for those travelling outside the bus, but it posed a risk to people in the shuttle.



THE SHUTTLE AND OTHER ROAD USERS SHARE ASTRUPSTIEN (18.05.2021)

5.6 THE SPEED OF THE SHUTTLES – BORING AND IMPRACTICAL, OR REASSURING AND TRAFFIC-SAFE?

The informants expressed different attitudes towards the speed of the bus. The shuttle travelled at a maximum of 18 km/h, with a realized average speed of 8.6 km/h. Both children and adults regarded the shuttle as running very slowly and consistently viewed this as a negative.

Some described the shuttle's slowness as making it boring. For example, on opening day a mother said:

Resident:
"It's my 10-year-old daughter who wants to take the bus to school – then she won't have to walk for the next two years, she says, but let's see how long she thinks it's fun when it drives so slowly."

Children in the 6th grade also said that they found it boring when it drove so slowly, and they wished it would drive faster. During a workshop with a 1st-grade class, the children were instructed to draw and tell what they liked and disliked about the driverless shuttle. Here, the speed of the shuttle was a subject towards which the children had a critical attitude. For some, the criticism was linked to how fun the shuttle was to ride, while others related it to practicality.

Informants from a focus group interview in 2018 mentioned that the shuttles ran very slowly and would not be practical for those who could walk faster than the bus. Several informants in 2020 and 2021 who did not use the shuttle remarked that it was "faster" and "easier" to walk and that "you might as well walk". Several believed that the shuttle did not work as a practical solution for them due to the low speed and the many stops. A resident said: "In my eyes, it's an experiment, and it only has value as an experiment". He elaborated:

Resident:
"[...] I want to say, right when I heard about it and saw the planning with the renovation and such... that there was to be a bus down through Astrupstien, I thought: "so it will be really dangerous for the children there". Because I had absolutely no expectations that it would be this kind of bus coming here. I thought it was some of the yellow [city buses] that were supposed to be rumbling through there too. So I have become a little more assured."

Resident:
"It drives slowly, and it stops extremely often. And that means, to me, that it doesn't make much sense to consider it a bus. So that's probably what makes me feel that it's clearly an experimental project... But with that, it's not so realistic to see it as a means of transport. [...]"

The shuttles were also described as something that could not be compared to cycling due to the low speed. A cyclist said, for example: "in that context, it is not competitive in any way". The operators also noted that more passengers wanted the shuttle to run faster on the route.

SHUTTLE SPEED AND SAFETY ON ASTRUPSTIEN

Several adults had concerns about the children's safety in 2018 before the implementation of the bus, but the concern was lessened for some informants once they knew how slowly the shuttles would drive. A resident explained in 2018:

We asked a cyclist if the shuttle was a nuisance in traffic, to which he replied: "They drive slowly and have their lights on, so that's fine". Some cyclists found it easy and "safe" because it ran slowly. A local cyclist explained in 2021:

"You have this very, very slow pace, which means that I don't feel unsafe."

The speed was also important for safety inside the shuttle and in relation to the severity of the hard braking that took place when the sensors detected an object close by. Here, the low speed was seen as a safety factor. A few children talked about the hard braking, and one of them remarked: "that's why it's good that it doesn't go faster".



SOME OF THE MANY DIFFERENT USERS OF ASTRUPSTIEN TOGETHER WITH THE DRIVERLESS SHUTTLE (18.05.21)

5.7 SHUTTLE OPERATION IN SNOWY WEATHER

The operators predicted in 2020 that there would be problems with snow in winter as snowflakes and piles of snow would probably interfere with the sensors. Even though Aalborg Municipality set Astrupstien as the first priority for snow removal, it turned out that the operators were right in their predictions. In the winter of 2020–2021, the shuttle had problems driving in snowy weather, and an operator described the problem in 2021:

Operator:
”Suddenly we had a winter with snow, for once. Direct snowfall – we cannot drive in that. And we do not have permission to operate if there is snow on the ground... We cannot drive as long as the snow is hailing down, or in sleet. In other words, as long as there is enough “thickness” in the snowfall, we cannot drive.”

Some informants observed the shuttles’ challenges in snowy weather, including one resident who wanted to use it in the cold winter weather:

Resident:
”It was actually a bit of a shame, because then it was actually really needed. There was something about the fact that it could not drive if it snowed, because it then registered it in the sensors. Before it started driving, we had talked about: “Well, when it snows or the weather is bad, we can take it down to the nursery”. But it’s probably also something that will be invented at some point – that it can do that.”

Three craftsmen who worked in the area explained that they found it frustrating that the municipality did not clear the pavement of snow and ice and found it “strange” that there was no good access to the stops on the pavements in winter “when you want such a nice bus out here”. The operators also wrote in their logbooks that the path had not been salted, that the shuttle had mis-detected some things at the stops due to snow and that a customer had wanted the stops to be cleared of snow and ice.



THE OPENING DAY IN MARCH 2020 GATHERED MANY CITIZENS AND STAKEHOLDERS (05.03.20)

5.8 TIMETABLES AND WAITING TIMES

The shuttle’s timetable was mentioned by both users and non-users of the bus. In a 2018 focus group interview, two informants were sceptical of the practicality of planning for two shuttles as they believed that was more than was needed. However, other informants – a resident and someone employed in the area, respectively – argued in 2018 that frequent departures were important:

Resident:
”[...] if you want someone to use that bus, if you want anyone at all who is not disabled or elderly or... ordinary people to use that bus, then it has to run almost every quarter of an hour. Otherwise, it is not an attractive offer. Then people don’t want to wait. You have to have some frequency before it can be used by anyone other than those who absolutely cannot walk.”

Employee in the area:
”I also think of saying that the reliability of the bus [schedule] will be decisive for whether it is used. [...] if there are a huge number of stops and you are therefore late for work or from A to B, then you don’t bother using it.”

Several informants in both 2020 and 2021 commented on the wait times at the stops and stated that they did not use the shuttle due to uncertain departure times and long wait times (15–30 minutes).

Although Holo launched an app (lets holo) and the municipality had a website (smartbus.dk) showing the current positions of the shuttles on the route, several users wanted a “fixed timetable” and a clear overview of departure times at the stops themselves. An operator explained that the route took longer when travelling north as the shuttle had to cross the path to get to the stops.

Operator:
”When we drive north, as we do now, and we follow this winding slow path at every stop, well, a pram can keep up with us. [...] Northbound takes about 3.5 minutes longer than southbound, because we have to [cross the path].”

The operator also explained that most people chose to walk if the shuttle was not going in the direction they were going:

Operator:
”Well then they go. Because they don’t want to wait 10 minutes for... When they can walk 10 minutes the other way. There are many who [when] they see it [think] “well, I can take it”. The more times we come, the more often we will pick someone up.”

The operators found that they had more riders when there were two shuttles in operation rather than just one. During our fieldwork, there was only one shuttle in operation on some days due to, for example, a lack of operators, and here the waiting time was long if the shuttle was at the other end of the path. A boy explained in 2021: “If I can see it, I‘ll probably choose to wait“.

5.9 EASY-GOING TRAFFIC ON ASTRUPSTIEN



DIFFERENT ROAD USERS AND THE SHUTTLE ON ASTRUPSTIEN (18.05.2021)

After the conversion, there was a pavement for pedestrians on the western part of Astrupstien and a wide lane without striping on the eastern part for cyclists, mopeds and shuttles. However, it was often seen that pedestrians, for example dog walkers, used the eastern part of the path rather than the pavement, which means that they travelled on the lane intended for shuttles and cyclists. Sometimes they moved so close to the shuttles that these detected them and slowed down.

Especially at Trekanten, operators noted a lot of traffic and that "many people have their own idea of where they should be on the path". Both the operators' log notes and our field notes from observations of the test route show that path users had a general tendency to use the entire width of the path: families and groups joined together in the middle of the path, and children played on the path or crossed it without orienting themselves. Two field notes illustrate this:

Field note:
The wide cycle- and footpath is used by many children on scooters and cyclists. Fill the entire path [...] The bus is behind them, in a northbound direction (do they know? They don't seem to pay attention to it – loose, calm, free behaviour – not like on a busy road, more playful, takes up a lot of space.

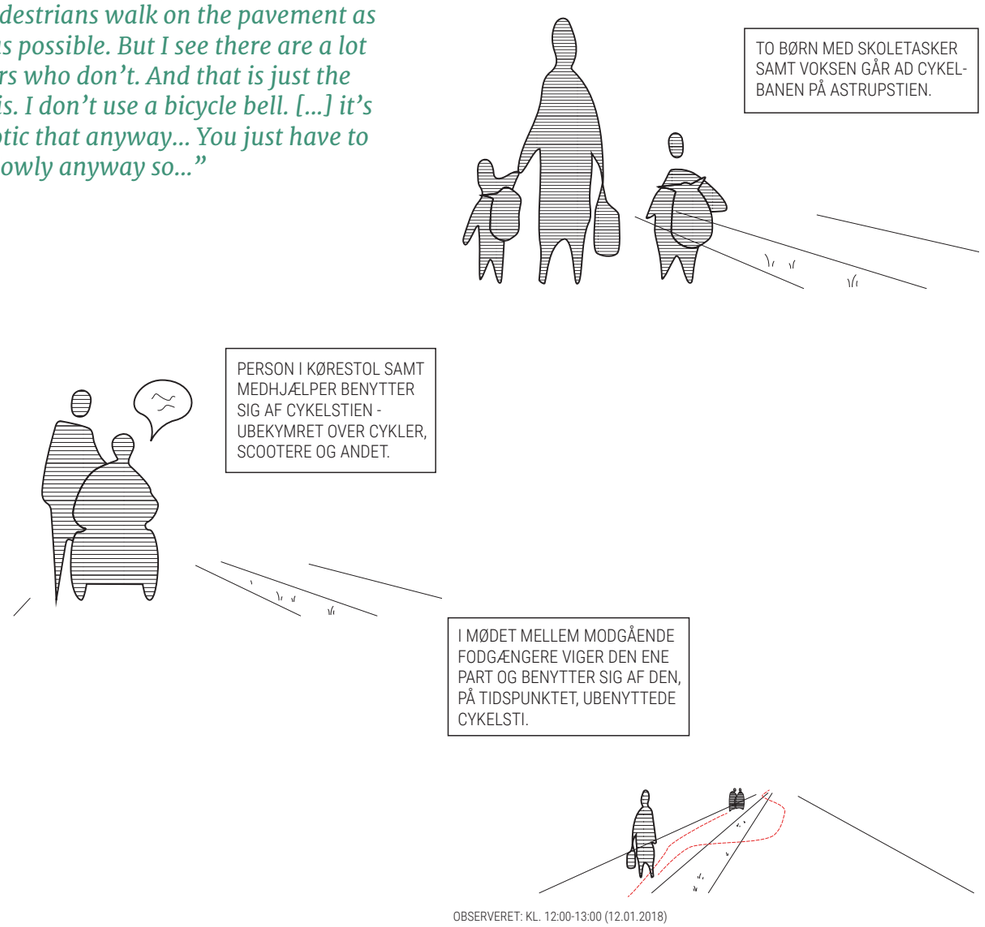
Field note:
A girl has to turn up a side road, and she wobbles four times across the path before turning. As if she owns the road – she looked happy and had a playful approach to cycling. She fills the entire space.

When we asked two residents about this in 2021, they explained that they generally found that traffic rules were observed, and they did not consider it a major problem when, for example, pedestrians walked on the cycle path:

Resident:
"When I come by bike, I think it's nice that pedestrians walk on the pavement as much as possible. But I see there are a lot of others who don't. And that is just the way it is. I don't use a bicycle bell. [...] it's so chaotic that anyway... You just have to drive slowly anyway so..."

Resident:
"I walk on the pavement, yes. When I'm out for a run, I actually run out on the tarmac – I don't know why. But it's fun because when the bus is running, I run onto the pavement."

Traffic on Astrupstien was observed and described as being based on a mutual understanding between road users. The following describes what happened when a pre-programmed driverless shuttle entered the the path space and encountered the flexible and varied use that characterizes Astrupstien.



Field notes from observations on Astrupstien before the shuttles were put into operation.

5.10 NORTHBOUND DRIVING – CROSSING THE PATH AT THE STOPS

In general, the shuttles were described by other road users on Astrupstien as problem-free, and most cyclists using the path simply rode around them. There were, however, some specific recurring situations that were described by informants as "confusing". The northbound route in particular was mentioned by many.

As mentioned, stops were located only on the western side of the path. This meant that when the shuttle was driving north on the right side of the road, as prescribed by the Traffic Act, it had to turn left and cross the path to reach the stops (see Illustration 1 below). In doing so, it stopped opposite the direction of travel that applied to other road users on the same side of the path. This caused some confusion – primarily for cyclists.

During the fieldwork in 2020, we observe repeated situations where cyclists chose to overtake the shuttle by driving between the shuttle and the bus stop when the shuttle was about to turn towards a bus stop in the northbound direction, as illustrated on Route B below. This resulted in the shuttle detecting that the bicycle was too close and therefore braking. The confusion also arose when cyclists came from the north and drove south, therefore driving towards the bus.

A cyclist explained that in these situations he was in doubt as to what the shuttle's "intentions" were because it slowed down completely before turning towards the stop. He said, "it looks like it holds for you". This may explain why some cyclists chose to ride between the shuttle and the bus stop.

The operators also noted these episodes in their logbooks as unsafe situations. The following log note about a moped is a good example:

LOG:
"Once again nearly collided [with] a moped, [because] it was going between the shuttle and the ramp"

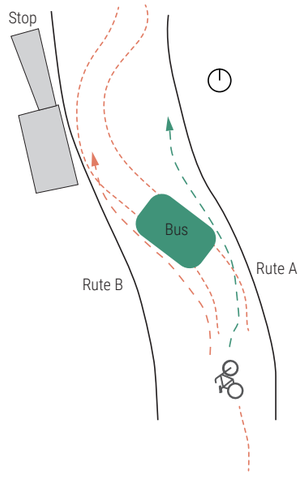


Illustration of the shuttle's interaction with a northbound cyclist

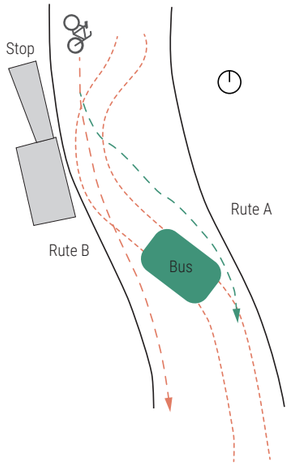


Illustration of the shuttle's interaction with a southbound cyclist

The operators also explained that in order to avoid confusion, they sometimes waited to drive on from the stops in a northbound direction when there were other road users. In 2021, several operators mentioned that most cyclists had become "better at it" and that they had "got used to it". As one operator put it:

Operator:
"Well, it's that thing again that I can really see that they're looking at its turn signal, because they can see it start flashing and think: "okay, it's going in there". It is also a situation where I am constantly looking at them: "what do they want right now?". Because I can see them slowing down and looking like: "okay, it's turning in!" and then they drive around it."

However, in 2021 we observed more and more episodes where cyclists tried to ride between the shuttle and the ramp, and this also continued to be noted by the operators, as in this log note:

LOG:
"Had a bicycle cross in front of the shuttle when it was docking even though there was almost no room. Stopped the vehicle manually."

In addition, children in a 2021 focus group interview explained the problem they faced when they needed to overtake the shuttle on electric scooters and the shuttle had to cross the road. One boy said:

Boy:
"And I also think that it takes up far too much of the road. It is so wide that when it drives in [to the stops on the way north] it drives out and then it stays in the middle, so you have to drive out on the side of it. And then when we have to pass it, because it is so slow – when you have to overtake it – it just stops out of the blue."

A cyclist explained in 2021 that even though she had "got used to it", she still had doubts about which way she should choose to drive around the shuttle when it had to cross the road to reach a stop. Another cyclist explained that after some time he had understood the shuttle's "intentions" and thus always rode on the side opposite the shuttle's turning path.

Some wondered why there were not stops on both sides of the path. A few informants suggested marking the path where the shuttle travelled when it turned into a stop in the northbound direction to avoid confusion. A cyclist also suggested that the shuttle could have its own side of the path:

Cyclist:
"If it now had a track of its own that was just called a bus track or something, then it might have been something else. Because there have been some situations where I have thought "aah okay!?" and then had to stop the bike. And it has mostly been in situations where it has to turn in or out from the stop."

In the illustration, in a situation where a bike, scooter or moped is coming from either the north or the south when the shuttle is pulling into the stop, the line called 'Route A' is the most appropriate if the cyclists are not to be registered by the bus's sensors. However, this can create unsafe situations when two riders are coming from different directions and take Route A at the same time.



Still images from a video of cyclists overtaking between the shuttle and the stop and triggering hard braking (03.06.2021)

5.11 OVERTAKING AND OTHER INTERACTIONS WITH THE SHUTTLES

The shuttles' software was programmed to detect objects close to the shuttle, and if there was any doubt about the objects' movement or if the distance was too small, the shuttle braked immediately. Therefore, distance was central to the interactions between the shuttle and other road users. Some road users apparently did not know how far away they should be. The shuttles in Aalborg East had a safety zone of 3 metres in front of them, but less to the sides.

During the test period, we observed several situations in which cyclists or mopeds overtook the bus, drove in front of it and triggered an emergency brake. Several cyclists believed that they had kept an appropriate distance of 2–3 metres, but the shuttle still braked hard. Children stated in 2021 that they found it strange that the shuttle braked when they themselves felt they were keeping a good distance.

There was a general discrepancy between the safety settings of the shuttles (which require a long distance) and the perception road users had of what was a sufficient distance to the bus. A cyclist explained in 2021:

Cyclist:
"And then we have also got used to the fact that we actually have to be quite far in front of the bus before we can pull in again without it stopping. After all, we don't want to disturb the bus because it will then make an emergency stop."

Several operators were asked by other road users about how best to overtake the shuttle, and confusion arose, especially when the shuttle's demands meant that they had to break conventional traffic rules. An operator elaborated in a log note:

LOG:
"(...) it's hard to figure out. Because when you overtake the bus you pass it on the left, and that in normal traffic isn't legal, so it causes some confusion on how to behave."

Operators reported several times in their log that children were walking too close to the bus, so that either the operators had to brake manually or the shuttle itself would stop. This also happened in situations where children were "racing" with the bus, as in this log note:

LOG:
"Kids love running next to the shuttle while it drives. If any of them were to fall towards shuttle, it might be an issue."

The operators said that they were generally extra attentive around children and dogs – especially if the dogs were not on a leash. The operators also described cyclists and mopeds who came close to hitting the bus, prompting the operators to choose to brake manually. An operator wrote this log note:

LOG:
"A woman on a Christiana-bike with her child in it drowe out right in front on me when I was leaving Jerupstien busstop. I made a manual stop".

An operator reported that cyclists sometimes rode close behind the bus, which would have resulted in an accident if the shuttle had suddenly braked. This was also a concern for a couple of informants, respectively a mother and a 7th-grade student in 2021:

Mother:
”It hasn’t happened, but I have sometimes thought that even if the bus brakes, it is not certain that my children will be able to brake.”

Boy:
”I haven’t seen it, but I could well imagine it could really be a problem. For example, if you are riding a bicycle and your brakes are not working very well. That you then just smack into the back of it.”

Overall, the driverless shuttles on Astrupstien did not run quite as the road users immediately expected and were used to. In other words, the shuttles seemed to require slightly different ‘rules’ and slightly different timing from interactions with conventional vehicles. A cyclist described training children’s traffic skills:

Cyclist:
”And we teach our children that, but our children become a little uncertain, because when we have practised in traffic, it’s a bit: “Well, now the shuttle is coming and then there are slightly different rules…”, then we either drive around it or stay back.”

The other road users thus described that they had to learn to adapt to the shuttle by decoding the different requirements for greater distance and the different overtaking procedures and generally getting used to the bus’s driving pattern.



TWO OF THE SHUTTLES ARE SEEN PASSING EACH OTHER UNDER THE BRIDGE AT TORNHØJ (08.05.2021)

5.12 SUMMARY – THE DRIVERLESS SHUTTLES ARE NOW ON THE ROADS

An important benefit of the Smartbus trial has been a greater knowledge of how driverless vehicles act in traffic and thus how they can eventually contribute to improved mobility.

Overall, the experiment went well, in the sense that the driverless shuttles were able to drive on the path, technical challenges were resolved, and the users of Astrupstien were able to adapt to the new type of road user, without this leading to an increased unmitigated risk for vulnerable road users.

Dangerous traffic situations were prevented by the relatively low speed of the shuttles, by the attentiveness of the operators and by the fact that the shuttles were programmed to consistently stop when the sensors detected anything. The shuttles’ low speed and consistent defensive driving pattern meant that the users of the path gradually became familiar with their driving pattern and, in the vast majority of situations, could interact with them on the path without much difficulty.

The operators on the shuttles played an important role, partly as an extra security layer in relation to maintaining traffic safety and partly as problem solvers when situations arose where the shuttles could not proceed without manual override. Some of these manual overrides dealt with teasing, or overly bold or harassing actions directed at the bus. It is unclear whether these types of actions would have had the same form if the shuttles had been unstaffed, but it seems obvious that there would have been situations where, for example, objects – either deliberately placed on the path or present due to accidental circumstances – would have blocked the shuttles from running.

An unfortunate side effect of the shuttles’ consistent safety braking was that these decelerations often occurred very suddenly and seemed arbitrary, as they were sometimes caused by leaves, birds or the like, which would not normally have caused a vehicle to brake hard. Some braking was startling for passengers in the shuttles or was very harsh. Braking led to falls and to passengers being thrown out of their seats inside the bus. Some potential users reportedly did not use the shuttle due to the risk of abrupt stops. Operators, who had to stand up while driving, also reported falling and sustaining injuries as a result of hard braking.

Informants and operators alike reported particular challenges regarding the northbound operation, which required the shuttles to pull into stops located on the left side of the road. As the path was not wider than two shuttles passing each other, the northbound shuttle was in the oncoming lane and opposite to the direction of travel when paused at bus stops. This created situations that were difficult for other road users to decode, in which both overtaking and oncoming road users found it unclear how they should behave. Also, situations arose wherein road users driving around the shuttles passed so close that they accidentally stopped them, disrupting and delaying their operation. These situations were generally resolved by both operators and path users getting used to holding back for each other in such circumstances. It is unclear whether this traffic setup would not have presented similar challenges to an ordinary, non-driverless bus.



MURAL OF THE SHUTTLE IN TREKANTEN (08.05.2021)

6. THE DRIVERLESS SHUTTLES AS A FORMATIVE NARRATIVE IN AALBORG EAST

Comprehensive plans, social housing initiatives and citizen-oriented projects are repeated elements in a narrative about Aalborg East that goes back many years in the district's history. It is a story that has been shaped both by accounts of disorder and social problems and by counter-accounts of commitment, diversity, inclusiveness and dynamism. The driverless shuttles and the informants' responses to them add to this long story – both as a completely new, innovative and news-making agenda and as another way of interpreting the history of Aalborg East.

6.1 “I’VE HEARD THAT IT’S SORT OF EMBARRASSING TO COME FROM AALBORG EAST”

In our investigation into how the path’s transformation and the deployment of the driverless shuttles have affected the city and the people around Astrupstien, we found that preconceptions about Aalborg East’s reputation and history were often mentioned as something people in the district were aware of. This was also something that for many was included as an implicit expectation when talking about the use of the path as well as the expectations and experiences with the driverless shuttles.

One of the secondary purposes that Aalborg Municipality had mentioned for the trial had been to put Aalborg East on the map for something other than the stories about socio-economic challenges that the district had been associated with. It is, therefore, in a way both understandable and paradoxical that the study shows precisely how this narrative is an unshakeable part of the sociological context within which the Smartbus project is interpreted. The approach of the children we spoke to in particular illustrates how the history of Aalborg East as a socially problematic district is something they both retell and wonder about. A 7th-grade girl said during a focus group interview in 2021:

Girl:
”I’ve heard that it’s kind of embarrassing to come from Aalborg East. Or it was. There used to be some strange people who lived here in Aalborg East.”

The research literature on Aalborg East, as well as testimonies and cultural products referring to the district, support this image of a district that at once protests, acknowledges and wonders about its special (often negative) image in the outside world – an image that has roots all the way back to its construction.

As the 1978 song above illustrates, thoughts about the buildings in Aalborg East have not been exclusively positive. In Arne Lybech’s Danish book, a translation of the title reading Aalborg Øst Book – A Time Journey, from Planet City to Universal District (2008) and consisting of accounts from residents of the district, a 15-year-old contributor refers to the song as a good description of “how an area, even before the district had taken shape, had acquired a bad reputation” (Lybech 2008:73).

In our investigations, in the reports in Lybech’s book and in an analysis of the media coverage (Jensen & Christensen 2012), it turns out that many Aalborg East citizens have ambivalent feelings about their own district. This is also illustrated in Lybeck’s book, where the young resident expresses it thus:

> *”It is incredible that such a reputation has endured for so many years, as it has changed a lot since then. […] I have experienced that when I tell where I come from, people frown and often make a comment like “How can you stand it?” Often it is people who do not know the area, but are informed via the press.”*
>
> (Kathrine Glinvad Nielsen i Lybech, 2008:73)

This description falls in line with many other statements, which on the one hand indicated a devotion to ‘their’ district – several could not see themselves living anywhere else in the world and in principle wanted to remain resident in Aalborg East for their entire lifetime – and on the other hand expressed frustration at the stigmatization and ‘low status’ they experienced in relation to the district of Aalborg Øst and the associated postcode 9220. Many experienced a sense of disconnect in the face of a picture drawn by outsiders which they themselves did not recognize (Jensen & Christensen 2012, Lybech 2008). As Skjøtt-Larsen (2008) notes:

> *”The remarkable thing about Aalborg East is the consensus that apparently exists about the district’s status. A consensus that is largely only challenged by the district’s own residents.”*
>
> (Skjøtt-Larsen 2008:26)

Upon closer examination of the media’s coverage of the district, one finds a possible reason for the resentment towards the media expressed by some of the district’s citizens:

> *“The appearance of Aalborg East in articles without actual relation to the area illustrates the use of Aalborg East as a negative point of reference in the social geography of Aalborg. The negative image was also clear in media texts related directly to the area. While some stories are neutral or positive, two types of media coverage draw attention. The first type we call paradoxical stories. They are often positive in their overall approach but entail an implicit negative description of the area; for example, stories about positive things happening in Aalborg East as an exception (implying that the reader is assumed not to expect positive things to happen there). […] The second type of stories addressed here is unambiguously negative, and greatly outnumbers the paradoxical stories. The most significant stories are about dysfunctional schools, eviction of ‘criminal’ tenants, and about Aalborg East as an insecure area dominated by crime and trouble.”*
>
> *(Jensen & Christensen 2012:80-81)*

ASPHALT BALL

”The asphalt ball is well under way
now the icy wind sings
in the planet city are the hostages
of other people’s distorted whim
The investors do not live there
they leave it to others to be bored to death
Where bellflowers tinkled
where you could hear the bees buzzing
rose a city of concrete
so nature had to fall silent
It is evening and the planet city flares
neon signs are the only decoration
the wind is cold, the concrete is grey
and the evening has only just begun
In the heartless city, everything is quietly suffocated
Officially, it is a lie that something is wrong
The asphalt ball is well under way
Single mothers and others without jobs
are crowded together until the neighbourhood is full
The streets and houses are drawn with a ruler
this is where life is to be lived, if you don’t go crazy
In the grill bar’s fumes of deep-fried food and roast
chicken, dreams are to thrive, imaginations run wild,
never mistake that money was the motive,
nothing was built out of love for life.”

Asfaltballet – Jomfru Ane Band, 1978

Several sources (Jensen & Christensen 2012, Skjøtt-Larsen 2008) confirm that there are social problems but also point out that these cannot rationally explain the image of the district. Jensen and Christensen therefore argue that it is more relevant to understand the image of the area as an expression of territorial stigmatization, which describes the sociological phenomenon that an area can be designated as the bearer of a particularly negative narrative, which is routinely also attributed to the residents associated with the area. This stigmatization derives much of its credibility from the district's composition of ages, genders and ethnicities and the related discourses stereotyping young, ethnic minority men as criminal . However, assumptions about the meaning of ethnicity do not constitute the entire explanation for the district's stigma:

> *"Aalborg East becomes a symbol of poverty, crime and other social problems, regardless of the fact that several express that it is probably a truth with modifications, and regardless of the fact that Aalborg East is probably placed below average on most 'objective' social indicators, but not lower than many other and more anonymous areas."*
>
> (Skjøtt-Larsen 2008:26)

In Arne Lybech's book of accounts, Bjarne Mortensen, a teacher at Tornhøjskolen, describes his personal memories from teaching in Aalborg East as follows:

"The first thing that strikes you when you meet Aalborg East is the diversity. Colours from pink, almost white, to a dark brown bordering on pitch black. Occasionally all shades; cocoa, chocolate (from Nestlé Crunch to Dark Gold Bar), yellow, red, sunburnt and on and on.

In the ten years I have been at Tornhøjskolen, I have – in addition to the ethnic Danes – met students and families from most of the civilized world. Greenland, the Faroe Islands, Iceland, China, Vietnam, Palestine, Lebanon, Israel, Albania, Somalia, Afghanistan, Indonesia, Pakistan, Nigeria, Dubai, Iraq, Poland, England, USA, Turkey and Iran. We have students from around 30 different countries, representing at least as many languages and cultures.

There are first-, second- and third-generation refugees and immigrants. There are families that are insecure about everything foreign, huddle together and distance themselves and, if possible, become even more foreign than they were at home. Burkas, gold chains, "respect", truancy from school, no respect for teachers and authorities and a little car theft every now and then. At the other end of the scale: Families and children who do everything they can to become as Danish as possible. Parties, alcohol, solarium, money, bonanza and it just can't go fast enough.

Between these extremes there are all kinds of imaginable variations, characterized by quite ordinary people who want to have a job, support themselves, see that their children are doing well in life and otherwise just have some peace and quiet. Moderate in speech, lifestyle and conviction, a little inspiration from home and a little from Denmark. Trying to be both themselves and Danish. In this difficult balancing act, the vast majority succeed."

(Lybech, 2008:61-63)

"GHETTO" – AN IMAGE AS A SHARED BUT DISPUTED REFERENCE IN AALBORG EAST

In one of the study's 2018 focus group interviews with people working in Aalborg East, it was discussed how Aalborg East is referred to and what this means for expectations regarding the reception of the driverless shuttles. For example, one employee at Aalborg East said:

Employee in Aalborg East:
Aalborg East is already so stigmatized [as] a ghetto and I don't know what, right. So if a little bit of bad happens, it confirms everyone's prejudices. "It's simply a ghetto", "all the criminals live there" and "typical Aalborg East", and "now they've been out again and set fire to something and assaulted someone", right?"

A similar discussion can be seen in another focus group interview with residents in Aalborg East in 2018:

Resident:
"You can also read that in Nordjyske Media [local newspaper] . If something happened in Aalborg East, it was blown out of proportion, and someone said: "it's typical of Aalborg East" and all that sort of thing, but they just forgot that Aalborg East – the district itself – is bigger than the whole Frederikshavn is up there."

In 2018, both employees and residents of Aalborg East mentioned the "ghetto image" that is reproduced in the media and among people outside the area; they referred to prejudice and stigmatization, which are experienced as colouring the public's understanding of Aalborg East. In 2018, a resident referred to the "stories" "that have been retold six to seven hundred times and have turned into a really big elephant". These stories were also mentioned in 2020 and 2021, for example by this resident:

Resident:
"Those stories from Aalborg East... every single time there was a fire in a small dustbin, it was in Nordjyske and TV2, wasn't it... you could say that there was just as much crime in all sorts of other places, but you just didn't hear about it in the same way."

Three children in the 7th grade talked about Aalborg East in an interview in 2021. This boy's remark was typical:

Boy:
"Aalborg East is just well-known [...] There are just a lot of troublemakers and criminals out here."

A young resident we spoke to in 2020 was moving to the area. He explained that he was aware that it was a vulnerable residential area, but that "one's prejudices are put to shame". Several also mentioned that there was not "as much" happening as people expect, and some did not experience crime or insecurity in the area at all. Two residents interviewed said that they did not experience Aalborg East as unsafe and believed that this is a misleading description: "Perhaps you can hear someone say something, but that is not our experience".

Some informants complained about experiences with break-ins and insecurity on the path in the evening. Three children also said in 2021 that they witnessed crime and violence in Aalborg East, coming up with several stories accompanied by comments such as "it happens every day" and "it's normal out here". Primarily, however, we met informants who described Aalborg East as safe, pleasant and a place of unity and development. Informants explained that it was most often outsiders, who did not move around Aalborg East themselves, who experienced it as the "ghetto" with a lot of crime. Several referred both in 2018 and 2021 to the fact that things were better than 10 years ago. The study's data did not specifically show what influence the driverless shuttles and the transformation of the district had otherwise had on this perception of Aalborg East.

6.2 THE INFORMANTS' ASSESSMENTS OF THE SMARTBUS PROJECT

Several informants described the "news value" the shuttle has had for the area. A 14-year-old girl explained that it was "great" that the shuttle had arrived:

Girl:
"Because... Aalborg East is known as a ghetto area, and no energy has really been put into making it better out here."

The girl also expressed a pride associated with the district, especially in relation to the bus: "we are the first to have them out here". An informant explained in 2020 that:

"We are lucky that we are the first! [...] That the development of the technology has started in Aalborg East in relation to the shuttles. [...] the most important thing about it is that you start talking a lot about Aalborg East in a positive way."

Another resident informant elaborated:

Resident:
"It just gives a positive look at our historical background here as a district. That it starts from here. [...] And that can change the district and inspire."

The positive publicity was described by several informants and was mentioned in connection with descriptions of Aalborg East as "part of the technological development" and as being "first movers".

Despite predominantly positive experiences of the bus, we also met several people who saw it as an expensive and impractical initiative. The project was described by various informants, for example, with the words "prestige project", "gimmick", "fancy", "experiment" and "waste of money". An informant mentioned the cost of the project and believed that the shuttle's practicality should be evaluated in relation to the cost. One resident in 2020 perceived the shuttle as an attempt to solve social problems in the area but believed that "It is foolish!" and referred to the area as needing other measures concerning its bad reputation and the young people who were "petty criminals and flabby". Especially in 2021, we met informants who did not think that the shuttle was practical. Several mentioned that there were few passengers on the bus, and three informants independently described the shuttle with the words: "there is almost never anyone on it."

LASTING LOCAL EFFECTS

Many of the experiences and considerations expressed by Astrupstien's users were also described by an after-school club director during an interview about the project's local effects, which was held in 2021 at the end of the project. Not least, the importance of the shuttles for the way the path was widened and given space was highlighted as positive for the area. The informant warned against limiting the possibilities of using the path by setting up barriers based on stories of individual mopeds behaving stupidly. In this interview, too, the experience resurfaced of an old negative narrative that is difficult to eliminate. The national attention that the project has brought, with visits from the Minister of Transport and other high-profile guests, was described as something that, all else being equal, has had a positive impact on self-image in the area.

The new urban space in the south and the stairs at Trekanten were highlighted as an important new gathering place, providing more citizens in Aalborg East the opportunity to attend events. The upgraded path system was described as a central and stronger place in the district, and the new urban facilities with their squares and playgrounds have made it easier for social events to take place.

The after-school club director commented, in line with other informants, that the driverless shuttles had limited utility as a means of transport due to their capacity and speed, but believed that there still is a need for some form of mobility-enhancing public transport between north and south – especially when the new hospital comes into operation.

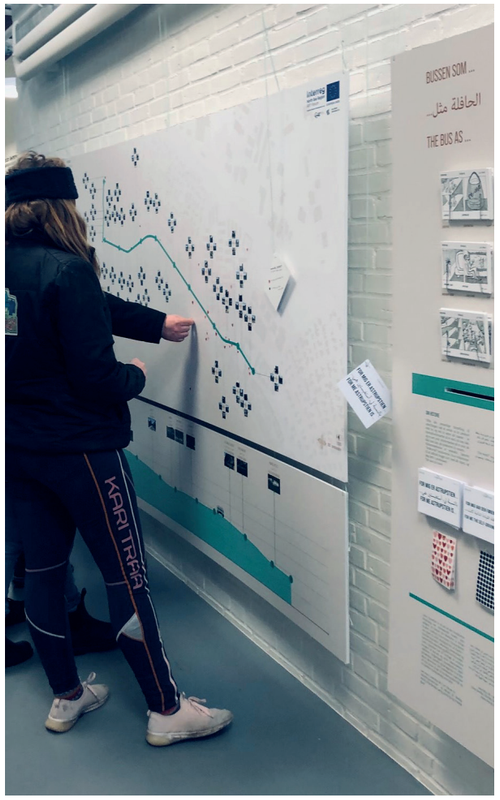


CITY SPACE AROUND TREKANTEN (08.06.2021)

FINAL INTERACTIONAL EXHIBITION

To give the many residents who were affected by the Smartbus project in one way or another the opportunity to express what it meant to them, an exhibition wall was established in Trekanten at the end of the project. Here, it was possible to see a graphic representation of the test route with photos in four directions at selected locations. Visitors could also mark places on the map they liked with a heart and places they didn't care for along the route with a black dot.

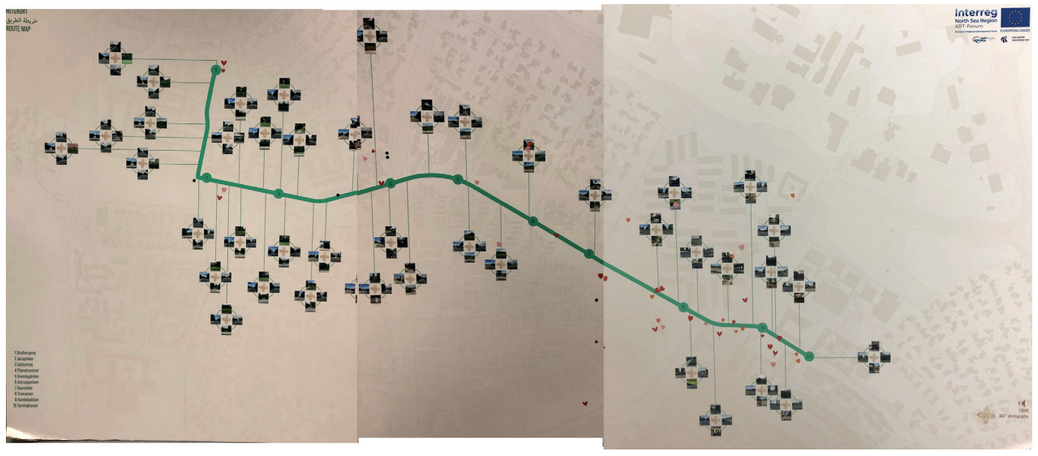
As can be seen on the board below, the greatest number of places marked as having positive meaning are located along the southern part of the route, but people did also mark places that they liked on the northern part of the route.



Hearts and black dots are put on the map at the exhibition in Trekanten (26.11.21)



HEARTS AND BLACK DOTS ARE PUT ON THE MAP AT THE EXHIBITION IN TREKANTEN (26.11.21)

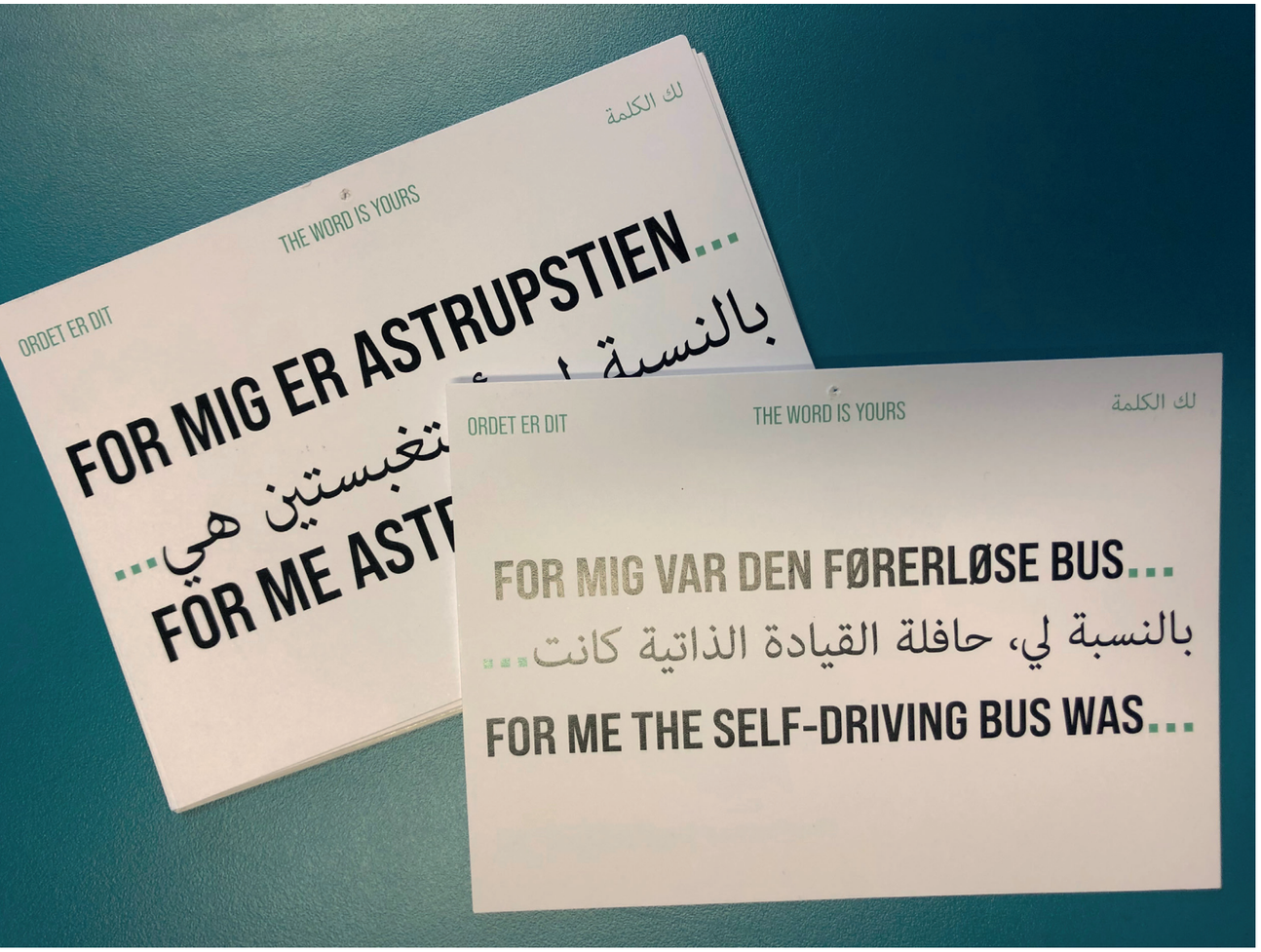


The map of the test route, with hearts and black dots applied by visitors to Trekanten during the exhibition period (26.11.21 – 10.12.21). A concentration of hearts (places they liked) can be seen in the southern part of the route (to the right on the map), while the black dots (places they didn't like) are sparser and more scattered

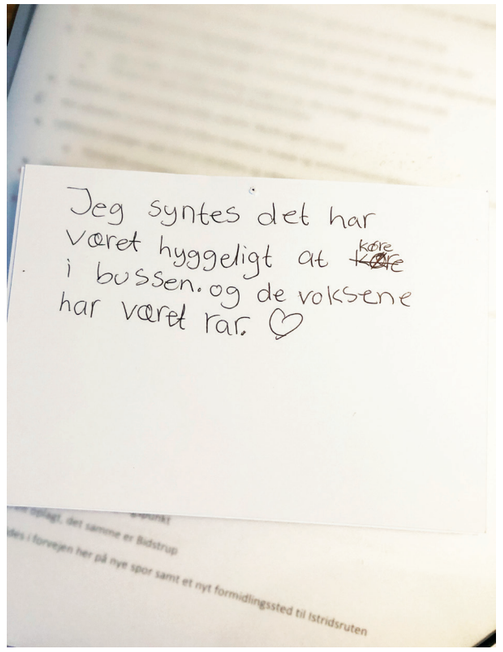


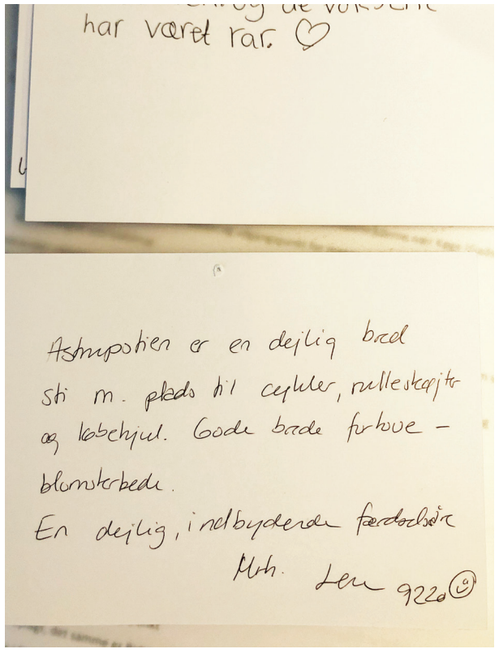
Reproduction of material from the exhibition, 'Life within sytsmes', which was hung in the cultural centre Trekanten from 26.11.2021–10.12.2021

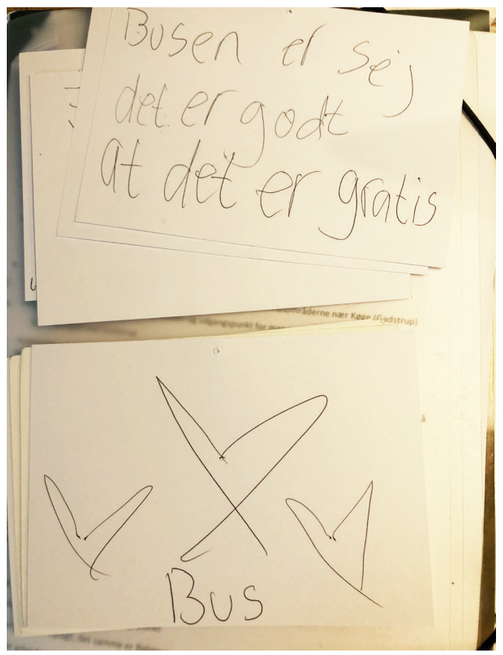
The interactional exhibition also allowed visitors to write a postcard about Astrupstien or the driverless shuttles. Very fittingly for the experiment and for the many different people who contributed to the data collection in this study, the maps illustrate – perhaps unsurprisingly – that the Smartbus project has meant different things to different people. The messages could be freely worded, and the following presents a sample of the messages we received.

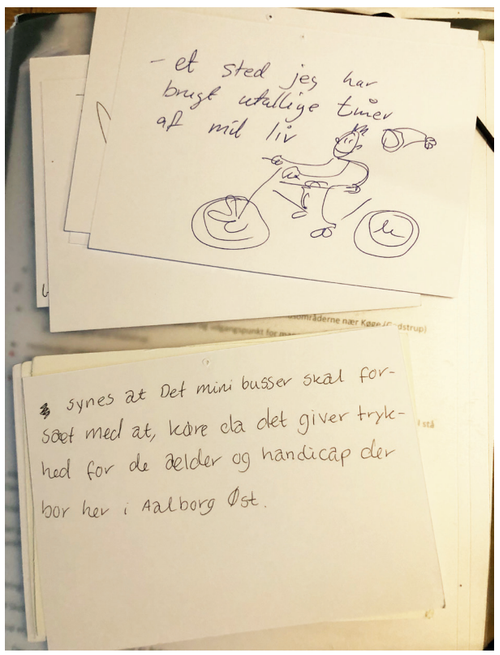


Postcards from the exhibition. On the back, visitors could write down their thoughts or attitudes about the driverless shuttles and Astrupstien, returning the card to the researchers via a mailbox (26.11.2021)

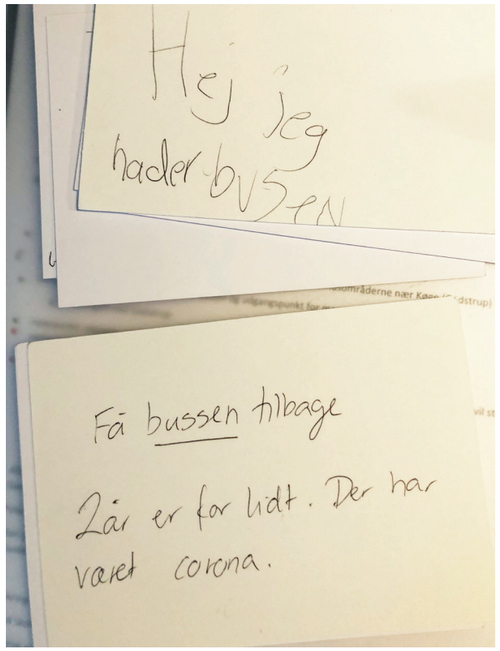


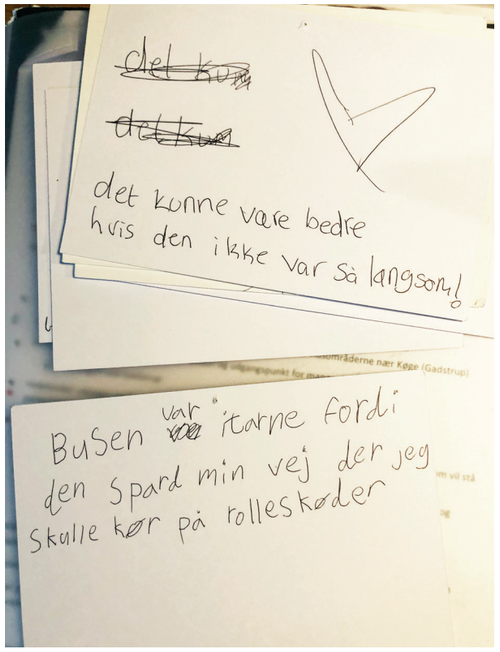


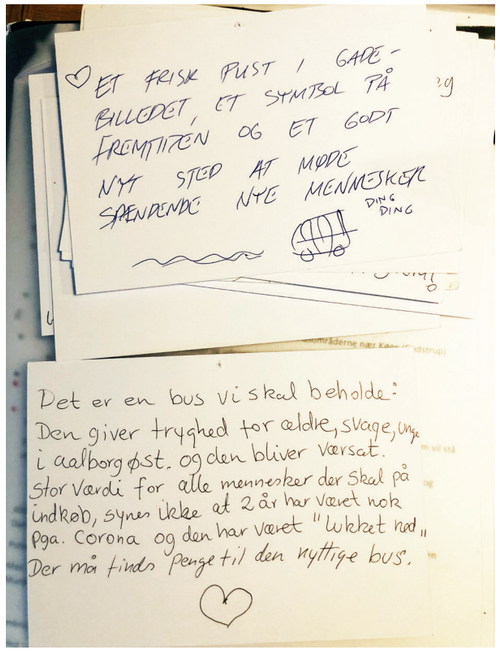


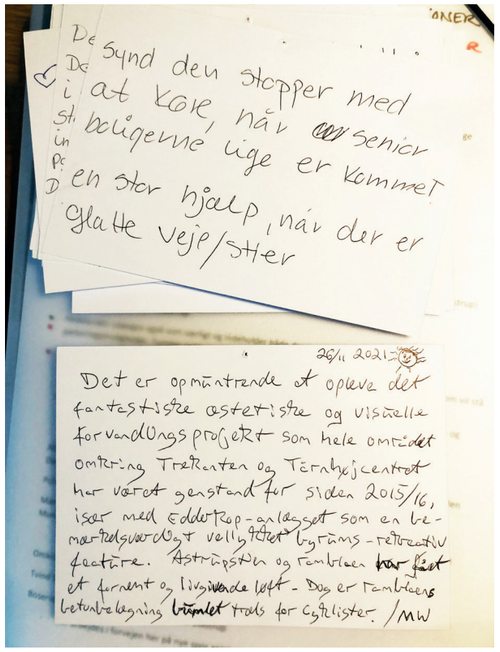


Visitors' submitted postcards (10.12.2021)









Visitors' submitted postcards (10.12.2021)

6.3 SUMMARY – FORMATIVE NARRATIVES IN AALBORG ØST

As a result of delving into the history of Aalborg East and the narrative that exists about the district, both in the outside world and internally in the district, a picture emerges that is pieced together by persistent narratives about social problems and strong counter-narratives about unity, local flavour and diversity.

The driverless shuttles, with their national novelty value and the demands they placed on the infrastructure, which had to be widened, constitute a new chapter in this compilation of narratives. Although the shuttle operation has been discontinued, the path remains an updated example of how a prioritized path system for active mobility can be designed.

The narrative surrounding the driverless shuttles is also a tale of a technology that is not technologically mature enough to compete with the flexibility of cyclists and pedestrians. For some, this has meant that the positive experience of being the first place in Denmark to test this type of vehicle may have lost some of its appeal, because the shuttles did not quite live up to all expectations. According to our informants, the narrative about Aalborg East over the past 10 years has moved away from the stereotypical negative image. Many expressed the sense that despite the problems, e.g. in snowy weather and the generally slow pace, the driverless shuttles have contributed to Aalborg East's being referred to positively and in new contexts – not least outside the district.



THE RAVNKILDE STOP ON ASTRUPSTIEN (08.05.2021)

7. EXPERIENCES FROM OTHER STUDIES OF DRIVERLESS TRANSPORT

The Smartbus project in Aalborg East is a unique project combining many elements that are significant for the development of forms of mobility that are socially, environmentally and economically sustainable. As part of AAU's work to investigate the project, intersections with other projects and studies with driverless technology have been explored. In this chapter, a number of areas are reviewed where the experiences from other studies support or contrast with the experiences from the investigation of the Smartbus project and contribute to a broader perspective.

7.1 COMPARISON WITH OTHER TRIALS OF DRIVERLESS MOBILITY SOLUTIONS

The shuttle was generally experienced positively on Astrupstien, which has also been the case in other, comparable case studies with driverless shuttles[1]. An article about tests in Norway, however, pointed out that the positive reception of driverless shuttles may be due to the news value it has as an innovative technology[2]. Our informants observed that the shuttles created positive publicity for Aalborg East, and similar experiences have been reported in other experiments with driverless shuttles, e.g. in Greece and Switzerland, where residents considered the shuttles to be good publicity for their city[3].

For many, the shuttle on Astrupstien did not have practical value primarily as a means of transport. Similar experiences have been described in several other case studies[4].

USERS OF THE BUS

The majority of shuttle users were children in Aalborg East, a feature that distinguishes this study from other studies of driverless shuttles. However, many studies did not categorize user types[5]. One explanation for the many children on the shuttle could be that many children are generally seen on Astrupstien, and the children themselves said that they prefer hanging out outside to being at home. A study of previous experiments with driverless shuttles reported on many families with small children who used the shuttle[6].

The majority of the informants in Aalborg East were of the opinion that the shuttle was for the elderly and those with walking difficulties. Other studies have indicated a general expectation that driverless vehicles can create increased accessibility for the elderly and those with walking difficulties[7], and in 2017 driverless shuttles were deployed in a rural area in Japan specifically to provide better transport options for older people[8].

The wheelchair users we spoke to at Astrupstien said that they did not feel that there was enough room for them in the shuttle or good access to it. An earlier trial of driverless shuttles in Europe concluded in 2016 that there was a lack of accessibility for people with disabilities[9]. This was also a theme in a study of a trial with driverless shuttles in Norway[10]. Here, informants found that the shuttle was too small for wheelchair users. Based on these results, researchers have proposed an increased focus on accessibility in driverless shuttles, and not just for wheelchair users.

The presence of the operators was commented on by the informants in Aalborg East, and emphasis was placed on the fact that the shuttles were not truly "driverless". This topic has been discussed in several other studies[11], and some customers were disappointed that operators often had to drive manually[12].

1 (Mouratidis and Cobeña Serrano 2021; Salonen and Haavisto 2019; Rehrl and Zankl 2018; Mahmoodi Nesheli et al. 2021)
2 (Mouratidis and Cobeña Serrano 2021)
3 (Papadima et al. 2020; Eden et al. 2017b)
4 (Mouratidis and Cobeña Serrano 2021; Eden et al. 2017a)
5 (Mahmoodi Nesheli et al. 2021)
6 (Christie et al. 2016)
7 (Nogués, González-González, and Cordera 2020; Guerra 2016)
8 (Tajitsu 2017). Et enkelt casestudie viser, at ældre er mere skeptiske overfor brug af førerløse busser (Mouratidis and Cobeña Serrano 2021)
9 (Christie et al. 2016)
10 (Mouratidis and Cobeña Serrano 2021)
11 (Mouratidis and Cobeña Serrano 2021; Nordhoff et al. 2019)
12 (Rehrl and Zankl 2018)

Other studies have placed great emphasis on the importance of the operators' role in relation to citizens' perception of road safety. Results from a trial of driverless shuttles in Austria showed that passengers generally felt a high level of road safety on the bus, but for some passengers this was based solely on the fact that there was an operator on the shuttle[13]. The trial in Norway emphasized the importance of the operator's ability to take over control in city traffic when confusion arose between motorists, pedestrians and the shuttle[14].

Results from a case study in Finland showed that although the operator in this trial did not manually assist the bus, the presence of the operator was an important factor for trust in driverless shuttles.[15]. American transport researchers[16] have tried to investigate the importance of having operators in self-driving shuttles for informants without practical experience with driverless shuttles. In a 2015 survey of 930 American respondents who had not tried a driverless vehicle themselves, the researchers found that the presence and tasks of operators were of decisive importance in determining whether people would use a self-driving shuttle. However, another large study, in which passengers from four countries answered a questionnaire after riding in a driverless bus, showed that the majority were willing to ride in a driverless shuttle without an operator in the future[17].

The operators on Astrupstien were described by our informants as important social actors. In Oslo, it was similarly observed that passengers had conversations with the operators of the driverless shuttles[18]. Another study indicated that although the operators's role in relation to the actual driving was important, their social presence was also significant[19]. Our results show that operators are experienced as authorities who, in addition to their social role, maintain peace and order.

This was not seen as a theme in similar studies, which is possibly due to the special context with many children on Astrupstien.

CONFLICTING CONSIDERATIONS – SAFETY AND SPEED

Unexpected and hard braking is a frequent theme in other case studies from around the world[20]. For some passengers in Austria, abrupt braking meant that they did not feel safe on the shuttle[21], and some informants expressed doubts about the functionality of the technology in Germany[22]. Passengers in Germany described the braking as unpleasant and were surprised that the vehicle did not work as they expected[23], while in Norway, for example, braking was simply described as something that was observed[24]. Several other studies highlighted hard braking as a pronounced point of criticism from passengers[25], and there was a general desire for this to be improved[26]. A British study investigating experiences of driverless cars showed that pedestrians found driverless cars safer than the passengers did as the latter felt less safe in them. The researchers behind the study believe that this difference may be due to pedestrians expecting driverless cars to prioritize their safety over that of passengers[27].

13 (Rehrl and Zankl 2018)
14 (Mouratidis and Cobeña Serrano 2021)
15 (Salonen and Haavisto 2019)
16 (Dong et al. 2019)
17 (Bellone et al. 2021)
18 (Mouratidis and Cobeña Serrano 2021)
19 (Dong, Discenna, and Guerra 2019)
20 (se Mahmoodi Nesheli et al., 2021)
21 (Rehrl and Zankl 2018)
22 (Nordhoff et al. 2019)
23 (Nordhoff et al. 2019)
24 (Mouratidis and Cobeña Serrano 2021)
25 (se Mahmoodi Nesheli et al., 2021)
26 (Mouratidis and Cobeña Serrano 2021; Bellone et al. 2021)
27 (Hulse, Xie, and Galea 2018)

Falls on driverless shuttles do not seem to have been a problem reported in other studies, although some passengers were found to request seat belts in driverless shuttles due to braking[28]. While one study mentioned that there may be an increased risk of falling due to braking, it did not state that this had already been the case[29]. Daily presses have described falls in driverless shuttles, including the cases of a woman who fell on a shuttle in Ohio[30] and an elderly man who was badly injured during a test drive in Salt Lake City, where the shuttle braked so suddenly that he fell out of his seat[31]. Both episodes immediately led to a temporary stop in operations, followed by testing of the shuttle in Salt Lake City and the introduction in Ohio of seat belts, signage and information about the possibility of hard braking. Similar measures were implemented in Oslo, where the operators now inform passengers about braking, and clear signage is visible on the shuttle[32].

Several of our informants reported that they experienced the shuttle as slow and that this made it boring or impractical as a means of transport. The same can be found in other case studies, where the low speed and hard braking are two central problems pointed out by passengers[33]. In addition, slow driving was ranked as the least positive aspect of a test of driverless shuttles in Germany[34]. In several studies, passengers wanted the shuttles to run faster[35], which was also a wish expressed by some informants on Astrupstien. However, our informants also stated that the slow speed made them feel safe on the shuttle and that it alleviated their worries. In several other studies, it was also reported that informants felt a high degree of security due to the slow speed[36].

These conflicting considerations and wishes in relation to braking, speed and traffic safety were also described in the study of driverless shuttles in Norway, which pointed out that a solution will require improvement of the technology:

> *"Driving with higher speed and minimizing abrupt breaking without compromising safety is a challenge for autonomous buses and autonomous vehicles in general. To achieve higher speeds and softer breaking while maintaining high safety, automation technology needs to be improved"*
>
> (Mouratidis and Cobeña Serrano 2021, p. 333).

Several informants who did not use the shuttle described it as impractical for them and indicated that it could not compete with walking or cycling. This was due to the short distance, the long wait times and the shuttle's low speed. Several other case studies also reported that informants did not find the shuttles competitive with existing means of transport[37]. Other studies also found desires for longer routes[38], shorter wait times[39] and faster speeds, as many can walk or cycle faster than the shuttles[40]. Several studies also reported that informants expected the driverless shuttles to run with the same or better frequencies than existing, ordinary buses[41].

THE BEHAVIOUR OF OTHER ROAD USERS AND THEIR INTERACTION WITH THE SHUTTLES

Situations arose on Astrupstien where road users found it confusing to interact with the shuttles due to ambiguous or absent communication with the shuttle. Communication has also been described as problematic in other studies. In an experiment in Switzerland, it was observed that other road users found it difficult to read the driverless shuttle's "intentions", and there was a desire for better signalling in the form of light or sound[42].] Interaction with other road users was also described as a central problem in Austria:

> *"In some situations, it is not clear what the vehicle will do next and how other road users should behave. For example, the shuttle signals a stop via a display on the back windshield. However, does this mean for the other road users that it is safe to overtake the shuttle, or should they also stop behind the shuttle? [...] In some situations, other road users were not aware whether the shuttle had recognized them as an obstacle and if they can continue their drive or if they should stop."*
>
> (Rehrl and Zankl 2018, p. 7)

This description has many similarities with the situations that we observed and described on Astrupstien. Mahmoodi Nesheli et al. (2021) called for the public to be informed about how driverless shuttles operate and for clear signage and pavement markings to be introduced to avoid confusion. We find that with the current technology, it is necessary for there to be an operator on board to take care of negotiations and prevent accidents, which is in line with the conclusions of other research[43].
Although much research currently focuses on driverless vehicles and how they can be programmed to travel in traffic with other people, there remains a need for studies on the interaction and negotiation that takes place between people and driverless vehicles[44].

28 (Eden et al. 2017a; Bellone et al. 2021)
29 (Bellone et al. 2021)
30 (Crowe 2021)
31 (Claburn 2019)
32 (Mouratidis and Cobeña Serrano 2021)
33 (Mouratidis and Cobeña Serrano 2021)
34 (Nordhoff et al. 2019)
35 (Mouratidis and Cobeña Serrano 2021; Rehrl and Zankl 2018)
36 (Salonen and Haavisto 2019; Mouratidis and Cobeña Serrano 2021)
37 (Eden et al. 2017a; Nordhoff et al. 2019; Mouratidis and Cobeña Serrano 2021)
38 (Rehrl and Zankl 2018)
39 (Nordhoff et al. 2019)
40 (Mouratidis and Cobeña Serrano 2021; Nordhoff et al. 2019)
41 (Mouratidis and Cobeña Serrano 2021; Nordhoff et al. 2019)
42 (Eden et al. 2017b)
43 (Dong, Discenna, and Guerra 2019; Mouratidis and Cobeña Serrano 2021)
44 (Rehrl and Zankl 2018; Crayton and Meier 2017; Fraedrich, Beiker, and Lenz 2015; Yeo and Lin 2020b)

7.2 SUMMARY – COMPARISON WITH THE PREVIOUS LITERATURE

EXPERIENCES THAT DIFFERED FROM OTHER STUDIES

That the majority of users on Atrupstien were children was a unique feature, possibly due to there generally being many children using the path. However, there is a widespread lack of categorization of user types in the literature (Mahmoodi Nesheli et al. 2016). In some studies, the shuttle was particularly used by families with smaller children (Christie et al. 2016).

- The operator's role as an authority who keeps an eye on, for example, loud groups of children was specific to Aalborg East, where there were many children without adult supervision and in large groups.
- The fact that the stops were located exclusively on the western side of Astrupstien led to significant confusion and misunderstandings when the northbound shuttle had to cross the road to reach the stops. Cyclists and other road users had difficulty reading the bus's intentions and did not know which way to go around it.

EXPERIENCES THAT WERE ALSO DESCRIBED IN OTHER STUDIES

- The positive experience of the shuttle was typical (Mouratidis and Cobeña Serrano 2021; Salonen and Haavisto 2019; Rehrl and Zankl 2018; Mahmoodi Nesheli et al. 2021); however, this may be due to the news value of innovative technology and positive publicity (see Mourtadis and Cobeña Serrano 2021, Papadima et al. 2020 and Eden et al. 2017b).
- Experiential value exceeded practical value as a means of transport (Mouratidis and Cobeña Serrano 2021; Eden et al. 2017a).
- Concern about the impact of driverless vehicles on health and disease as a result of their encouraging diminished exercise was also reported elsewhere (Crayton and Meier, 2017).
- Targeting of the offer towards the elderly and those with walking difficulties, as well as the general expectation that driverless vehicles will increase accessibility for these groups, was also common (Nogués, González-González and Cordera 2020; Guerra 2016; Tajitsu 2017).
- A desire for shelter at bus stops was also reported elsewhere (Papadima et al. 2020).
- The elderly are more sceptical of driverless vehicles (Mouratidis and Cobeña Serrano 2021).
- Lack of accessibility for people with disabilities was a repeated concern (Christie, 2016; Mouratidis and Cobeña Serrano 2021; Nordhoff et al. 2019; Rehrl and Zankl 2018).
- The criticism that the shuttle was not fully automated was a recurring theme (Mouratidis and Cobeña Serrano 2021; Nordhoff et al. 2019; Rehrl and Zankl 2018).
- Road safety and trust in the technology were repeatedly identified as related to the presence of an operator (Rehrl and Zankl 2018; Mouratidis and Cobeña Serrano 2021; Salonen and Haavisto 2019).
- The presence of an operator seems to be more important when users have no prior experience with driverless vehicles (Dong et al. 2019) and less important when they have tried it before (Bellone et al. 2021).
- Operators have social significance (Mouratidis and Cobeña Serrano 2021; Dong, Discerna and Guerra 2019).
- Unexpected and hard braking was a recurring phenomenon (Mahmoodi Nesheli et al. 2021; Nordhoff et al. 2019; Mouratidis and Cobeña Serrano 2021; Bellone et al. 2021), causing insecurity (Rehrl and Zankl 2018) and doubts about the functionality of the technology (Nordhoff et al. 2019).
- Falls in the shuttle due to hard braking were also reported elsewhere (Crowe 2019; Claubum 2019).
- A desire for seat belts was expressed elsewhere as well (Eden et al. 2017a; Bellone et al. 2021).
- There was also a call for increased information via signage about, e.g., the hard braking (Mouratidis and Cobeña Serrano 2021).
- Slow driving was experienced as a negative aspect of the shuttles (Mouratidis and Cobeña Serrano 2021; Nordhoff et al. 2019; Rehrl and Zankl 2018).
- At the same time, slow driving was seen as contributing to safety (Salonen and Haavisto 2019; Mouratidis and Cobeña Serrano 2021).
- Problems with driving in snowy weather were reported (Rehrl and Zankl 2018).
- By users driverless shuttles are considered to be particularly practical in bad weather (Nordhoff et al. 2019; Bellone et al. 2021).
- Driverless shuttles are not competitive with existing forms of transport, including walking and cycling (Eden et al. 2017a; Nordhoff et al. 2019; Mouratidis and Cobeña Serrano 2021).
- A desire for longer routes was reported (Rehrl and Zankl 2018).
- A desire for shorter wait times was reported (Nordhoff et al. 2019).
- A desire for more departures (increased frequency) was a recurring theme (Mouratidis and Cobeña Serrano 2021; Nordhoff et al. 2019).
- Problems were reported with unclear or missing communication between driverless vehicles and other road users (Eden et al. 2017b; Rehrl and Zanke 2018).
- A need was expressed for more information about the behaviour of driverless vehicles via clear signage and road striping (Mahmoodi Nesheli et al. 2021).
- The operator can – unlike the shuttle itself – 'negotiate' with other road users and thereby prevent accidents (Ding, Discenna, and Guerra 2019; Mouratidis and Cobeña Serrano 2021).
- Multiple studies stressed the need for more research on interaction and negotiation between humans and driverless vehicles (Rehrl and Zankl 2018; Crayton and Meier 2017; Fraedrich, Beiker, and Lenz 2015; Yeo and Lin 2020b).

THE SHUTTLE ON THE TEST ROUTE (24.10.2020)

8. DISCUSSION OF THE RESULTS AND PERSPECTIVES

To put the experiences from the Smartbus project in the context of Aalborg Municipality's three concrete goals for the project – i.e. better mobility for vulnerable groups, accentuating Astrupstien as a central urban space and supporting positive stories about the district – it is necessary to discuss these experiences both within the framework of the specific project and in relation to aspects that the experiment does not fully illuminate. This chapter discusses what the findings mean for assessing the future potential for driverless public transport in both the Danish and international contexts.

8.1 DISCUSSION OF THE RESULTS AND PERSPECTIVES

As outlined in the introduction, Aalborg Municipality's original vision for the trial was defined by three objectives in particular:

- To mobilize citizens and users internally in the suburb as well as between the suburb and the rest of Aalborg;
- To develop Astrupstien as an important urban space in the structure of the suburb;
- To "put Aalborg East on the map" in a positive way by making the district a centre for testing innovative technology.

The previous chapters have described the many different elements and effects of the project based on the observations, testimonies and attitudes that we collected before, during and after the shuttles ran on the test route. In this chapter, the experiences are discussed in relation to Aalborg Municipality's concrete goals for the project to illuminate what the experiences can mean for the future potential for driverless shuttle operation in interaction with soft road users in the Danish and international contexts.

LIMITATIONS OF THE SMARTBUS TRIAL AND AAU'S STUDY

As is characteristic of all experiments, this test was designed with some artificial constraints that would not have been in place if, for example, a conventional bus had been put into operation. There is nothing strange or problematic about this, but these constraints constitute limitations that have an impact on the analysis and on what we can conclude based on the experiences.

Three aspects of the test's design in particular have been important: the truncation of the test route to the south at Tornhøj; the complex course of the northbound route and the shuttle's stopping at all stops; and the significant role of the operators as social actors in an operation which in its final form is expected to be unstaffed. Added to this was the Covid-19 pandemic, which continuously changed the conditions governing how and when the shuttles were in operation and everyday life more generally among the users for whom the experiment was intended.

These significant factors have formed the background for the experiences described in the previous chapters. In this chapter, we discuss the significance of the limitations for the experiences gained in the experiment and explain what the opportunities and central points that we find in these experiences – despite the limitations – support in relation to future projects in and outside Aalborg East.

INTERNAL AND EXTERNAL MOBILITY

The trial cannot reasonably either confirm or deny that shuttles on Astrupstien can improve internal and external mobility. This is because – even though we found that few users had found their way onto the driverless shuttles during the test period – we identified a number of circumstances that, both together and individually, may be the reasons why the shuttles were not more widely used.

The first circumstance concerns the shorter course of the test route compared to the envisioned route. It turned out in conversations with users of the path that many felt that the route was too short for it to really make sense to wait for the bus. The functions and destinations that the shuttle route connected were perceived by most pedestrians as being within walking distance. Those currently using the path on foot found it predominantly unappealing to replace the walk with a ride in a driverless shuttle, which runs relatively slowly and has many stops. However, there was an exception for days with bad weather and for people carrying heavy loads. In that light, it seems understandable and reasonable that the users suggested that a route connecting Jerupstien in the north to the university campus and Føtex further south would represent a more relevant boost to the mobility offer for these and other path users.

Another circumstance that must be considered to have had a limiting effect on the use of the shuttle as a means of transport was the lockdowns and reduced capacity as a result of the Covid-19 pandemic. A supporting argument for testing the shuttle for the relatively long period of two years was that the use of the shuttle would require new habits and changed mobility behaviour in relation to the practices that the residents had already built up. This would require both knowledge on the part of potential users that the shuttle was running and the arising of suitable occasions to test and routinize the new way of getting around. This importance of time and regular operation was reinforced by the fact that the target group by definition consists of people who do not get around much in the first place. It is likely that there is a large overlap between people referred to in the report as the 'walking impaired' or 'mobility challenged' and the group of citizens who, especially at the start of the pandemic in 2020, were advised to limit their social contacts due to the risk of serious illness from infection with the new coronavirus. It is, therefore, likely that this target group further limited their outward-directed activities compared to the background situation that existed before the pandemic.

The operators pointed out that this target group had little by little begun to try the shuttles when the increased incidence of infection in late summer 2021 brought renewed restrictions. The empirical basis in the data material does not justify the claim that these users would have used the driverless shuttles in greater numbers had the circumstances been more favourable, but at the same time it would be wrong to use the small number of utility passengers as a fair measure of the need among this target group or of the relevance of the bus connection.

Based on experience with electric wheelchairs, it seems reasonable to conclude that the difficulty of getting on and off the shuttle deprives these users of some of the autonomy that the wheelchair itself provides. There is not much space in the shuttle, and special measures (including, but not limited to, a ramp) are needed for them to get on board. Overall, it is therefore our assessment that only a small number of electric wheelchair users would benefit from the driverless shuttles in their current form and over such a relatively short distance.

To answer whether an automated bus service can improve mobility and autonomy for mobility-challenged citizens in the district, it would, in our view, make sense to revisit the arguments behind the originally envisioned route and possibly carry out an analysis of mobility-challenged residents' needs and transport patterns in light of the recently completed Smartbus trial.

ASTRUPSTIEN AS 'MAIN STREET' AND URBAN SPACE

Especially on the southern part of the test route around Tornhøj and Trekanten, the transformation and expansion of Astrupstien have had a clear interaction with the formation of a much-used urban space, where the use of the path as a transport and traffic artery is supplemented with many types of functions and recreational activities – on, by and across the path.

In the use of this urban space, a strict division between living areas and traffic areas is not maintained, which means that the road users who travel on the path must keep an eye on the behaviour of other users to ensure that they do not collide. In the south, the path has the character of a 'shared space', which means that users share the public space with each other, without any group being dominant.

In the Danish Road Directorate's guidance for the design of shared spaces, it is recommended that traffic move at a maximum speed of 15–20 km/h, as experience from Sweden, among others, shows that the desired traffic behaviour, where road

users negotiate the right of way, is mostly seen at speeds of 20 km/h and below. The driverless shuttles in the trial can be said to fit well into the shared space concept, as they are programmed precisely to not assume the right of way in relation to light road users, and as their speed matches the speed that has been empirically found to support well-functioning shared spaces.

The informants in the Smartbus trial experienced the shuttles as too slow to be practical. This is explained by the low average speed, which is due, among other things, to the fact that the shuttles routinely stopped at all stops and that many delays occurred when the shuttles had to cross the path at stops in the northbound direction. There is potential to achieve a higher average speed by stopping only as needed and by creating stops on both sides of the path.

North of Trekanten, the path is laid out more conventionally with a pavement and an asphalt lane for shuttles and bicycles. However, many pedestrians and runners also use the asphalt part of the path. Experiences with shared spaces show that the elderly and children can have particular difficulty finding their way around the more complex traffic situation that characterizes a shared space. Since the path on the northern part of the test route has fewer crossing traffic flows, which lowers the speed and supports the negotiated use of the area, it seems a good choice that there is pavement on this part of the route, which functions as a 'safe space', i.e. an area dedicated to pedestrians. This does not have the effect of limiting the mixed use of the asphalt surface as it has helped to give Astrupstien its character of "traffic freedom", as one informant put it and as many others confirmed in word and deed.

POSITIVE PUBLICITY AND PERSPECTIVES FOR FUTURE DRIVERLESS SHUTTLE PROJECTS

The Smartbus project in Aalborg East constituted an innovative approach to new mobility technology by introducing the technology as part of an urban strategic vision rather than purely as a test of technological and traffic functionality. In this way, the Smartbus trial is in itself an innovative contribution.

The embedding of the test in the particular social and spatial geography of Aalborg East made it possible to examine the driverless shuttles and their use as these unfolded when the shuttles and pathway were used by people preoccupied with their ordinary tasks and not primarily interested in the technology itself. In that context, it is central to highlight what the informants themselves also pointed out – namely that the shuttles were not driverless. Many of the observations and testimonies we collected during the test were not about the effects of removing the human driver but almost paradoxically about the effects of adding accessible and familiar people who 'patrolled' the path. In the analysis of the data material, it is not empirically possible to put the operators outside of parentheses to deduce what an unstaffed driverless bus would mean for Astrupstien. We can state that the new space that the shuttles added to Astrupstien was to a large extent a socially regulated space that required a conscious effort on the part of the operators to establish.

If the hope was to establish an economically sustainable unstaffed bus service by eliminating the cost of a driver's salary, then the experiences from the project are not encouraging, as both the social and technical presence of an operator was absolutely crucial for user acceptance and the feasibility of the project as a whole. On the other hand, the project indicates 1) that Astrupstien can accommodate a slow-moving vehicle that, in terms of right-of-way, is on an equal footing with other path users; 2) that the active presence of the shuttles and operators on Astrupstien promoted the experience of safety for many people; and 3) that the mobility-promoting potentials were not fully developed in the project due to the short test route. These experiences warrant continued curiosity and could possibly give rise to the desire to investigate whether a community approach to driverless technology can be further developed.

For example, equal access, social work and safety in the public space can be combined in a new formula, in a collaborative project where local actors, such as companies, leisure facilities, transport companies, housing associations and care homes, come together to establish a local citizen-oriented driverless service bus.

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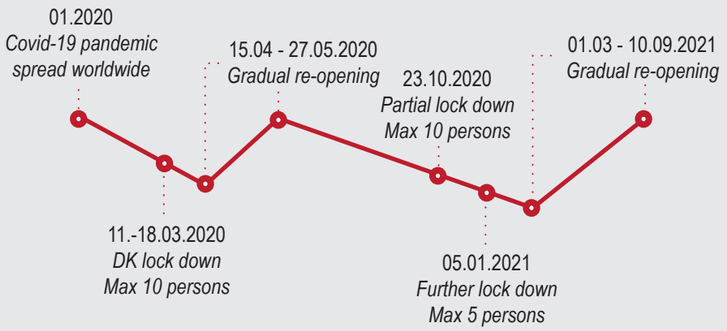
APPENDIX: THE INTERCONNECTED TIMELINES OF THE PROJECT

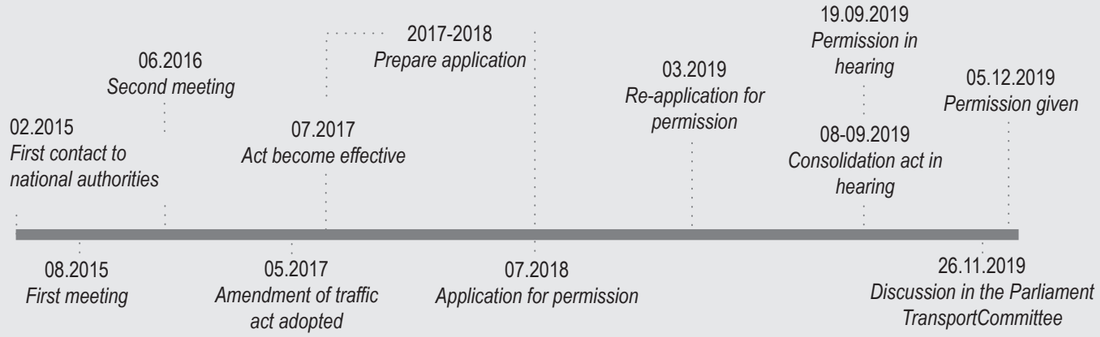
COVID-19 RESTRICTIONS

Actors: Danish Government



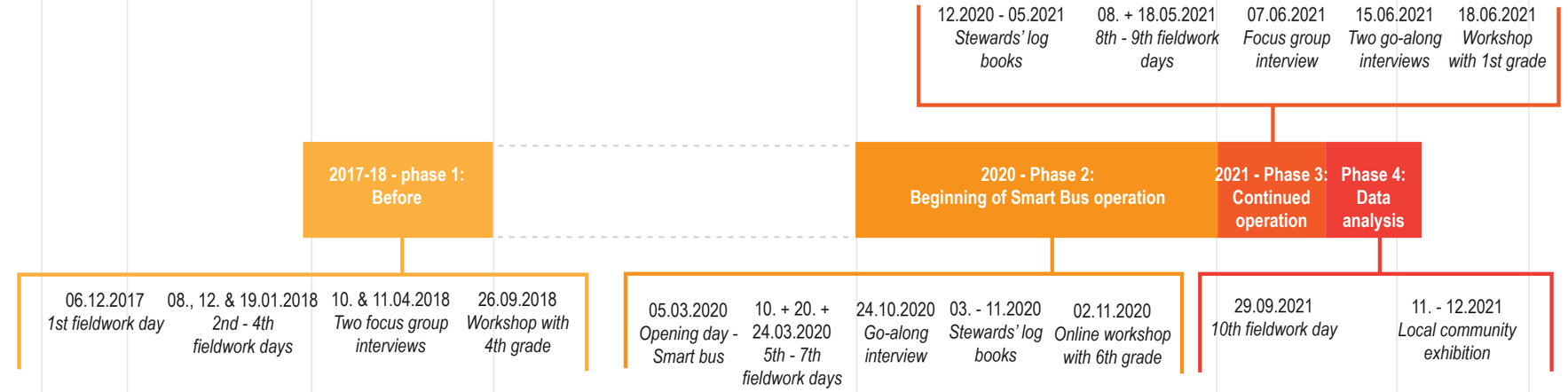
REGULATIONS, PERMISSION

Actors: City of Aalborg, Danish Road Directorate & Danish Parliament Transport Committee



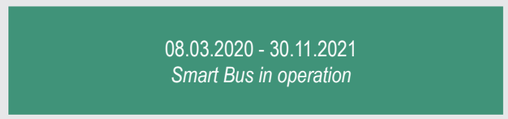
AAU'S QUALITATIVE ANALYSIS

Actor: Aalborg University (AAU)



SMART BUS

Actors: Holo, City of Aalborg, citizens, users



URBAN DEVELOPMENT AND TRANSFORMATION

Actors: housing organisations, City of Aalborg, others



A QUALITATIVE STUDY OF A TRIAL WITH DRIVERLESS SHUTTLES IN AALBORG EAST

MEETING OF CITY, PEOPLE AND TECHNOLOGY