PUBLIC TRANSPORT FOR SUSTAINABLE CITIES AND REGIONS

Insights from Ten Years of Research

Editors: Helena Svensson and John Hultén

K2 is the Swedish National Centre for research and education on public transport. Here, academia, public sector organisations and the business community come together to discuss and develop the role of public transport in Sweden.

We conduct research on how public transport can contribute to attractive and sustainable cities and regions of the future. We train public transport professionals and disseminate knowledge to decision-makers so that the debate on public transport is conducted on a scientific basis.

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On our website www.k2centrum.se/en/, you can access further publications from K2.

Public Transport for Sustainable Cities and Regions

Insights from Ten Years of Research

This book has been produced within K2, the National Knowledge Centre for Public Transport.

The conclusions and recommendations expressed in this book are those of the authors and do not necessarily reflect the views of K2.

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Foreword

This book brings together some of the research contributed by K2, The National Knowledge Centre for Public Transport, over the years. It has been more than ten years since K2 began researching how public transport can contribute to sustainable cities and regions. What do we know now that we did not know ten years ago?

Society today faces major challenges that require us to transition to more sustainable ways of living. Public transport has an obvious role to play and can contribute to this transition in various ways. More than ten years of research about public transport has taught us a great deal about how this can be achieved, what the challenges are and how this transition can be done in an equitable way.

This book includes texts about how people's travelling has changed and how public transport management has developed over the years, how public transport can be planned to become a more efficient system and how new technology can contribute, but also how inequalities can arise and be addressed. In addition, the book describes how K2 has worked to contribute to the development of public transport and public transport research. The individual authors have contributed with texts within their respective fields of expertise, which means that the chapters of the book have a varied tone with different approaches and focuses.

A big thank you to all the authors who have contributed with text to this book. A special thank you also to all the researchers who have developed research at K2 over the past ten years. It is all the data, analyses, discussions and conclusions gathered from you that have made this book possible. Many thanks also to Ebba Wihlborg, Emma Strömblad, Martin Larsson and Helene Lidestam for their work in bringing the book together, and to John Hultén for his holistic view and suggestions on which areas should be included in the book. Finally, a big thank you to K2's financiers and all the professionals in the public transport sector who, through their contributions in conversations and meetings, have enriched the research at K2 over the past ten years.

K2 continues to research and learn more about public transport and collective mobility. We know that there is great interest and that there are many who are eager to collaborate, contribute, discuss and acquire new knowledge about collective mobility in the future.

*Helena Svensso*n, Director at K2

Lund, March 2026

1 The story of K2

John Hultén & Helena Svensson

K2 – The Swedish Knowledge Centre for Public Transport was established in 2013 following studies and discussions between government agencies, regions and the academic community. It was and remains a unique endeavour, with no clear equivalent in other countries. Why was such a centre created, and what circumstances have influenced the direction it is taking?

A formative stage for public transport

In the early 2000s, Swedish public transport experienced positive momentum. A new sustainability agenda was emerging, focusing on the adverse environmental impact of cars. Somewhat pointedly, it could be said that public transport made the switch from a low-status marker to a solution for the future. Studies were then launched both nationally and regionally with a view to increasing travel by public transport [1] [2]. This led to ambitious plans, new collaboration models between the State and the regions, and eventually to a new Swedish Public Transport Act, which emphasised the strategic role of public transport in a sustainable transition. Many perceived opportunities in this new spirit of the age. Commercial transport operators and public authorities joined forces in a joint initiative with a visionary goal – to double the number of trips made by public transport [3]. However, the State took on a more proactive role which included general sectoral responsibilities. Out of this mire emerged an insight into the need for more research and development in the field of public transport.

The sustainability agenda was also gaining ground in the world of research in the early 2000s. One of the many stakeholders pushing for this was VREF, the Volvo Research and Educational Foundations. But when they wanted to invest in a Swedish career programme for young researchers working with public transport, they found there was no environment that was good enough to invest in. Public transport research being conducted at universities of technology was regarded as

being too fragmented and insufficiently linked to practice. Instead, a letter was sent to three government agencies, Vinnova-Sweden's Innovation Agency, the Swedish Rail Administration and the Swedish Road Administration, asking them to review research into public transport. It gained traction. Before long, an inquiry was up and running to consider the formation of a centre of excellence for public transport.[1] The investigator's analysis was clear:

> ***Public transport is a long way behind other sectors. The tradition of engaging with research is essentially absent, to the detriment of both the research that does take place and the industry itself. Therefore, an initiative must aim to simultaneously elevate both research and the level of knowledge in the industry [4].***

The new Swedish Public Transport Act came into force in 2012. New Regional Public Transport Authorities were set up all over Sweden, with a changed, more strategic mandate. The pioneering spirit that prevailed resulted in the definition of the outlines of a centre of excellence that later went on to be K2. The government agencies were prepared to invest, but only if the regional public transport authorities were on board. The question was asked of the three metropolitan regions, because it was in these metropolitan areas that the challenges and potential for public transport were deemed to be greatest. The three regions jumped on board. Together, they came up with themes that they wanted the new centre to focus on. When the Region Västra Götaland had made a decision, they issued a press release on the new initiative:

> ***Regional expansion, increased accessibility and attractiveness, greater focus on passengers, structural changes in the organisation of public transport and a new Public Transport Act from 1 January 2012 place new and complex demands on the various stakeholders in the public transport system. The Public Transport Centre, the location of which has yet to be decided, will provide a hub for Swedish public transport research and projects going forward. […] The centre will start off with five knowledge fields/areas based on the knowledge perceived to be needed by of public transport partners. This includes focusing on the role of policy in***

1 The assignment was allocated to Måns Lönnroth, chairman of VREF at that time.

> ***increasing travel and market share, public transport in urban planning, the customer perspective and the ambition to increase market share, the roles for collaboration between operator and authority and the development of technology and services [5].***

Two issues remained unresolved. Who would run the centre, and where would it be based? A competition in which academies in metropolitan regions were invited to participate presented the solution. Three proposals were received, one centred on each metropolitan region. K2, the winning concept, was submitted by Lund University, Malmö University and the Swedish National Road and Transport Research Institute (VTI) with the support of the consultancy company Trivector as a driving force. According to people involved in the decision-making process, the winning proposal was not the one offering the greatest academic excellence. What was crucial, however, was having the best idea about how research could be conducted in collaboration between the academic community and practice. K2 began operating in January 2013 with a physical base in Lund.

A research agenda emerges

There was thus an explicit aim that the research should support the industry's ambitions for an increased market share for public transport, but issues relating to collaboration, urban planning and new technology were also identified as themes. When around 70 people gathered for a workshop, close to the Öresund Bridge in Malmö, their job was to identify clearer priorities for the future focus of K2. This resulted in five focus areas that later formed a basis for K2's first field of research.[2]

Governance of a market

One area was based on the changes to public services that had characterised Sweden (and many other countries) since the late 1980s, which had involved making the public sector more like the private sector. Result-oriented management, deregulation and privatisation were all part of the toolbox. It was in this spirit that competitive procurement of public transport services began, and a new market of commercial transport operators emerged. The design of contracts,

2 Decision made in 2016.

reimbursement models and requirements specifications became key elements of political governance, and hence important issues on which it was necessary to develop new knowledge.

Collaboration between levels

The changes in the organisation of society also resulted in increased specialisation, both vertically between national, regional and local levels, and horizontally between public and private sectors. Rail services are a clear example. The Swedish State Railways was gradually divided into a large number of private and public organisations, each with its own specific responsibilities. There were increased demands for collaboration in this more fragmented organisational environment. Collaboration was a key issue for public transport, which was reliant on both national infrastructure planning, regional public transport planning and municipal urban planning. That was why it became a key area in K2's emerging field of research.

Passengers and customers

The late 20th and early 21st centuries saw the development of new ideas about the relationship between public authorities and citizens. Passengers became customers and consumers. The final report in 2003 of a parliamentary committee on public transport stressed that 'All public transport measures should be based on a consumer perspective and should be evaluated on the basis of aspects such as the consumer benefits they entail'. Increased knowledge of passengers was key to the ambitions of getting people out of their cars and onto public transport. From the outset, passengers' attitudes and behaviour were an obvious theme within K2 as well.

The digital revolution

Digitalisation was another trend that had a profound impact on society in the first decades of the 21st century. This was expressed in many tangible ways when it came to public transport. Printed timetables were replaced by digital journey planners[3], while paper tickets were replaced by travel cards. JoJo, ToGo and Access became well-known brands in Sweden. Digital signage and social media brought new opportunities for communication with passengers. K2 took on a slightly different role from other, more technically focused research environments.

3 The first organisation to do this was Östgötatrafiken in 2012, while printed timetables continued to be offered in Stockholm until 2020 and by Västtrafik until 2022.

Instead of focusing on developing the technology, K2's role was to monitor and understand how digital technology was used, and its consequences.

The benefits of public transport

While the organisation of society and technology evolved, other things remained unchanged, such as the methods used for planning infrastructure. There was criticism in the industry of established forecasting models and socio-economic calculations that were thought to favour the continued expansion of car use. A common metaphor deployed was known as the iceberg. Only the top of the benefits created by public transport for society were regarded as being included in the models. Hence, there was a desire to develop new ways of highlighting benefits in planning processes at local, regional and national levels. Research was initiated within K2 to explore the benefits of public transport from a broader perspective.

In retrospect, it is possible to give rational explanations as to why certain issues ended up on K2's research agenda. However, we know that the direction decided upon can also be the result of chance and coincidence. Personal perspectives and interests, and the positions of power of various stakeholders, all have their part to play. The direction that characterised the emerging K2 in 2013–2014, and which influenced its direction for the next decade, was far from obvious. For instance, K2 did not focus on areas that dominated public transport research at the time, such as vehicle development, road safety or optimisation models for public transport planning. There was a clear demand for a different approach. Compared to other, often technically orientated research environments, K2 took a broader, more social science-based approach, although other perspectives were also present.

The importance of education and communication

Education has been an important part of K2's activities over the years. It was emphasised already in the application that education and dissemination of knowledge would form part of the centre. The two Ks in K2 stood for *Kompetens* (competence) and *Kunskap* (knowledge); and the organisation focused on not only producing knowledge but also disseminating it. In 2015, following a two-year start-up phase, K2 embarked upon a new phase with the development of a communication strategy. It was established at that time that K2 would be the national knowledge centre for public transport. Again, it was emphasised that it

would be not a research centre, but a knowledge centre. This has become part of K2's DNA over the years.

In the decade in which K2 has been fully operational, around twenty courses have been organised for professionals, involving some 350 participants. These courses have covered general knowledge in the field of public transport, innovation in public transport, high-capacity bus rapid transit (BRT), more general courses on how to plan for sustainable transport, and on Special Transport Service and other publicly funded journeys. Participants themselves have emphasised the fact that the courses have given them time to reflect and discuss, create new networks and, of course, gain useful new knowledge. For these reasons, K2 has opted primarily to organise face-to-face courses on site, usually in Lund.

One of the courses offered by K2 dates further back. Strategic Public Transport Planning, as the course is known, was established in the late 1990s at Lund University. The Strategic Public Transport Planning course has been run every year since K2 took it over. This course illustrates how the level of education in the sector has changed over the years. In the beginning almost 30 years ago, the majority of participants rarely had a university education. While today, most participants do have a university degree, although perhaps not always in subjects related closely to public transport. Another clear difference can be seen in the proportion of women taking the course. When the course began, it was almost exclusively attended by men. Women have been in the majority in recent years.

Local and regional politicians make up an important, but sometimes forgotten, group of people in great need of knowledge. Political committees make key decisions on the development of public transport. To help politicians better understand and deal with complex issues, K2 has conducted its one-day course on two occasions in cooperation with the Swedish Public Transport Association and the Swedish Association of Local Authorities and Regions (SALAR). Around 100 politicians from public transport committees or equivalent in 16 regions have attended courses on public transport.

There were courses on and about public transport even before K2, and even now courses are run by other stakeholders, but it appears that K2 is the organisation of choice for professionals when it comes to longer and broader training programmes. Regarding the two-week Strategic Public Transport Planning course, it is sometimes said in the industry that 'this is the course that anybody new to the industry should take'. People who have been working with public transport for a number of years also attend the course, and it is precisely this mix of participants with different experience and from different organisations that is its strength. The

importance of raising the educational level within the industry was also emphasised when the doubling goal was being developed.

There has been an ongoing discussion in society over the years about lifelong learning, which aligns perfectly with K2's ambition for education. Many aspects have worked well with K2's educational activities, but it has also become clear that determining the right content for new courses to make them appealing and encourage professionals to attend them presents a challenge. One important principle has been that K2 should provide courses that are aligned with the research conducted at K2. When a survey was conducted to identify a suitable course format, it was revealed that courses should ideally be short and preferably digital. Despite this, however, K2's two-week face-to-face course held in Lund every autumn is always booked up.

K2 realised early on just how important and necessary it was to communicate with the surrounding community. And here is another K, for *Kommunikation* – communication. A full-time communications officer was hired early on. K2's knowledge lunches are one example of how its communication activities have developed. Initially, a few researchers in-house met up for a sandwich and a presentation about a research project. These events came to be known as knowledge lunches and were pleasant and convivial. When the communications officer at the time grew tired of ordering baguettes and the pandemic struck, an entirely different type of knowledge lunch was developed – digital ones involving 40–50 participants, including both researchers and industry professionals. Having a full-time communications officer not only meant that information could be disseminated and knowledge could be transferred, but also that researchers could learn how to communicate with the surrounding community. Many of the researchers associated with K2 find that having opportunities to get their research results out to society and harmonise their research with the surrounding community are key elements of K2.

> Experience-based knowledge is extremely important, but it needs to be complemented by knowledge based on science. At the time (the year 2015), K2 was the single largest investment in public transport research in Sweden.

A new approach to research and practice

Experience-based knowledge has always had a place in public transport. Individuals within public transport authorities, transport operators and consultancies who have been involved for a long time have learned lessons and documented their conclusions in memoranda and reports. Experience-based knowledge is extremely important, but it needs to be complemented by knowledge based on science. At the time (the year 2015), K2 was the single largest investment in public transport research in Sweden.[4] Just like any other form of production, the production of academic knowledge requires organisation, resources, equipment and, above all, people with the right expertise. Views on the role of research and how research should be organised have altered over time. K2 emerged at a time and in a context where the traditional view of research had been challenged for some time [6].

The traditional view was based on the notion of research as a matter of public interest that should be disengaged from the business community and other societal institutions. Research organisations were supposed to judge for themselves the relevance of what they were doing with a view to publishing independent knowledge. This knowledge was then expected to be picked up by the business community and society in ways that helped to bring about positive development. Public transport research, working on the basis of this notion, had primarily developed within the departments of transport planning at universities of technology, but also as a subdiscipline within economics.

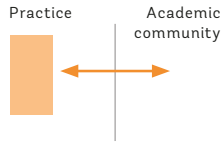
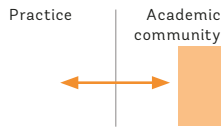
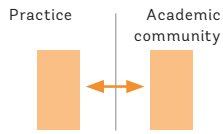
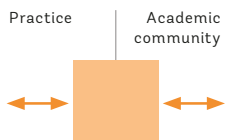
An alternative approach to the role of research in society emerged from the 1980s onwards. In the context of globalisation, greater emphasis on national competitiveness and a fear of falling behind, it was questioned whether university research automatically contributed to development. New approaches took hold that emphasised the importance of research involving collaboration between the academic community and practice where collective environments for joint learning became central. This approach has formed a basis for initiatives in network-oriented innovation environments of various kinds. In Sweden, Vinnova (Sweden's Innovation Agency) has played a driving role. The model for centres of excellence that was developed by the agency in the early 2000s set the tone for K2 as well.

The feasibility study that led to the creation of K2 recognised that the industry would participate in the development of research questions, the implementation of

4 In the early 2000s, the government research programme ‘Framtidens personresor’ [The future of passenger travel] took place and Karlstad University had its Samot Research Centre.

the research and the dissemination of the results. Co-production became the concept that summed up K2's ambitions. In the early years, there was a strong ambition to involve practitioners as much as possible. This was expressed in several ways. People from municipalities, regions and enterprises formed part of the project teams that were set up. A living lab involving stakeholders was implemented around the development of public transport around a specific location. Activities were implemented where researchers and practitioners met to discuss the state of knowledge in various fields.

There are of course many different ways to organise collaboration within the framework of a research centre. The table below highlights four main variants [7] [8]. They differ in terms of who directs the focus and who constitutes the primary target audience for the results.

Collaboration typ	Process and output	Illustration
Focused on assign-ment	Practice sets the agenda and controls what research is to be carried out, either by formulating specific assignments or by making decisions on allocation of project funding. The industry's own perceptions of challenges and problems are in focus. The results are published in the form of reports.	
Research-led	The logic of the research dominates. Major empha-sis on academic publishing. Practice plays the role of passive funding body which monitors the work without actively controlling it, with expectations that the research will gradually benefit the industry.	
Long-distance relationship	The academic community and practice share responsibility for the direction of the research. However, daily work takes place along different paths, and researchers and practicians meet sporadically. Separate publication strategies for the academic community and practic	
Symbiosis	The academic community and practice co-produce in respect of both knowledge development and application on a common path. Researchers and practicians form part of the same project team and work closely together. The results are published in collective academic articles	

K2 was founded with the notion of a symbiotic relationship between research and practice, but in reality it has usually resembled a long-distance relationship. However, although the long-distance relationship is the dominant image, there are many examples of instances in which researchers and practitioners worked closely together. One such example involves the development of BRT (Bus Rapid Transit)

in Sweden, where researchers at K2 and industry stakeholders jointly developed guidelines and planning tools for a new generation of bus solutions. Another is the on-demand public transport policy lab, where K2, together with regions and transport operators, is creating shared learning from ongoing pilots. A third is 'Rådslaget', a K2 initiative for the renewal of public transport and a change towards collective mobility. This work was ongoing for over a year and involved 80 or so leading experts in public transport, other shared mobility services, urban planning and research. This resulted in an innovation agenda for the Future of Collective Mobility, which also helped to bring about a new strategic innovation programme for the built environment and mobility. These examples illustrate the role that K2 has come to play in the field of innovation. Rather than being a stakeholder that develops and manages its own products or services, K2 has brought together stakeholders for joint learning, reflection and development of ideas.

In retrospect – what have we learned

K2 emerged out of challenges and ideas that were prominent in society, research and public transport at the beginning of the last decade. These remain fundamentally relevant, but changes have also taken place over the last 10 to 15 years. New technologies have emerged, meaning that we now have electric bicycles, cars and buses; sharing services that were mostly just futuristic ideas a decade ago are now common features in our cities; new apps, social media and payment systems are increasingly shaping our daily lives. New ideas about how best to organise and govern society have emerged as a reaction to the focus in the late 20th and early 21st centuries on privatisation, deregulation and specialisation. Old but renewed issues relating to social exclusion, urban and rural issues and participation of citizens have gained greater prominence on the agenda. We have experienced a pandemic that has altered travel habits and increased remote working. K2 has kept pace with these changes and contributed with research to increase the understanding of what is happening.

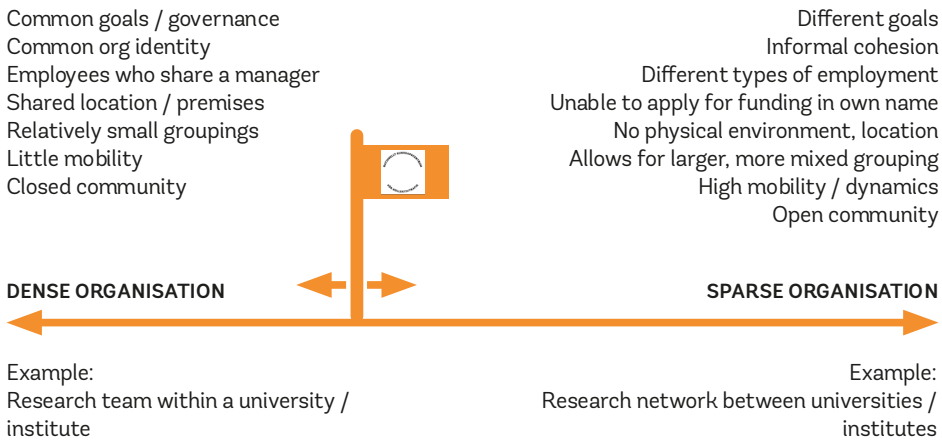
If an organisation like K2 is to make a difference, an idea is needed that has both potential and support; but that is not enough. It also requires work to ensure that this potential is realised. That work has been shaped on the basis of the added value that we have seen K2 is capable of contributing with; values that do not naturally emerge within existing universities, research institutes or the industry's own organisations. In the case of K2, this involves three things.

Firstly, it has involved creating a platform for collaboration between researchers from different organisations and disciplines. Researchers who are active within K2 often refer to this as a success factor. It may seem obvious but encounters across organisational and disciplinary boundaries are conspicuous by their absence in modern research; at least at a more systematic level. Establishing connections and building relationships between researchers and people working with public transport issues in practice is even more difficult. Differences in temporal perspectives, experiences and frames of reference mean that such collaboration is easier to discuss in theory than to achieve in practice. It requires resources and commitment from both 'sides', and it requires an organisation that is determined to make it happen. K2 has facilitated such collaboration.

The second added value has involved tackling issues of strategic importance. Both researchers and practitioners need to help shape that direction in some way. At K2, this has been achieved through the field of research described earlier in this chapter, which has undergone continuous development over the years. However, having a field of research is not enough: it is also necessary to have the resources to translate it into new knowledge. In short, funding is essential. Without funding, K2 would have been unable to take on researchers with the time to familiarise themselves with new questions, conduct interviews, gather data, perform analyses, write, discuss, workshop and carry out all the other activities that form part of a research project. Having the funding to conduct research is an essential part of the appeal that makes a research environment an attractive place to work. However, it has been important for K2 to present itself not as a research funding body, but rather as a research environment in which researchers can collaborate and contribute. K2 has not distributed funding for research like a funding agency but has invited researchers to collaborate and contribute to the research agenda and received funding for that work.

The third added value has involved contributing to skills development. And as indicated in this chapter, skills development can take a number of forms, from traditional academic education to courses for professionals and more continuous knowledge updates by means of initiatives such as knowledge lunches. Working with one format will not suffice: several are needed. It is not enough for a knowledge centre just to produce new knowledge: that is only half the job. It is every bit as important to ensure that the knowledge is applied in ways that might lead to new approaches, working methods, solutions. For this to happen, there needs to be continuous dialogue between the people leading and working within a research environment and the people who represent target audiences for that

knowledge. It is necessary to keep an ear to the ground in order to understand and respond to current knowledge needs.



Besides focusing on added value, a knowledge centre needs to be organised in ways that allow that potential added value to be realised. Research and education can be organised in many different ways, as illustrated in the figure above [9]. These range from loosely connected network organisations (sparse organisation) based on voluntary and often informal structures, to organisational forms based on formal structures and a common legal entity (dense organisation). K2 has positioned itself between these extremes right from the start. This position can be flexible and allows for openness and flexibility, but it requires a constant supply of energy in the form of activities that bring people together and make them communicate.

The physical location has been a key element in K2's organisation. The office – which was initially located at the outskirts of Lund and later (2018) moved to an area very close to the central station– has served as a place for both spontaneous and scheduled meetings. In a way, the physical location embodies the organisation. K2 has never been a separate legal entity, and the office has helped the organisation to establish its own independent identity with its own brand. K2 has provided a home for researchers alongside and as a complement to their home department or institute. K2 with its office has provided opportunities for meetings between researchers and between research and practice, and discussions that are multidisciplinary in nature. The fact that partners and funding bodies are willing to carry on into a new phase from 2025 onwards is the best testament to the value created by K2.

Swedish public transport has undergone positive development in recent decades, but it needs to play more of a role if Sweden and the rest of the world are to make a successful transition to a climate-neutral and sustainable transport system. Public transport needs academically-based knowledge development to help it navigate a complex world with new perspectives on what public transport is and can be, and to further understand how it can pave the way for people's access to work, education, leisure, commerce and social contacts in the sustainable society of the future.

K2's role and importance for the public transport authority in Region Västra Götaland

During the investigation aimed at developing a proposal for a new law for organisation of public transport in Sweden, in the beginning of 2000, a broader discussion in the industry about challenges, problems and opportunities for developing public transport in Sweden arose. There was a desire to change. But how? One of several conclusions identified was that we had a weakly developed research-based foundation to stand on in Sweden. Research existed but was fragmented, scattered and was rarely used as support for the development of the industry. An extensive and broad dialogue process was initiated to define the basis for a new research centre for public transport. Due to the high level of participation from both industry and research organisations in the process of the centre's formation, there was a relatively good connection between the two from the very start. The Region Västra Götaland, as a new public transport authority from 2012, with Västtrafik as the public transport company, was involved from the start.

K2 has contributed to our organization through mutual exchange and learning, as well as increased understanding of research and its importance for development. K2 has also contributed to supporting the development of skills within the organization. Partly through the basic training that has been recurring almost since K2 was formed, but also with training developed from needs from the authority, for example regarding BRT (bus rapid transit) and innovation. Of course, there is much left to do to further strengthen and develop research and much left to do to continue developing public transport and other sustainable mobility services. This requires deep knowledge and understanding of as well the history as what is happening now and what might come in the future. K2's strong connection between practice and research, while the research has a sufficiently independent position, is a difficult but important balancing act to continue upon.

Ulrika Bokeberg

Public Transport Director for the Västra Götaland Region at the formation of K2

2 Public transport governance – a historical perspective on everlasting goal-conflicts

Jens Portinson Hylander

Public transport has influenced people's movement patterns and the development of society for as long as it has existed. Before the widespread adoption of the car, public transport was the main organised mode of transport for people; and as sustainability issues and congestion problems have come to the fore in the political arena, public transport has once again taken on an important role in transport policy and planning.

K2's research focuses primarily on contemporary and future challenges and opportunities; but to view this research in a broader context, this chapter provides a historical overview of how responsibility for and planning of local and regional public transport in Sweden has evolved. Two basic conflicting goals in public transport governance and planning are presented, followed by a brief historical review with emphasis on public transport legislation from the 1970s onwards. The chapter concludes with reflections on what a historical perspective can bring to our understanding of the contemporary and future challenges for public transport governance.

Conflicting goals in public transport governance

In slightly simplified terms, the political and planning-related criteria for public transport can be understood as a tension between two different conflicting goals that are inherent in the nature of public transport.

The first conflicting goal is the tension between *efficiency* and *equitable accessibility* in the public transport system. This relates to how the planning and

provision of public transport should balance requirements for both different forms of efficiency (economic or climate-related) and that public transport offerings make travel accessible to people who live outside the most densely populated areas. Transport researcher Jarret Walker has referred to this contradiction as the need for public transport systems to balance ambitions to promote high patronage on the one hand, and geographical coverage on the other [1].

The second conflicting goal concerns the relationship between *competition* and *coordination* in the governance of public transport. Here, competition refers to the way in which ideals of competition, both between different modes of transport and between different operators working with the same mode, have influenced the governance of public transport. Coordination refers to the way in which regulations, policies and practices are designed to increase collaboration between different stakeholders and public transport operators.

Representing ideal types, it is thus possible to imagine different public transport systems representing the extremes of these conflicting goals: see Figure 1. That is to say, a system defined by maximised cost-effectiveness and full competition, another characterised by full focus on high geographical accessibility and total coordination, a third with maximised cost-effectiveness and full coordination, and finally one with maximised geographical accessibility and completely free competition. However, the fourth option appears to be too contradictory to be a genuine alternative, as free competition and services in different geographical locations rarely go together; the deregulated system in the United Kingdom is evidence of this [2]. In reality, none of these ideal types exist and few, if any, public transport systems have been at the extremes of these scales. However, various legislative changes, policies and practices can pull the system in different directions on the basis of these dimensions, and the relationships between the conceptual pairs have been key to and recurrent in policy discussions about public transport.

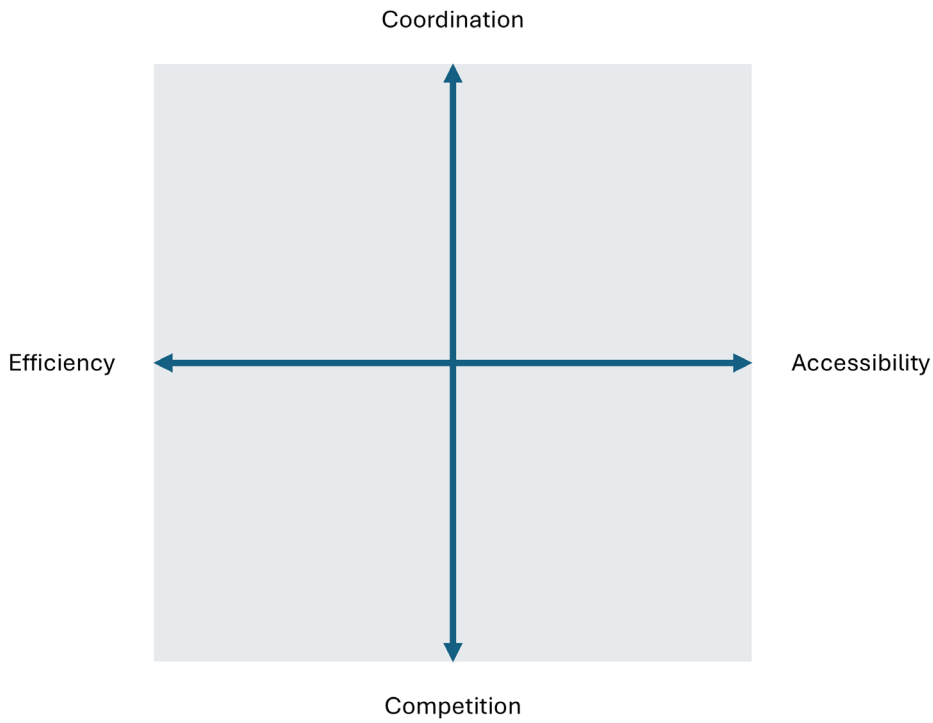


Figure 1. Schematic illustration of ideal type relationships between fundamental conflicting goals of public transport, coordination versus competition and efficiency versus equitable accessibility.

Public transport before transport policy

Public transport in Sweden as we know it today emerged in the second half of the 19th century. Railways were built between cities, revolutionising the geographical evolution of society. The State initiated the construction of trunk lines between the biggest cities, and the first section was opened in 1856. The construction of local tracks was left to private consortia, often consisting of both municipalities and business owners. Omnibuses were introduced to cities in the 1840s, initially pulled by horses on cobblestone streets, but later on rails, and gradually the horses were replaced, first by steam engines, then by electrical traction. Also in cities public transport was initially largely driven by private capital, but the electrification of trams required greater coordination of energy production, technical infrastructure and street space, which led to the formation of municipal transport companies around the turn of the last century. In this, we can see an early aspect of a

coordinated public transport system, driven by technological shifts in the transport and energy system.

The first few decades of the 20th century also saw the development of bus routes, which initially were uncompetitive, but gained momentum after the end of the First World War. Route concessions were introduced to reduce competition and create coordination, which gave one bus operator exclusive rights to provide public transport along specific routes [3]. Bus routes were often more attractive to passengers than railways, which were adapted for industrial purposes, contributing to profitability challenges for rail services. The railway network was nationalised in the 1940s in response to falling profits on private railways and to achieve economies of scale. This meant that over time, Statens Järnvägar (SJ, Swedish State Railways) developed a monopoly on both infrastructure and the operation of rail services in Sweden. In parallel with the monopoly, restrictions were also imposed on route concessions for bus services that were regarded as being capable of competing with railways. However, the nationalisation of the railways was not something that was specifically sought, and the State has been described by political scientist Björn Hasselgren as 'the reluctant infrastructure manager' [4]. Following nationalisation, there was extensive rationalisation of the rail network: about a quarter of the rail network was closed and major elements of regional public transport were transferred from rail to bus between 1950 and 1972 [5].

Introduction of a public transport policy

Although bus services gained ground at the expense of trains, they were quickly challenged by a rapidly growing phenomenon: private cars. With increasing prosperity and active policies promoting car use, travel by bus declined rapidly in the post-war period; and 1961 saw the introduction of the first government subsidies for operating road-based public transport in rural areas.

The first transport policy decision

The first **transport policy decision** in Sweden represented an important institutional change for both public transport and the transport system in general. The need for a cohesive transport policy had been the subject of much debate since the 1940s, but it was not until 1963 that a proposal was presented to Parliament [6]. The transport policy decision, which has since been updated in 1979, 1988, 1997 and 2008, constitutes the central framework for the long-term development of the Swedish transport system and includes comprehensive principles for

conducting transport policy, which aim to help achieve the transport policy goals. The first transport policy goal was to: '*to ensure a satisfactory supply of transport at the lowest possible cost and under conditions that permit business efficiency and sound development of the transport system*' [7, p. 18]. Some were of the opinion that transport in Sweden was too heavily regulated and that, essentially, attempts should be made to bring about effective competition whereby all modes of transport were priced so that socio-economic costs were covered by journeys. The ideal, therefore, was to implement a transport policy that emphasised efficiency and free competition. However, policymakers realised that '*the need for profitability must in some instances give way to other social considerations. Therefore, there can be no equivalence between a profitable transport supply and a satisfactory transport supply*' [7, p. 20]. As can be seen from the citations above, the conflicting goals of efficiency/equitable accessibility and competition/coordination were codified in Swedish transport policy right from the outset and have persisted ever since, with varying emphasis on the various aspects.

Formation of public transport authorities

Several processes contributed to public transport facing significant challenges in the post-war period. The car-oriented infrastructure policy, increased car ownership, the transport policy decision (which in practice resulted in substantial benefits for private car use, for which it was difficult to calculate and internalise all costs), SJ's closure of passenger rail services, and the poor coordination of public transport, collectively eroded the public transport system. Declining bus company revenues at this time led municipalities to increasingly take over and municipalise bus services in and between cities [8].

The 1970s saw a partial reversal of the trend. Increasing congestion in cities and the first oil crisis in 1973 brought public transport back into the political debate. In the 1970s, the criteria for organising public transport were reviewed on a number of occasions in order to address the increase in public transport fares and the poorly coordinated and displaced public transport system [9] [10] [11]. A key issue related to the introduction of regional season tickets for journeys on public transport within each county, which some local federations and county councils had launched on their own initiative. The study concluded that coordinated governance of public transport was also needed in order to introduce county season tickets for public transport. The review therefore recommended the introduction of county public transport authorities, which led to what was known as the **public transport authority reform**, adopted in 1978 [12]. Under the public transport authority reform, each county was to establish a public transport

authority to take over responsibility for local and regional road-based public transport from 1981.[5] Responsibility was to be shared between municipalities and county councils in all counties except for Stockholm and Gotland.[6] Responsibility for rail services remained with SJ. However, state subsidies for unprofitable regional public transport were greatly increased in order to reduce costs for individual passengers, while municipalities increasingly subsidised urban services. Alongside the establishment of public transport authorities, a new transport policy decision was passed in 1979 which represented a shift away from a transport policy based on free competition towards one that focused instead on planning and socio-economic perspectives [13].

Public transport governance following the public transport authority reform

The public transport authority reform had the desired effect in many respects. Regional season tickets were introduced in the counties, and travel by public transport increased sharply in the late 1970s and early 1980s. However, new problems emerged. The route concessions granted to the transport companies meant that the new public transport authorities were not free to plan services as they saw fit, and subsidies for public transport grew faster than passenger numbers, which made services more and more expensive for public authorities. Furthermore, petrol prices fell sharply from 1982, prompting more people to choose cars over public transport while urban planning encouraged the dispersal of housing, which failed to encourage provision of cost-effective public transport.

Coordination and procurement

The Social Democratic government that took office after the 1982 elections was also keen to reduce government expenditure [14] and introduced a number of reforms that were intended to lower the State's cost burden for public transport.

5 Västra Götaland, Halland and Bohuslän were given until 1983 to form public transport authorities on account of extensive cross-county commuting, which created a complex division of responsibilities for services.

6 Stockholm and Gotland were exempt from this rule. In Stockholm, responsibility for public transport had already been transferred to the county council in 1967 through the Hörjel Agreement, in conjunction with the expansion of the Stockholm metro. As the municipality of Gotland is the only political level on the island, there is no county council with which it can share responsibility.

Responsibility for passenger rail services outside the main railway routes was gradually transferred to the public transport authorities, while state funding for unprofitable regional public transport was phased out. Both reforms meant that public transport authorities bore greater responsibility and took on greater economic burdens for public transport. A decision was also made in 1985 to abolish route concessions, which were deemed to inhibit transport system efficiency [15]. This meant that from 1989, all previously existing route concessions were removed, and public transport authorities were given full rights (and responsibility) to plan routes. Concerns were raised about the risk of public transport authorities becoming monopolistic providers of transport services, but what actually happened was that in many cases municipal transport companies were sold to private owners and transport services were put out to tender instead, in line with the new public management philosophy of the 1990s. Initially, the combination of procurement procedures and increased ability to plan transport services in cost-effective ways by cutting down on unprofitable routes led to major cost reductions of between 15 and 25 per cent; and twelve years after the law came into force, 98 per cent of local and regional public transport services were subject to procurement procedures [16]. However, costs began to rise again at the turn of the millennium and have continued to increase ever since. The most significant cause of these cost increases has been identified as the cost of providing services during peak hours, but quality, accessibility and sustainability requirements in respect of vehicles also have an impact [17].

Focus on accessibility

A new amendment to the Swedish Public Transport Act was implemented in 1997 [18]. This time, two aspects were in focus: increasing accessibility and clarifying responsibilities for public transport. Increasing accessibility involved making public transport more accessible to people with disabilities by imposing higher standards for accessibility of vehicles and stops. It was also hoped that this requirement would rationalise transport services by facilitating coordination of regular scheduled public transport and special passenger transport, thereby reducing the need for expensive special transport services, the cost of which had risen sharply. Coordination was made possible by allowing municipalities (which have statutory responsibility for special transport services) to transfer responsibility for special passenger transport services to public transport authorities.

Clarified responsibility for public transport involved providing clarity on who held ultimate political responsibility for local and regional public transport. As the

public transport authorities were almost exclusively configured as transport companies owned by municipal associations, they were managed at a certain distance from the municipal and regional assemblies [19]. To clarify the responsibilities of municipalities and county councils, they were designated as 'county transport managers', which was not the same as the operational and planning responsibilities of the public transport authorities.

The new Public Transport Act

Swedish public transport was facing a shift in the early part of the 21st century. On the one hand, the initial economic gains from procurement procedures had begun to slow and costs were rising once more. On the other hand, public transport had taken on a new central position in discourses on sustainable development and climate change. A comprehensive study on public transport was presented in 2003 [20]. As the title of the report – *Kollektivtrafik med människan i centrum* [Public transport focusing on people] – suggests, the lack of a distinct passenger perspective was viewed as a key challenge for the development of public transport. The investigators were of the opinion that public transport needed to become more attractive in order to both retain existing passengers and persuade car users to use public transport. These insights were carried forward into the vision for the development of public transport formulated in 2007, which has come to be known as **the doubling goal**, which aimed to double travel by public transport by 2020 [21]. For at least a decade, this vision was the guiding principle for a broad collective of stakeholders governing, planning and providing public transport services.

In parallel with the presentation of the doubling goal, the government started work on updating the Swedish Public Transport Act [22]. The motivation for a new public transport regime was to align Swedish public transport legislation with the EU's regulatory framework, to increase the opportunities for regionalised and cross-county public transport, to clarify the political governance of public transport, and to increase competition and the attractiveness in the public transport market.

The alignment with the EU's regulatory framework involved clarifying concepts such as public service obligations and the introduction of what are known as **Regional Public Transport Authorities (RPTAs)**. As stated previously, the legislation in force at that time resulted in a division between public transport authorities (laid down in law in 1978) and county transport managers (laid down in law in 1997). The perception that public transport authorities were operating at too great a distance from political decision-making persisted, and the regional public

transport authority form was introduced to address this. The regional public transport authority is the political body that bears ultimate responsibility for public transport. To emphasise this political mandate, RPTA responsibility cannot be assigned to a transport company or any other operational entity.

The hopes for increased competition in public transport also tell an interesting story: the study that preceded the new Swedish Public Transport Act proposed that private operators should have the right of first refusal to establish scheduled services in a free market where they deemed that there was sufficient demand, and that the public sector should provide services on the remaining routes [23]. However, this proposal met with strong opposition from most organisations commenting the proposal, highlighting the risk of cherry-picking – that is, the risk of private companies choosing to run services on profitable routes and leave unprofitable and expensive public transport to the public sector. In response to the criticism, the government clarified that the bill was *not* based on the previous investigation, but followed the line presented by the critics [22, p. 23]. This meant that by making decisions on public service obligations, public transport authorities could procure services that were both more and less profitable, thereby cross-subsidising transport services in order to maintain a comprehensive transport service offering. This can be viewed as a critical point in the organisation of public transport, where the existing model involving general public responsibility and procured transport services was strengthened while free market principles were rejected. An 'off-road' model of competition, rather than 'on-road' – as public transport researcher Didier van de Velde calls it – has thus been selected [24]. This means that competition for market share takes place off-road during the procurement phase, rather than on-road in direct competition for passengers. Despite public transport being formally opened up to competition by allowing private operators to run services freely, this has also resulted in complete marginalisation of fully private provision of local and regional public transport, essentially consisting of just a few air transport routes [25].

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Public transport today

The new Swedish Public Transport Act also enabled municipalities to transfer responsibility for public transport to the regional political level. This had already been done in a few cases (Stockholm and Skåne), but from 2012 onwards it became possible in all Swedish regions. More and more municipalities and regions have taken this opportunity; in 2024, just two out of 21 regions have public transport that is jointly owned by municipalities and the region in the form of municipal associations. As regions have taken over responsibility for public transport from municipalities, the distribution of public funds has also shifted to the regional level: see Figure 2. Municipalities gradually reduced their financial commitments to public transport between 2010 and 2019, while regional commitments increased; during the same years, regional funding for public transport more than doubled from SEK 12 billion to SEK 29 billion. This rescaling of public transport governance and organisation from the local to the regional level also leads to shifts and increases the regional 'gaze' on the form and function of local and regional public transport. This, in turn, influences how public transport is designed and operated between local and regional perspectives on public transport as a provider of welfare [26] [27].

A number of regions have also transformed their transport companies into administrations in conjunction with or independently of the transfer of responsibility to the region. Although the specific impact of this is unclear, the development suggests a renewed interest in increasing political control over public transport governance.

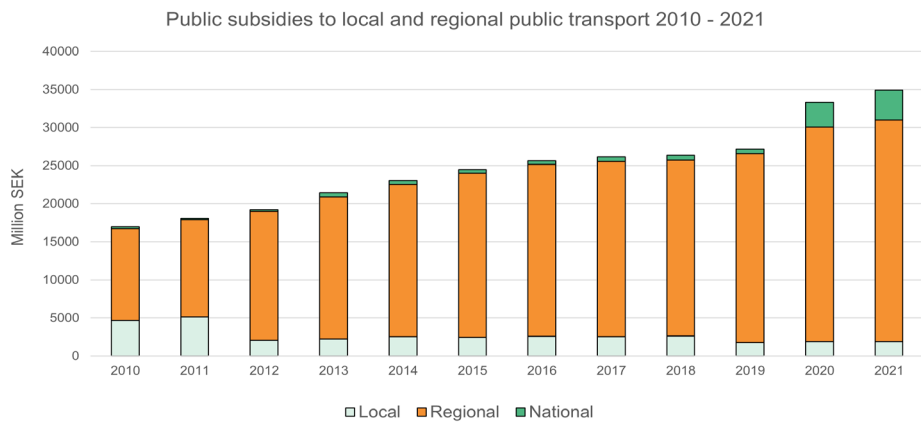

Figure 2. Evolution of public subsidies for local and regional public transport in Sweden, 2010–2021, divided between local, regional and state levels. Based on data from Transport Analysis.

While the regionalisation of public transport has accelerated, there are also trends that have stalled to some extent.

One involves the next stage of regionalisation; that is, the creation of a small number of large regions, a popular move in the early 2010s but currently a non-issue on the political agenda [28]. The introduction of large regions is likely to have implications for public transport governance and implementation, as the geographical scope of each regional public transport authority would be greatly expanded while the number of public authorities would be reduced.

The second issue relates to the introduction of a national ticketing system for public transport. This proposal was part of what is known as the January Agreement (Januariavtalet) that formed the basis for formation of the government following the 2018 elections, where the Social Democrats and the Green Party governed with the support of the Centre Party and the Liberals. An inquiry was launched in 2019, and its findings were presented the following year [29]. The proposals set out by the inquiry were based on the introduction of a digital infrastructure for a national ticketing system, a single point of access for mobility services (both collective and individual) and a competition-neutral sales channel. The premise was that the national government would take responsibility for establishing rules and functions for this – to which all RPTAs would be obliged to subscribe – and that commercial public transport operators could do so on a voluntary basis. Although this has been demanded by many politicians and citizens for a long time, not much has happened since the inquiry's findings were presented.

The COVID-19 pandemic was another significant event in the development of public transport. Public transport was heavily affected by the orders to stay at home and travel less. The government contributed ‘pandemic funds’ to public transport in order to reduce the risk of cuts in public transport services (which would defeat the purpose of allowing people who needed to travel to work to avoid overcrowding on buses and trains): while government subsidies had doubled between 2010 and 2019, during the pandemic they increased by no less than 625 per cent. The effects of the pandemic on public transport gave rise to extensive research, including at K2 [30] [31] [32] [33] [34] [35] [36] [37].

Where is public transport heading?

As we can see from this brief historical overview, neither recurring crises in public transport nor the State's attempts to address them through regulatory frameworks and resources are new phenomena, but rather a constant feature in the evolution of public transport. The public transport crisis in the 1970s was resolved by introducing public transport authorities and increased funding for transport. The economic situation in the 1980s was resolved by means of procurement, and public transport in the 2000s has been kept afloat by increased public funding.

Public finances are under strain at present, and cuts in services and routes can be observed alongside increases in ticket prices in most Swedish regions. The pandemic and rising inflation have renewed the debate on the role of the State in public transport. An ongoing intelligence analysis by K2 shows that a number of European countries have introduced substantial government subsidies on fares in order to meet the rising costs of public transport and maintain or increase demand. In Sweden, some parties are pushing for increased state funding of public transport operations, but no definitive changes or decisions have been made in this respect. Under K2's leadership, public transport stakeholders have also come together to form Rådslaget for a 'sustainable restart' for public transport after the pandemic, and the *Shift Sweden* innovation programme for the future of public mobility has been initiated in 2024 [38] [39].

In summary, it can be concluded that public transport has been characterised by a combination of increased coordination and the hope of increased competition. At first glance, this parallel development may appear to be contradictory. However, a closer look reveals two parallel trajectories. On the one hand, policy has sought to bring about greater *coordination of planning responsibilities*, pushing a regionalisation where both state and municipal political assemblies have handed over responsibilities to the regions, voluntarily or otherwise. On the other hand, attempts have been made to find ways of mobilising *competition as a force for development* in the actual provision of public transport, which in practice has resulted in institutionalisation of public transport procurement. This development follows societal trends emphasising both the importance of strategic and integrated planning *and* the governance ideology of New Public Management, through which attempts have been made to emulate a market approach in the public sector [40]. An enhanced market approach and separation of functions within and between organisations is also increasing the demands for collaboration. While K2 has been operating, there has been a great deal of research focusing on both the prerequisites for and boundaries of collaboration [41] [32] [42].

As regards the relationship between efficiency and equitable accessibility, it can be noted that the efficiency ideal has prevailed over focus on equitable accessibility for most of the history of public transport legislation since the 1970s, despite differences in emphasis. Regional expansion, labour market policy and environmental issues have all driven focus on investment in strong corridors in the form of long, fast connections between major cities [26]. However, backlash effects in the form of protests against high fuel prices and the position of rural areas in political discourse [43] have renewed the debate on equitable accessibility to public transport (and other public services) and its place in transforming the transport system for all.

One conclusion to be drawn from the review of the modern history of public transport is that the tensions between both efficiency and equitable accessibility and coordination and competition are aspects that are inherent in public transport structures. These tensions cannot be resolved once and for all, but remain constant aspects that politicians, policymakers and citizens need to take into account when allocating resources to, planning or making demands of the public transport system. What is regarded as a good response to the tension between conflicting goals also shifts over time and varies from place to place. What resources, demands and planning ideals will define future public transport and its response to its unresolvable conflicting goals remains to be seen.

3 How travelling habits have changed

Lena Winslott Hiselius & Emma Strömblad

The percentage of trips made by public transport increased steadily up to 2019. Public transport took up a position on the agenda and began to be seriously viewed as a key element in attainment of a sustainable society. The industry had big plans for growth in travel, and the Swedish Public Transport Association launched its target – to double the market share for public transport by 2030. However, all upward trends were abruptly interrupted at the onset of the COVID-19 pandemic. Travel in general declined, and public transport in particular saw its figures reversed as public transport was deemed to be the mode of transport presenting the greatest risk of spreading the disease. There were also fears of congestion on the roads as public transport users switched to cars. However, this did not materialise as society at large embraced remote working [1] and self-isolation was encouraged. However, public transport responded to the changing – more flexible – nature of travel by devising new ticket types such as flexi tickets for people who did not commute every day.

Research shows that the pandemic impacted various aspects of people's daily lives [2]. Different groups were affected in different ways, with women being more affected and older people in particular experiencing isolation. The results indicate that the impact of the pandemic helped to exacerbate existing disparities related to gender, geographical location and mobility.

Reduced travel in the wake of the pandemic

When the pandemic restrictions were lifted, some people predicted that travel would quickly make a resurgence and potentially exceed the levels seen in 2019; while others predicted that the new habits of remote working and reduced public transport use would persist. There is much to indicate that developments to date have been somewhere in between. New digital working habits have persisted to varying degrees since the COVID-19 pandemic, and travel statistics suggest that

public transport in some regions is still experiencing lower ridership aligning with 2019 levels rather than the previously forecast travel figures for 2024. That said, the Kollektivtrafikbarometern survey indicates an increase in the proportion of flexible car owners who switch between public transport and their cars, which is a general indication of more flexible travel behaviour.

However, the option of working from home differs depending on the type of work people do. In general, working from home is possible for a higher proportion of the population in metropolitan areas, where there is a high proportion of service companies [3]. This is also evident from how public transport has recovered in different areas. SL in Stockholm, for example, is still seeing clearly lower levels of public transport use (minus about 20 per cent compared to 2019) two years after the end of the pandemic: see Figure 1, which presents SL passenger figures [4].

Figure 1 Passengers using SL services in relation to corresponding figures for 2019 [4]

Moreover, analyses conducted during the pandemic revealed that commuting patterns differed between areas of different socio-economic status, probably due to differing opportunities to work from home. Areas with higher incomes and higher levels of education saw a greater reduction in travel [4]. SL analyses indicate that these differences still exist, albeit to a lesser extent.

Today's reduced travel does, of course, present economic challenges for public transport in the form of lost revenue. However, morning and afternoon peak hours still persist and did not disappear even during the pandemic: see Figure 2, which presents statistics from Region Skåne [5]. This cost-driving travel pattern thus

persists. However, there is growing interest in measures to distribute travel more evenly, such as adjusted school start times and fare differentiation, in order to make more cost-effective use of public transport infrastructure, buses and drivers throughout the day [6]. There is a slight tendency towards lower travel rates at the beginning and end of the week. Midweek days deviate the least from how things used to be in a normal week, when everyone was expected to turn up at the office five days a week [4].

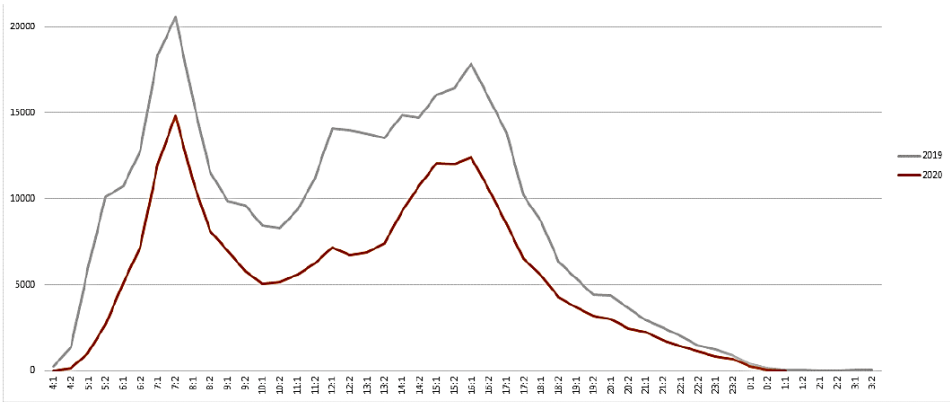

Figure 2 Weekday travel in week 37 of 2020 (affected by the pandemic) compared to the same week in 2019 (unaffected) [5]

Leisure travel increasingly important, but difficult to switch to public transport

Most journeys made by public transport are still for work purposes. Other types of travel are typically more diverse in terms of timing and destinations, making it more challenging to accommodate cost-effectively with traditional public transport.

However, analysis of statistics from the Swedish National Travel survey, RVU Sweden 2011–2016 [7] shows that everyday leisure trips account for 33 per cent of the total distance travelled by car. These statistics date back to before the COVID-19 pandemic, but there is no indication that travel patterns have altered significantly. About one-third of social and recreational trips by car cover less than 5 kilometres. However, despite the large number of short journeys, long journeys account for a significantly larger proportion of the number of kilometres travelled when the number of passenger-kilometres is considered instead. Hence there is potential for sustainability here.

In an analysis of leisure travel among different groups [8], a group with a high proportion of people aged 64 or over stands out as travelling the highest number of kilometres by car and making the highest number of trips per day for leisure purposes. The result can be interpreted as meaning that this group has more time to travel for leisure purposes than other age groups, and they have good access to cars. The analysis also shows that the length of car journeys for leisure purposes increases with age, which suggests that the 64+ age group will be filled with people who have previous experience of using cars for longer leisure trips. This highlights the need to discuss car reduction measures and alternative modes of travel for this older age group.

From a sustainability standpoint, it is important also to take into account the number of people travelling in the car, as the number of vehicle-kilometres travelled is more directly related to emissions than the number of passenger-kilometres. The findings show that leisure trips are often of a shared nature, and that less than a third of these trips are made unaccompanied [7]. Social trips involve 0.9 accompanying person on average, or 1.5 accompanying persons for entertainment and culture purposes, compared to 0.2 person for business travel and school trips. Moreover, the results show that the longer the journey, the more people travel together. The climate efficiency of car use increases as more people travels in each car, and the shared nature of leisure travel thus impacts the efficiency of the transport mode selected. From this perspective, switching from car to bus is not always the most climate-efficient measure. From a passenger perspective, it may also be more cost-effective (depending on the fare structure and travel costs) to travel by car rather than public transport.

Studies have shown that leisure travel is important for people's well-being, and so there is low acceptance of changing such travel. Moreover, leisure travel destinations are often seen as fixed and difficult to influence. Family and friends, for example, cannot be replaced easily and their choice of accommodation is usually impossible to change, which means that social leisure travel for the purposes of visiting family and friends can be the most difficult of all travel to change. While trips to visit family and friends are often linked to a specific location, less fixed destinations – such as the choice of recreational area – can be influenced by promoting areas that are closer or that offer better accessibility. Finally, the increased use of remote working may mean that leisure travel becomes increasingly important as a way of getting out of the house and meeting people.

Decline in air travel but cars continue to dominate

Air travel by Swedish people decreased between 2017 and 2019, even before the pandemic. The introduction of the aviation tax, but also the debate on 'flight shame', were then highlighted as potential reasons for the change. Air travel almost vanished during the pandemic, and as the effects of the pandemic have subsided, descriptions of a 'recovery' in the aviation industry have become more frequent. But statistics show that Swedes are flying significantly less than they used to. Figures from the state-owned company Swedavia [9] show that the number of landings at Swedish airports was 31 per cent lower in 2023 than in 2017 – the year in which air traffic peaked. Measured in terms of passenger numbers at Swedish airports, the decline is also clear: 23 per cent fewer passengers in 2023 compared to 2017. The shortest and longest journeys, domestic travel and travel outside Europe respectively are demonstrating the weakest recovery.

Although many stakeholders are working together to increase sustainability in the transport sector, progress is slow. Domestic passenger transport is still dominated by cars. Almost 80 per cent of the distance travelled is covered by car. Rail travel accounts for less than one-tenth of passenger travel, while bus travel accounts for one-tenth of kilometres travelled [10].

Changes in data collection methods

Statistics are needed if we are to understand travel habits: firstly, so that we can analyse current travel in detail, and secondly, so that we can estimate the impact of different policy measures and their distribution in society. Travel surveys have struggled with very low response rates for a long time, and so other data collection methods have been evaluated by Transport Analysis [11]. The data collection method for the Swedish National Travel survey (RVU Sweden) has been adjusted slightly, and this survey is now conducted using a combination of online surveys and surveys on paper. Gathering information about travel habits through mobile network data is one way forward, but this does not provide detailed information and lacks information as to why people are travelling. Another option is to collect data via mobile apps, which provides both detailed information about the journey and the individual making the trip [12] [8]. However, there are also problems with recruiting people to participate in the studies, and there is a risk of the sample being biased. Thus, the problem remains: how to collect data so that we can make informed decisions on how to design the sustainable transport system of the future.

> Although many stakeholders are working together to increase sustainability in the transport sector, progress is slow. Domestic passenger transport is still dominated by cars. Almost 80 per cent of the distance travelled is covered by car.

4 Geographical accessibility and public transport

Jean Ryan

Both academics and practitioners have long grappled with how geographical accessibility (hereafter referred to as 'accessibility') should be defined and measured. Currently, there is no consensus regarding which definition(s) or measure(s) of accessibility should be applied in what context [1] [2] [3]. The most common definitions include 'the ability to physically reach activities' and/or 'the ease with which activities are reached' [4] [5]. Recently, based on insights from research, it has been suggested that accessibility should be defined as '*the possibility to be able to participate in society by overcoming barriers (such as a distance)*' [6].

The term 'accessibility' is considered to relate to the transport and land use system, how people and their different characteristics interact with the system, and the time it takes to move to and from starting points and destinations within the system [7]. The different components of accessibility interact with and influence one another in many different ways. It can thus be argued that the concept of accessibility encompasses more or less 'everything', if it takes into account people, their combinations of different characteristics, the transport and land use system and everything that influences the respective components. Therefore, it could actually be difficult to come up with anything that does *not* affect accessibility in one way or another, even if it is to a very small extent.

This chapter focuses on research on accessibility at the meso or macro level [8] [9].[1]This means that the content of the chapter is delimited to research regarding accessibility that concerns travel between city districts or from one municipality to another, focusing in particular on journeys that are or could be made by public transport. Accessibility at what is known as the 'micro level' (such as between starting points and destinations within districts) is thus beyond the scope of this

1 This can be compared to accessibility at municipal and regional level for simplicity.

chapter. As accessibility can be regarded as encompassing or being influenced by ‘everything’ (or almost ‘everything’), it can be argued that virtually all of K2’s research relates to accessibility in one way or another. However, this chapter includes projects, reports and articles that explicitly address accessibility.

Why has there been more focus on accessibility?

In recent years, greater attention has been paid to the concept of accessibility, both within Sweden and elsewhere. This development appears to have come about partly in response to the sustainable mobility transition required in the context of the climate crisis [9], and partly in tandem with a greater emphasis on transport justice in transport and urban planning contexts [10]. Transport justice (and distributive justice in particular) has become more prominent in research and policy agendas over the last decade. In the context of this shift, there has perhaps been slightly less focus on the optimisation of the transport system itself [11] [12], and more on the role of the transport system in facilitating participation in society.

The concept of accessibility characterises both Sweden’s national transport policy goal [13] and objectives found in policy documents at regional and municipal levels, although the approaches, definitions and measures applied in different contexts differ [6].

Accessibility is approached and measured in different ways

The prevailing approach to transport planning assumes that accessibility is an objectively understood concept that can be measured and quantified [14]. A great deal of emphasis has been placed on the design and development of standardised accessibility measures that describe accessibility within a given geographical area, or between geographical areas.

Accessibility is usually measured by applying one of the following four methods [1]:

1. distance (or journey time by a specific means of transport) to the closest type of destination;

2. cumulative measures (the sum of a certain type of destination, e.g. the number of jobs to be found within a certain radius, based on a certain distance or journey time);
3. gravity models (which weight destinations where values decrease with increasing distance or journey time); and
4. measures based on marginal utility (such as the log-sum, that takes average preferences into account).

Results, conclusions and choices may differ depending on the definition, method and measure applied. That is why it is important to be able to identify *what kinds* of differences can arise and *why* when applying different definitions, methods and measures.

Many measures of accessibility overlook variation

In some cases, employing simpler measures can be justified. Simpler measures can mean that the application and results can be communicated and explained with greater ease. They can also allow for changes to be measured and monitored in a standardised manner over time [9] [15] [16]. However, these simpler measures do not capture all aspects related to accessibility, and they tend to overlook certain types of people, usually people who are further away from the characteristics associated with 'the average individual' [16] [14] [5].

A study based on data from Canada [5] has indicated that what are known as **normative accessibility measures** are specified in terms of how far it is considered reasonable for people to travel, while what are known as **positive accessibility measures** are specified in terms of how far people actually travel (based on data from travel behaviour surveys, for example). There are several problems associated with both types of measures. Both can influence people's actual travel behaviour, regardless of whether the approach defines new frameworks for travel behaviour going forward or reinforces the frameworks associated with existing travel behaviour.

Some of K2's research has aimed to highlight aspects that are sometimes overlooked when defining and measuring accessibility, both methodologically and theoretically [16] [17] [18] [19] [20].

> These simpler measures do not capture all aspects related to accessibility, and they tend to overlook certain types of people, usually people who are further away from the characteristics associated with "the average individual".

What do we know about accessibility?

K2's research into accessibility is characterised by elements and perspectives from various disciplines. Some studies include the estimation and analysis of (potential) effects **from a socio-economic perspective,** with emphasis on residential location and commuting patterns [21] [22] [23], while others are characterised by **transport justice perspectives** [24] [25] [16] [26] with less emphasis on commuting and where specific groups [27] [18][2], specific geographical areas [20] and other activities [28] [29][3] are considered. Ongoing K2 projects are characterised by more focus on **environmental aspects**[4] and **links between other means of transport and public transport** [30].

These themes and multidisciplinary cross-fertilisation of approaches and methods also characterise the composition of accessibility research in general [9].

Effects of public transport initiatives to increase accessibility

Several aspects related to accessibility such as regional development, proximity, agglomeration and location effects linked to public transport investments have been studied in detail in a K2 project [31] . This project studied aspects such as the scale and character of public transport investments in the region of Scania and along the West Coast Line (Västkustbanan) within the project. Comparisons between rail and bus investments and their respective estimated impacts were also conducted. The project concluded that, in line with other research findings in the field, the effects of investments in increased accessibility appear to be highly dependent on context. Thus, there are no set rules that can be applied across the board (in all contexts) to determine or predict the outcome of investments.

Property prices served as an indicator of willingness to pay in one of the studies included in the larger project [23]. The study found that property prices around stations with high labour market accessibility (either in terms of shorter journey times or actual physical proximity) appeared to be more affected by price

2 There is also an ongoing project that is focusing on accessibility for children. Read more here: https://www.k2centrum.se/barns-tillganglighet-och-mobilitet-i-ett-digitaliserat-transportsystem-hur-arbetar-nationella-och

3 A recently completed research project focused on accessibility to, from and outdoor recreational areas. For more information on the project, see: https://www.k2centrum.se/aurora-pre-study-accessibility-and-areas-national-interest-outdoor-recreation

4 A project is ongoing that is focusing on accessibility and planning across planetary and social boundaries. See: https://www.k2centrum.se/kollektivtrafikens-roll-och-egenskaper-mellan-planetara-och-sociala-granser-troskelvarden-scenarier

increases. The effects for stations with lower accessibility to labour market centres were not as clear-cut.

The study also found that railway stations characterised by accessibility to major labour markets in large parts of the region appear to be regarded by households as more attractive [23]. The study concluded that cities that are located close to other cities can be strengthened by means of their public transport connections, which in turn contributes to agglomeration benefits.

The overall results of the project indicate and emphasise that the effects of public transport investments do not happen by themselves but need to be complemented by other measures in order to promote regional development and increased accessibility. The authors emphasise the fact that there are distributional aspects that may be important to take into account and include in the planning of both infrastructure investments and service provision [31].

Investments and cuts in public transport

The effects of changes in public transport provision for some areas were analysed as part of another K2 study. Here, some areas saw increased access to public transport with the introduction of the 'Pågatåg Nordost' service, while other towns or parts of towns experienced reduced access, when regional bus services were partially or entirely withdrawn [20]. The location of railway stations on the outskirts of towns was associated with reduced access to public transport for some people, with a number of respondents feeling that public transport was further away than it used to be (compared to when bus routes formed the core of public transport provision). This change appears to have had the effect of reducing (perceived) access to – and accessibility of – public transport for some residents.

Variation in pre-conditions for public transport accessibility among different groups

Mobility strategies with a particular focus on how public transport is perceived, used and can meet the mobility needs of people who live, work or pursue other activities in selected disadvantaged areas in Swedish cities were examined as part of a K2 study focusing on accessibility [24]. This study focused on how public transport could contribute to accessibility and social equity in the transport system.

The study concluded that an efficient public transport system is important for aspects such as participation and integration in society, especially where, for various reasons, there are limited opportunities to obtain a driving licence, acquire a car, relocate or change jobs. Accessibility by public transport was perceived to

be particularly limited by people who work evenings, nights and weekends, as opening hours/timetables did not correspond to their working hours.

The K2 *Access* project studied how conceptualisations of 'collective mobility' can be adapted to groups with low levels of car possession and access [18]. The study culminated in a number of recommendations for how the mobility needs of different groups (such as people living in sparsely populated areas and young people) could be met by the introduction of new mobility concepts, functioning as a complement and/or alternative to public transport. The project has culminated in several recommendations, including the fact that just one ticket should be valid for several modes of transport, that the vehicle pool could include a range of different vehicles, that stakeholders should communicate and provide information in different languages, and that a specific stakeholder should be designated as being responsible for providing information about transport options.

Methodological development focusing on the dimension of time

A number of K2 studies have had a particular focus on methodological development, targeted at refining and adjusting accessibility analyses. Methods and perspectives have been both developed and broadened [16] [25] [28] [26]. The advent and standardisation of GTFS data [5] has facilitated the development of public transport-based accessibility analyses during the last decade. Developments have also allowed delays to be taken into account in accessibility analyses by applying positioning and real-time data [26]. K2 research has used GTFS data in various forms in accessibility analyses. Tools such as Network Analyst [19], OpenTripPlanner [16] and, more recently, r5r through R5 have been used [32] [25] [28] [26].[6] The K2 project *Equitable accessibility by public transport: Moving from static analyses to incorporating time-space dynamics* is one example of a project where there has been an emphasis on methodological development related to the time dimension of accessibility, and where the tools and methods referred to above have been applied and adjusted. This project studied the concept of accessibility in different ways with case studies in the regions of Stockholm, Västra Götaland and Scania. The project aimed to develop the understanding of the concept of public transport-based accessibility, taking into account the times of

5 For more information on GTFS, see: https://gtfs.org/.

6 For more information on Network Analyst, see: https://pro.arcgis.com/en/pro-app/latest/help/analysis/networks/what-is-network-analyst-.htm. For more information on OpenTripPlanner, see: https://docs.opentripplanner.org/en/dev–2.x/Product-Overview/. For information on R5 and r5r, see: https://ipeagit.github.io/r5r/.

day that different individuals travel and how the opportunities for and accessibility of different (potential) passengers are influenced by public transport provision.

The project analysed travel survey data from the region of Stockholm in combination with estimated journey times by public transport [25]. It compared accessibility by public transport to workplaces for different groups of people during different timeframes. Factors that may influence the timeframe within which commuters (choose to) travel and the transport modes they select were studied. The results showed that accessibility by public transport in the region of Stockholm varies when accessibility during peak hours is compared with accessibility within timeframes before and after peak hours. This means that some groups are more likely to benefit from 'better' accessibility (shorter travel times to work) than others. The results suggest that commuters who have the opportunity to be flexible choose to travel during peak hours, which can be partly explained by the fact that public transport-based accessibility is better during those timeframes. Commuters who do not have the same flexibility are more likely to use other transport modes to get to work.

The distribution of accessibility losses arising as a result of public transport delays in Scania was studied in order to highlight the potential effects of such delays [26]. The analysis shows that recurring public transport delays lead to a reduction in accessibility to work in the order of 4–9 per cent in the region of Scania. The study also shows a correlation between recurring delays and a lower propensity to travel by public transport compared to other motorised modes of transport.

Spatial inequalities in accessibility were analysed as part of another K2 project. This was done by investigating how the public transport provision can influence the time available to public transport passengers living in two selected districts located on the outskirts of the city of Malmö [19]. The study applied a GIS-based analysis to explore whether and how the public transport provision (a) enables study participants to take part in activities; (b) is spatially and temporally consistent with their activities; and (c) supports or hinders study participants' ability to manage their time. The results of the study suggest that public transport provision results in inequalities of opportunity in terms of faster connections for some and slower ones for others, which may mean an increased risk of time-related transport problems among some passengers. Additionally, there is evidence that the service provision does not always meet participants' accessibility needs, especially during off-peak hours.

Differences in estimated and perceived accessibility

In line with the broader research trend of a sharpened focus on differences between how accessibility is ('objectively') measured and how it is ('subjectively') perceived [14] [33] [34] [35], K2 research has explored what we (analysts or researchers) miss when measuring accessibility [16]. A K2 study compared estimated and perceived accessibility among different groups of older people by means of an accessibility analysis and a survey. The accessibility analysis was adapted by adjusting the values of estimated (often referred to as 'objective') accessibility for respondents who felt that they did/did not have access to the mode of transport to which the accessibility analysis related. Furthermore, cases in which there was a 'mismatch' between the estimated accessibility and the self-reported accessibility on account of the perceived inability to use certain transport modes were analysed. The study found that respondents with greater 'mobility resources' (such as access to more transport modes) were less likely to have a mismatch between the self-reported and estimated accessibility indicators. Thus, the transport modes available to people seem to play a role in how different people perceive their accessibility. This aspect is not usually captured by standard accessibility measures and analyses.

In the K2 project *Capturing the impacts of changes in public transport accessibility*, emphasis was placed on applying and developing the use of what are known as participatory-GIS methods. The objective was to capture perceptions of changes in the accessibility of and access to public transport. The project was based on two case studies: one in an urban context in Malmö, and the other in a regional context in the region of Västra Götaland. A survey was conducted within the framework of the project with a view to capturing changing travel patterns among residents of the city of Malmö at the start of the pandemic [36]. The results showed that (not least perceived) accessibility by public transport was severely limited at the start of the pandemic.

A survey was conducted among residents in sparsely populated areas in the Västra Götaland region within the framework of the K2 *BAS* project. This survey was conducted among two samples, one consisting of residents aged 15–18 and the other consisting of residents aged 19 and over. The survey aimed to answer questions about the accessibility needs of different groups and whether such needs are or are not met by the public transport provision, and to what extent. The results suggest that young people are more affected by relatively low accessibility, with some respondents stating that they limit their activities and adjust their

expectations of participation in society according to the low levels of accessibility in which they live.

The concept of accessibility in policy documents

How the concept of accessibility is considered when drafting policy documents and in policy development in general has been addressed in a number of different K2 studies [17] [37] [38] [39]. Given the fact that accessibility is defined and measured in so many different ways, it comes as no surprise that the concept is treated differently when drafting policy documents.

How a basic, equitable and sufficient level of public transport-based accessibility could be defined and implemented was explored in a study that focused on policy development in Sweden's metropolitan regions [17]. Officials in Sweden's metropolitan regions were interviewed so that they could provide their perspectives on their experiences working with the concept. Additional interviews were conducted with officials and experts in Belgium and the UK, and approximately 40 policy documents were analysed as part of this study. The study resulted in recommendations for how an equitable and basic level of accessibility could be defined as a policy concept, and how the concept could be implemented in connection with the drafting of various policy documents such as public transport service provision programmes. The recommendation comprises four different steps: (1) how accessibility is defined and measured is agreed upon and established, (2) a standard and an assessment framework is put in place by means of a process involving a series of different stakeholders, (3) the scope of the standard is delimited and defined, (4) where the responsibility (or responsibilities) for the coordination, implementation and monitoring of the standard among stakeholders and public authorities is established and formalised.

Another K2 study focusing on policy development in relation to accessibility examined the case of the region of Uppsala [37]. Uppsala was selected as a case because the region's general objective is to ensure that its transport system provides accessibility for all. The study found that people with disabilities are the group whose accessibility receives the most attention in the material studied. The study found that officials appear to have more vague perceptions of what accessibility means and how providing accessibility should be achieved for groups other than people with disabilities. Interviewees were aware of other groups and any public transport-related accessibility problems they may encounter, but the work focusing on accessibility appeared to be focused on people with disabilities as a group.

Accessibility influenced by interactions between policy areas

A number of K2 projects have studied how the interaction between different policy areas may potentially affect the accessibility of or to different places, One study analysed how accessibility to schools by sustainable transport modes could be affected by (1) the introduction of municipal school choice policies and (2) the public transport infrastructure investment in the form of the Malmö Ring railway line [28]. The accessibility of lower secondary schools (grades 7-9) in Malmö was studied by estimating hypothetical school catchment areas. Furthermore, the study examined how the potential redistribution of accessibility could affect the composition of the schools affected. The results indicate that potential impacts are not distributed evenly throughout the city. However, the possibility of reaching schools further away may be greater among economically stronger groups/districts, among whom/which there is also a greater possibility for flexible work arrangements (among parents/guardians). Furthermore, it was argued that travel needs (travel demand) may increase as a consequence of the introduction of policies such as municipal school choice. This, in turn, may impose a temporal and economic burden on certain groups in society. The results of the study highlight the importance of taking a holistic approach to policy choices related to transport and urban planning (in combination with the planning of e.g. education and healthcare). Moreover, another K2 study has found that the Malmö Ring railway line does not seem to contribute much to the perception of accessibility by public transport in the affected areas. This is considered to be due to the fact that the areas affected most by the investment are served by high-quality bus services with higher service frequency and shorter journey times (to Malmö Central station, for example) than the train connection and service [40].

Whether accessibility can explain food prices in Swedish supermarkets, and to what extent, was examined in another K2 study [29]. This was done by analysing links between accessibility and food prices. The study found that there is a quadratic relationship between accessibility and food prices, with prices in the least and most accessible parts of Sweden being 2–3 per cent higher than in the cheapest parts.

What will be interesting to study going forward?

Although K2's research has contributed a great deal of knowledge regarding accessibility and public transport, there is still much to explore. There are a number of particularly interesting questions to study going forward.

Interventions that focus on increasing accessibility in areas that have previously been characterised by low accessibility may have unforeseen consequences. Property prices may increase, causing groups that would benefit from increased accessibility to instead relocate to areas with lower property prices. These areas are also likely to be characterised by lower accessibility. ‘Can transport interventions truly compensate in the long run for uneven distributions of accessibility in a more or less free housing market?’ is a particularly interesting question.

Giving greater consideration to perceived accessibility in transport and urban planning is gaining more attention. There is scope to develop and adapt transport models in order to take these aspects into account in a more nuanced way [6]. Studying ways of doing this is becoming increasingly important as more and more research shows that common accessibility measures fail to capture the perceptions of different people.

In the context of an increased focus on ‘collective’ or public mobility, and links between public transport and various forms of micromobility, accessibility becomes more dynamic and hence even more difficult to capture and measure. As new micromobility solutions – often viewed as complementing public transport – have become more prominent, it is important to investigate whether these solutions do actually complement – or whether they merely compete with – public transport and walking [41], whether they can help reduce – or whether they potentially increase – inequalities [42], and whether they can reduce emissions from the transport system, or whether they simply contribute to more emissions per passenger kilometre from a life cycle perspective [43].

It is imperative to ensure that the accessibility planned for by society paves the way for lower emissions and a fair existence within the boundaries of our planet [44]. This is also rather urgent.

5 Equality, gender equality and social justice perspectives in public transport

Christina Lindkvist

One research area developed within K2 falls under the heading of *Public Transport for All*. From having focused on questions relating to where buses or trains depart from and how often, and what passengers think of their journeys, research has been linked much more clearly to various analyses of power. This concerns vulnerable groups and the mobility strategies they use [1]; public transport costs for low-income households [2]; how people with disabilities can use public transport [3]; how the perspectives of older people and children are integrated into planning [4] [5]; what faster bus services mean for residents in socio-economically disadvantaged areas [6]; how sex, gender and gender equality perspectives are of relevance to planning [7]; how the rhythms of the city and public transport impose limits on accessibility for people [8] [9]; and how methods can be designed to conduct social impact assessments of planning [10], to name but a few. However, the fact is that most research projects conducted at K2 have an impact on social aspects and equity: how politicians decide on ticket prices affects the individual's perceived ability to pay, how transport models are designed affects perceived accessibility and thus has a social impact, land use for infrastructure investments has an impact on economic values, attractiveness and – as a consequence – who can afford to live where, changes in service frequency and routing in public transport affect people in different ways. An overview of the number of publications from projects dealing with social aspects – different social groups, that is – shows the following:

- General perspectives: 29 publications
- The perspective of older people: 15 publications
- Gender equality, gender, intersectionality: 8 publications
- Disabilities: 7 publications
- Safety: 6 publications
- Young people: 5 publications
- Spatial justice: 4 publications
- Poverty: 1 publication

It is not possible to comment on all the studies here, but two should be mentioned. Poverty is a common topic in international research. Sweden has not until recently focused on that topic, although more studies are starting to appear. Anders Bondemark is an exception, and his study on low-income households and public transport costs is an important contribution [2]. Bondemark shows that low-income households pay proportionally more for their travel than more affluent households. Although in many respects public transport is about accessibility to transport from a welfare policy/welfare economic perspective, studies that focus on households or individuals are limited. Another important area that is still in its infancy relates to people with neuropsychiatric diagnoses, known as NPF diagnoses (see [3], for example). Jessica Berg and Jonas Ihlström have conducted a study into people with neuropsychiatric disabilities, and their study aimed to compare the perception of barriers to travelling by public transport between people with and without diagnoses [11]. The results show that action is needed to make public transport accessible to people with NPF diagnoses.

Rosa Parks and the yellow vests

Perspectives on equity and gender equality in access to public transport can be traced back to the 381-day bus boycott in 1955 in Montgomery, Alabama, after the civil rights activist Rosa Parks refused to give up her seat on the bus for a white man, as the rules prescribed. This protest can be said to herald the start of the modern American civil rights movement demanding social justice [12] [13]. The social justice perspective of today is related to how environmental justice is understood. The Swedish government's definition of environmental justice [14] is

translated here as '...the just treatment and meaningful involvement of all people regardless of race, ethnicity or socio-economic status. No group should have to bear disproportionate burdens on account of the activities or operations initiated or conducted by the business community or the State.' [15]

The problem with this definition is that some groups in society find it easier than others to demand accountability from people in power and demand resources for their transport needs, while other groups are often overlooked. What researchers highlight is the fact that the definitions used are often imprecise: not all ethnic minorities are socio-economically vulnerable, not all older people have disabilities, and low-income households without migrant status may feel that they do not count. Other consequences highlighted by this type of definition are that simplified individual solutions are developed more frequently than systemic, transformative changes based on changes in land use and urban planning leading to inclusive lasting reforms [16].

Other perspectives on social injustice have emerged out of the protests towards racial inequality. Demands for justice have led to furious demonstrations, such as the riots that followed hikes in public transport fares in Santiago, Chile and Tehran, Iran. This illustrates the inherent social volatility in respect of issues relating to transport accessibility. Access to public transport for different groups and how different groups can use it equally thus provides a starting point for research into social perspectives and equity issues.

Alongside social injustice, there is also the spatial dimensions of (in)justice; that is, how different geographies create conditions for the people living in specific places. Analyses of spatial justice address various life conditions, since places give people different life opportunities. This can be described as segregation when there is focus on analysing different social groups linked to urban districts, but it is relating to the relationship between urban and rural areas as well. The yellow vest (gilets jaunes) protests that paralysed France for most of 2019 when the price of petrol and diesel was increased as a strategy to reduce emissions from traffic is a clear example of this spatial (geographical) dimension. Ultimately, it was about how people in rural areas could afford to go on living in the countryside, where private transport is needed due to longer distances and lack of public transport alternatives. This issue recurs over and over in Swedish debates and concerns aspects such as the distribution of services and service frequency on relatively well-served public transport routes compared to improved accessibility for residents in more sparsely populated parts of the country; and this is an area that researchers at K2 have also addressed [17]. It is difficult to make clear distinctions

between social and geographical conditions, as the geographical and social aspects often interact; and in many studies the perspectives are dependent on and integrated into one another, such as in Jessica Berg's study of mobility strategies among residents in Angered and Botkyrka. Growing up in these places included feeling forgotten by the authorities, and that people living in the area were unable to benefit from the resources that they perceived as being allocated to other, more affluent areas. A study on mainstreaming gender equality into transport planning, led by Lena Levin, found that planners felt that residents at intermediate stations received poorer service when there were regional interests in investing in regional commuter trains [18]. Stops were cancelled for some stations to increase the speed and range of regional commuting, and instead the intermediate stops ended up with slower and less frequent services.

Public transport as a welfare policy

The State and municipalities offer various solutions to address social exclusion and unemployment, as well as matching issues in the labour market. This often involves offering various training and labour market measures. This is by no means a uniquely Swedish strategy. The Government of the United Kingdom conducted a review of welfare policies following the economic downturn of the 1990s. Public transport accessibility turned out to be an important piece of the puzzle [19]. Researchers delivered scathing messages to the government institutions regarding the need to include public transport and transport accessibility in the analysis of a more equitable society. A lack of accessible transport can translate into transport poverty, and transport poverty has a part to play in social exclusion. Social exclusion has four dimensions: spatial confinement; time constraints; financial constraints; and mental or physical constraints [20]. People are at risk of social exclusion if they do not have access to transport.

Professor Karen Lucas, Manchester University and member of K2's international expert panel is one of the researchers who contributed to the British review of welfare policy and the importance of transport. According to Professor Lucas, lack of transport can translate into transport poverty. People are at risk of social exclusion if they do not have access to transportation. In an interview conducted in 2022, Lucas notes that the situation twenty years later remains difficult for groups in the British society. She makes it clear that unless access to transport is included when other social interventions are implemented to reduce economic and social

inequalities in society, it becomes a catch-22 situation for the people at the centre of the measures on offer. In the interview, Lucas notes that low-income households risk becoming spatially trapped in their residential areas without access to transport; that young criminals sentenced to community service and rehabilitation programmes risk being returned to prison due to a lack of transport to the places where they are to complete their community service; and that apprentices risk being unable to obtain their professional qualifications because they cannot reach their workplaces: ‘people are at risk of poverty due to a lack of transport’ [21]. A lack of accessible transport leads to exclusion from and ineligibility for the social programmes on which many people depend to improve their opportunities to make a living and participate in the wider community. The need to strengthen what is known as ‘linked social capital’ [22], whereby these groups establish contacts and social ties with people outside the areas in which they live, is crucial for social mobility and improved life opportunities. Mobility strategies and the significance of public transport for different groups have been the focus of a number of K2 research projects, such as Anders Melin’s study on Malmöexpressen’s route 5, in which he uses capability theories to show how Rosengård residents have expanded their range. Another study that examined mobility strategies is Jessica Berg’s study involving participants from Angered in Gothenburg and the municipality of Botkyrka, south of Stockholm. This study found that travelling is expensive, and that young people feel unsafe on public transport on account of both their fellow passengers and bus and tram drivers. According to the young people interviewed, it was best when someone had a driving licence and access to a car so that they did not have to use public transport. K2’s research into social sustainability has also resulted in training courses for officials working in transport planning, to translate theoretical knowledge into practice, such as the Social Impact Assessment for Transport Planning Professionals course that is being run jointly with the University of Gothenburg and the Gothenburg Region.

> Unless access to transport is included when other social interventions are implemented to reduce economic and social inequalities in society, it becomes a catch-22 situation for the people at the centre of the measures on offer.

Public transport as a service or a collective benefit?

Transport is a basic prerequisite for a dignified life. How public transport and other mobility resources are distributed so that the households with the lowest incomes can also reach important destinations is a key equity issue for a welfare society.

Some of these issues can be addressed by integrating these perspectives into urban planning at an early stage, but one problem often highlighted involves the siloed planning and forecasting tools used to calculate travel demand in new areas. Here, the social justice research field links up with the research field examining societal benefits and assessment models for investments in infrastructure. K2 research has contributed to efforts to identify models for calculating the impact of increased accessibility to public transport. One example is the study by Désirée Nilsson and Vanessa Stjernborg on Pågatåg in north-eastern Skåne, which combined conventional statistical methods with qualitative methods in order to gauge the impact of increased access to rail services [23]. A great deal of work remains to devise models that can deal with the complexities presented by increased accessibility through investment in public transport for people who live in the areas connected to the public transport network.

Equity issues are very much linked to urban planning, particularly in how it has evolved since the post-war period; but there were visions based on technological advances being made even in the early part of the 20th century. Le Corbusier's vision of the radiant city (Ville radieuse) was based on cars and rapid transport as the backbone of this plan. A radically different example is Ebenezer Howard's Garden city, where residents would live in healthier green enclaves outside the big city. Despite the differences, both planning ideals are based on good transport facilities. Le Corbusier left his mark on modernist urban planning, with traffic separation as a fundamental planning principle, and with emphasis on accessibility for cars. Almost all Swedish Million Programme areas are characterised by traffic separation between different road user types, designed according to what is known as the SCAFT model developed by Chalmers University of Technology on behalf of what was then the Swedish Road and Planning Administration [24]. Garden cities have also emerged in Sweden, such as Enskede Trädgårdsstad outside Stockholm. Both planning models favour high accessibility by private car.

Both of these planning ideals have had social consequences. Karel Martens is a transport researcher who has explored the meaning of transport justice from a planning perspective [25]. One of Martens' starting points is that by allowing

urban planning to focus on cars, and functional land use has contributed to monofunctional land use in many respects, where residential areas are planned separately from workplaces. The consequence of this and a continuing growing of urban areas is that people have longer and longer distances to cover on a daily basis. In one article, Martens tests the thesis of access to transport as a fundamental collective benefit [26]. The argument on which the thesis is based is that urban planning – as it has been conducted to date – has rewarded driving, speed and zoning and thus built in distances that people must cover. Modes of transport such as walking, cycling and public transport score low in the models used to prioritise infrastructure investments, which – according to Martens – means that cars are prioritised and an already privileged group in society is disproportionately well-served when it comes to meeting their transport needs. Martens' questions whether public transport should be regarded as a service sold on a market, or as a collective benefit that should be made available to as many people as possible, at the lowest price possible, as public planning has helped to ensure that individuals have ever-longer travel distances to cover.

By taking the car as the norm in planning, land use, land prices and functional zoning have all contributed to longer distances between housing, workplaces and services, thereby increasing mobility. Some groups have been forced further out to the outskirts of cities to afford housing, with consequences such as daily commutes that are often long and complex. The expansion of suburban residential areas historically confined women to a suburban existence. Anyone who did not have a car and a driving licence was unable to get out and about. The importance of gender and gender equality in increasing equal access to transport and mobility for both men and women is a theme that K2 researchers have devoted themselves to analysing and providing recommendations to address, such as in Transportplanering i förändring: en handbok om jämställdhetskonsekvens-bedömning i transportplaneringen [Transport planning in transition: a handbook on gender equality impact assessment in transport planning] [27] [28] [29].

Distribution, redistribution and recognition

Distribution policy decisions underpin the socio-economic models used to calculate the social benefits of transport investments made. The 'Swedish model' has aimed to balance the care sector with the labour market and fiscal policy and is based on the notion of 'människors lika värde och rätt till oberoende och självständiga liv' [the equal value of people and their right to independent and

autonomous lives] [30]. Swedish welfare policy has been designed to be universal and not distributed according to need; on the contrary, everyone has been covered by state care. This is a liberal notion of justice philosophy advocating that the investments made by society should benefit the majority, and this has been a guiding principle for how resources and burdens are to be distributed among the population. However, the universal welfare model applied in Sweden since the post-war period, where public institutions have taken great responsibility for distributing welfare among citizens through taxation, has gradually been replaced by what is referred to as a neo-liberal policy involving a greater proportion of private stakeholders operating in the welfare sector. This is exemplified by the Swedish Public Transport Act, which, on its introduction in 2012, paved the way for private operators to start competing to operate services.

Two strands (at least) of justice philosophy can be distinguished, one representing a liberal, general and generalised model that distributes resources and burdens equitably among the population, and the other focused on redistributing resources so that people with the greatest needs are given priority in terms of access to resources and are not the ones bearing unfair burdens. One important representative of the liberal approach is John Rawls, whose theory advocates for fundamental equal freedoms and rights, equality of opportunity, and ensuring that members of society with the least advantages receive the greatest benefit when inequality arises. This model of justice as fairness implies that it is 'moraliskt otillåtet att inskränka [individers] grundläggande friheter för att öka majoritetens välfärd eller liknande' [morally impermissible to restrict [individuals'] basic freedoms in order to increase the welfare of the majority or similar] [31]. One criticism levelled at this approach, in simple terms, is the starting point for reaching agreement at the societal level on what is equitable, as not all members of society are able to operate on equal terms depending on their social, economic and cultural status. From a justice perspective in respect of transport [26], the model has also been criticised for discussing justice in very general terms, but that social values are always socially constructed and given meaning through social processes. One example of social process is how public transport has been viewed as a mode of transport for children and older people, and also people who are not allowed to drive for various reasons. This reduces public transport passengers to a specific category in the transport system which, given the emphasis on private car use in transport planning, has been downgraded and thus given lower status. This is also a group of road users that is difficult to organise; unlike motorists, who therefore have a clearer voice when it comes to transport policy issues.

The difficulty with generalised welfare policy distribution models is that there are always groups and individuals who fall 'between the cracks' in the system. This calls for other models of justice philosophy that, instead of focusing on distribution, argue in favour of the need for redistribution between and recognition of different groups in society, as well as ensuring that different groups can interact on equal terms in decisions affecting society [32], as advocated by Nancy Fraser, for example. Fraser is clear that both redistribution of economic resources and recognition of different social groups are necessary in order to increase equality in society. This has been studied in one of K2's dissertations, for instance, on how cycling can be made more equal between different groups in society; but for this to happen, the 'cyclists' category must be broken down into various subcategories. It then becomes clear that one group of people, younger men, feel confident and in control of their cycling, while older people choose not to cycle because they do not feel safe in the traffic environment. Investments in cycling infrastructure to increase speed for one category means downgrading another at the same time. Informed choices can be made by highlighting different categories and the needs of different categories [33]. Fraser argues that there are three principles that help create a more equal society. These three principles relate to redistribution of economic resources; increased political influence for groups that are far from political institutions; and finally, the politics of recognition and the opportunity to participate in socio-political decisions on equal terms. Involving different road user groups in cycling planning helps planners to understand what is needed and whether resources can be allocated so that more people can feel safe and choose to cycle.

Research at K2 and ways forward

Based on the transport policy goals, research at K2 has examined how the transport system and public transport respond to the needs of different social groups and access to transport. There have been continuous efforts to investigate, explore, explain and assist planning authorities in how the gender equality policy goals can be implemented and translated into tools to develop the transport system so that it becomes more gender equal. This is also a field that is firmly rooted in an international context, and the research conducted often involves international collaboration. This ensures that what K2 is doing is of major relevance, not only in a Swedish context and for K2's Swedish partners, but also makes an international impact. This is something that K2 can be proud of. This is important knowledge

that has helped municipalities, regions and national authorities responsible for the transport system to meet existing needs and legislation. There is also a great deal of interest among transport planners and urban planners in understanding how political visions of equality in transport systems and how policies such as gender equality should be put into practice. Many planners find that working with equity and gender equality is difficult to implement in practice. This has been addressed by K2 research through the development of the handbook Transportplanering i förändring: en handbok om jämställdhetskonsekvensbedömning i transportplaneringen [Transport planning in transition: a handbook on gender equality impact assessment in transport planning], the inspirational handbook Socialt hållbar transportplanering: inspirationshandbok med exempel från forskning och praktik [Socially sustainable transport planning: inspirational handbook with examples from research and practice], which forms the basis of a course aimed at transport planners, and Social konsekvensanalys inom transportplaneringen [Social impact assessment in transport planning] [27] [18] [28] [29]. The following (taken from the handbook) are starting points for conducting a gender equality impact assessment (GEIA):

- → It should be inclusive

  The GEIA should have a part to play in the planning process and form an integral part of the organisation. This means that gender equality expertise should be included in the working group(s) from the outset.
- → It should be evaluative

  The GEIA should describe and assess the impacts of the content and actions in the plan or project. This is the impact assessment process itself. This is an important function, but it does not affect gender mainstreaming per se.
- → It should address impacts

  Based on the impact assessment, the GEIA should identify actions that are possible to implement to either maximise positive impacts or limit or avoid negative impacts. This element aims to both improve the design of the plan or project and describe what could have been achieved but has not been implemented for some reason.
- → It should be advisory

  The GEIA should identify what will happen when the current planning stage ends and makes the transition to a detailed planning stage. That is why the advisory function is very important in that it helps to shape a strategy for the further management of the impacts.

That said, new groups are being identified, such as the research that has started to be initiated in respect of people with various disabilities [34] [11] [35]. This area is in its infancy. Another area looks at whose needs and interests are the focal point in the planning of accessibility linked to land use and planning practices, and the impacts of these practices from a justice perspective [36] [37]. Here, K2 researchers have contributed to interpretations and proposals on how more socially just planning practices can be achieved, a central starting point emphasised by both Kjellström, Isaksson, Håkansson & Strohmayer and Vitrano & Lindkvist being to base planning on passengers and highlight them as a heterogeneous group with different needs and circumstances for their travel. Socially sustainable accessibility is also based on socially sustainable working conditions for people doing the work that makes public transport accessible. K2 has contributed a few studies indicating, for example, that bus drivers and train attendants feel vulnerable in their work and are sometimes forced to deal with situations in which both they and fellow passengers are threatened. The scheduling of working hours and working conditions leading to split shifts and problems with maintaining a work-life balance are other dimensions that negatively affect people who create the conditions for public transport [38] [39]. This area requires further development. Additional areas that will need to be explored from both a social and a justice perspective include digital accessibility as more and more transport services are based on digital solutions, and how safety and accessibility in the use of autonomous vehicles should be ensured. K2 has begun to explore these areas, but as in the field in general, there is more to learn and understand to create accessible and equitable transport for the diverse groups and individuals in society.

6 Swedish BRT – adapting Bus Rapid Transit to European conditions

Joel Hansson

BRT stands for *Bus Rapid Transit*. In practice, rapidity (speed) is only one of many quality attributes that form the concept of BRT, together with high service frequency and reliability, for example, as well as attractive stop environments and vehicles. In fact, speed is perhaps even the least prominent quality aspect of the BRT concept, at least when it comes to Swedish applications. This statement probably requires some explanation; but before we do that, we need to take a brief look back in time.

From trunk routes to BRT

The BRT concept began to gain a foothold in Swedish public transport planning at about the same time as K2 was formed, in the first half of the 2010s. This led to the publication of a set of BRT guidelines in 2015 with 'advice for the development of advanced public transport solutions with high quality and capacity' [1]. That same year, K2 organised a conference on BRT with speakers including researchers from the BRT research centre in Santiago, Chile. Both of these events illustrate a desire to try to begin gathering the knowledge that was then available about this relatively new concept in Sweden.

However, the idea of developing higher quality bus services was not new to Sweden, even though the concept had previously been known mostly as *stombuss*, trunk routes. An early example can be found in Jönköping, where the trunk network was developed – and inaugurated under the name *Citybussarna* in 1996 – under the motto 'think rail, drive buses'. Similar initiatives involving trunk routes were also implemented in Stockholm and Gothenburg in the following years.

In parallel, the BRT concept began to be established on an international level, often on a larger scale in mainly South American and Asian cities. The turn of the millennium and the following decade saw rapid expansion in the number of BRT systems worldwide. Applications in cities such as Bogotá, Jakarta and Guangzhou have been highlighted as success stories [2]. When the BRT concept was later adapted to suit Swedish conditions, many of the terms that had been central to the BRT systems in these megacities were inherited, such as high capacity, physically separated bus lanes along the entire route, and full priority at intersections [1]. Although this level of ambition is neither impossible nor unthinkable in a smaller-scale context, it has been shown that the BRT projects implemented in Sweden since then have focused on factors other than capacity and bus lanes [3].

In Sweden, the BRT concept has thus had to be adapted for application in small and medium-sized towns, or as a complement to rail services in Stockholm and Gothenburg. As a result, factors related to capacity and bus infrastructure have been downplayed in favour of other aspects, such as those related to the interaction with walking and cycling [4]. However, it should be emphasised that bus infrastructure is still viewed as a key element.

A similar trend can also be observed from a broader European perspective, with significantly lower demands for infrastructure giving priority to buses than in the South American and Asian role models [5]. These international BRT role models have characteristics similar to those of a metro system, but in Europe (where most larger cities have long-established rail service networks), BRT occupies a different niche; as a complement to rail services in larger cities, or as the backbone of public transport in small and medium-sized towns. The bus service is still of high quality, but on a smaller scale. However, this means that European and Swedish BRT differs from ‘conventional BRT’, the definition of which is based largely on bus infrastructure [2]. The term BHLS – *Buses with a High Level of Service* – is sometimes used in Europe to distinguish the system from conventional BRT, but BRT has taken over as a term here, too, in recent years.

The downplayed focus on infrastructure means that there is no clear definition of the European version of BRT to date. Broadly speaking, there are no other criteria than the fact that the route should in some way be recognised as a flagship in the city’s bus network [5]. Figure 3 shows one such example, the *S-linjen* service in Karlstad, which stands out among the city’s bus services thanks to its specially designed buses and bus stops. Bus lanes and busways do exist, but on a relatively small scale.

> The downplayed focus on infrastructure means that there is no clear definition of the European version of BRT to date. Broadly speaking, there are no other criteria than the fact that the route should in some way be recognised as a flagship in the city's bus network.

Figure 1. The flagship of Karlstad's urban transport system, the S-linjen service, with its specially designed bus stop signs and buses. Photo: Värmlandstrafik/Sofie Grahn

Regional BRT

The idea of applying the BRT concept also at the regional level arose almost immediately after it began to be discussed for urban transport systems in Sweden. The idea, as in the cities, was to try to achieve the same qualities as with high-quality rail services, but by bus. This was more or less uncharted territory; although regional bus routes with BRT qualities already existed in some parts of the world, this was not something that had been conceptualised in the same way as in urban environments. This was why guidelines with 'recommendations for the development of high-quality advanced regional bus transport concepts' were developed in 2016 with the help of experts from transport operators, industry, public authorities and academia [6].

As with urban BRT, 'uninterrupted travel between stations' was still a key part of the concept, but it was recognised early on that bus lanes or bus streets were usually not justified outside cities [6]. Thus, as in the European (and Swedish) version of BRT in urban environments, Regional BRT focuses considerably less

on infrastructure than conventional BRT; and as infrastructure in the form of bus lanes has been a mainstay of the origins of BRT in many ways, Regional BRT as a concept is vaguer. There is no clear definition, except for the fact that it ‘can be viewed as a further development of the concepts involving regional express bus routes and regional trunk routes, that have been created in different parts of Sweden’ [6].

Nevertheless, Regional BRT is deemed to have the potential to raise the standard of bus services in terms of several of the quality attributes that are often high on passengers’ wish lists. This was discussed in a doctoral thesis in 2022, where the most important quality attributes in the form of service frequency, comfort, reliability, connections to stations and travel time were also pointed out [7]. The assessment is that Regional BRT has the potential to achieve the same standard as the regional rail services, or even higher, for almost all of these quality attributes.

The exception is travel time, where buses in general do not have the same potential as rail. Bus services are constrained by speed limits on roads; and because buses have to stop at roadside bus stops, journeys by bus will always be slower than car journeys on the same route. The only exception is if the road is heavily congested and buses can pass any traffic jams using bus lanes and by priority at intersections. Rail services generally operate at higher speeds, which means that they are more capable of competing with cars in terms of travel time regardless of the level of congestion.

This should not be misinterpreted to mean that buses can never be a competitive alternative to cars; after all, travel time is only one of several significant quality attributes. Additionally, the perception of travel time may have altered in recent years in light of the increasing availability of mobile connectivity, which facilitates the use of digital activities while travelling. This should have provided better opportunities for passengers to spend their travel time on things that they find meaningful, be it work or relaxation. This area is still relatively unexplored but work at K2 has begun to shed light on the issue [8].

Terms such as BRT and express services are actually misleading

As explained above, no significant gains in terms of travel time can be expected when Regional BRT is introduced. Even in an urban environment, it has been shown that BRT and BRT-inspired solutions, as applied to date in Sweden, are not

noticeably faster than other urban bus routes [9]. However, this does not mean that the priority measures implemented have been ineffective. Research conducted at K2, for example, has shown that while the removal of stops has very little impact on average speeds, the impact on travel time variability can be greater [10]. Less travel time variability means that travel times become more predictable, which is fundamental for better reliability and, ultimately, more efficient service operation and higher service frequency.

Other aspects have also improved, and it is clear that the BRT initiatives implemented in Sweden over the last decade have resulted in a clear increase in quality compared to 'regular urban bus routes' [3], even if the travel time remains more or less the same. Despite this, the initiatives often have names that allude to speed, such as *Malmöexpressen* [the Malmö Express], *Helsingborgsexpressen* [the Helsingborg Express] or *Snabbusslinjen* [the Rapid Bus Route] (Karlstad). As noted in the introduction to this chapter, the term BRT also focuses on speed if interpreted literally.

It can therefore be argued that BRT, like other terms associated with speed, is misleading for the BRT-inspired projects that have been implemented in Sweden. Before its implementation, buses here did not get stuck in traffic as consistently as they did in the South American cities in which BRT originated. This means there has not been the same obvious need for infrastructure that prioritises buses, nor the same potential for improvements to journey times. Quality improvements are mainly apparent in other ways, with some variation from case to case [3].

Challenges when implementing BRT

The lack of clarity in respect of what BRT means in the Swedish context entails a risk of different stakeholders creating varying expectations in the early stages of the projects. This can create conflict when the projects are then implemented and the stakeholders involved have different visions of what is to be achieved [4] [11].

BRT projects require effective interaction between the municipality (sometimes several municipalities), the region, transport operators and sometimes also the state through the Swedish Transport Administration. Research has also shown that collaboration challenges can arise within each organisation during the transition from concept development to implementation. If concept development takes place in a closed group to make it easier to reach consensus on the actual concept, there is a risk that there will be a lack of understanding of the concept outside this group when the time comes for implementation [12].

During the development of the Regional Superbus concept in Skåne, such areas of conflict arose when the concept began to be discussed with a broader group of people other than those originally involved in development initiative. The biggest debate was sparked by the question of whether or not rural areas should have bus stops. A key component of the concept up to that point had been to remove rural bus stops in order to minimise travel times. When it came to translating this into specific proposals, this component began to be questioned by stakeholders who had not been involved in the original concept development [12]; they were not prepared to make that kind of sacrifice for an untested concept with rather unclear benefits. Moreover, recent research has shown that rural bus stops have only a marginal impact on journey times. They are certainly more important in terms of reliability; but the density of bus stops in urban areas is even more important, so focus should be directed there in the first instance [10].

Nevertheless, it is important to recognise that the improvements to be achieved will require compromises in other areas [12]. Better reliability or more direct routes often require certain controversial decisions to be made: the removal of bus stops, for example. BRT routes are never introduced as overlay systems, where the original route network remains intact. Instead, they are associated with different types of changes. While these changes may result in better public transport services for many, it is inevitable that some people will experience a deterioration at the same time. Planning BRT, like other public transport services, always involves trade-offs between different interests [7]. Understanding these trade-offs provides a more robust foundation for the implementation process.

Every bit as important is the understanding that measures prioritising buses mean that other demands in the urban environment need to take a back seat; that is the very meaning of ‘prioritising’. The introduction of BRT being accompanied by conflicts over the redistribution of street space from cars to public transport is a more or less global phenomenon. However, it has been shown that this conflict in the Scandinavian context also involves pedestrians and cyclists [13]. It also appears that there is a clearer conflict here between bus priority and urban qualities. This conflict has been internalised in a number of Swedish BRT projects by packaging them as urban development projects rather than purely traffic engineering projects [4] [14]. In practice, this means that the conflict has shifted from being between the BRT route as a whole and different urban qualities along the corridor, to becoming instead a matter of different design options along the BRT route.

> It is clear that the BRT initiatives implemented in Sweden over the last decade have resulted in a clear increase in quality compared to “regular urban bus routes.

Scorecards as a basis for planning

The adaptation of BRT to the Swedish context has gone through several phases and is still ongoing. Initially, the discussion on BRT was largely based on international experiences, presenting BRT as a (cheaper) alternative to rail services. When the first *Malmöexpressen* service was inaugurated in 2014, launched as 'Sweden's best urban bus route' [15], the concept was also based on the fact that it could be converted into a light rail service at a later stage. Figure 4 shows an example of how this is reflected in the design, at least on some sections of the route.

Figure 2. The first Malmöexpressen service (route 5) has bus lanes in the middle of the street on some sections of the route, a design reminiscent of light rail.

The perception of BRT as an alternative to (or a step towards) light rail has gradually become less and less prominent, although it is still mentioned occasionally. Discussions on BRT in Sweden now focus instead on improving bus services in many different contexts, even in areas where rail services are not considered to be a viable alternative.

An initial attempt to adapt BRT to Swedish and European conditions from a more general perspective was made in 2015, when a set of guidelines was published to support and inspire the development of high-quality bus concepts in Sweden. At the core of these guidelines is a list of parameters, each of which is described at two levels: green level, corresponding to 'full BRT', and yellow level, which 'can

be accepted to a limited extent' [1]. The parameters are divided into four categories: Urban Design, Public Transport Infrastructure, Vehicles and Support Systems, and Service Operation.

However, when these guidelines were later applied in practice, they were perceived by some stakeholders as being too vague, which meant that important components of the concept were at risk of being lost. To mitigate this risk, an assessment tool was developed for Swedish BRT, concretising the guidelines in the form of a scorecard with total scores from 0 to 100 and a resulting three-level rating [16]. The structure was taken from the international BRT literature, where a similar assessment tool had been developed previously [2].

After a few years of use in practical planning situations, a need to further develop the assessment tool was identified, which eventually led to an update under a new name: Planning Tool for Swedish BRT [17]. This change of name reflects the fact that the tool is now more clearly focused on primarily serving as support in the early planning stages and can be viewed as a response to the challenge identified when different stakeholders developed differing expectations for BRT projects. The planning tool is intended to prevent this by providing a platform for discussions on the level of ambition and concretisation of ideas relating to BRT and BRT-inspired measures.

The planning tool still does not provide a clear-cut definition, as BRT status can be achieved in several different ways. It thus offers a great deal of flexibility in relation to the BRT concept, where quality improvements can focus on different aspects that may vary in each individual case [4]. However, this is not the same as lowering the bar for BRT; the scorecard is designed to reward design decisions that ensure public transport quality standards are improved, and that are often politically challenging to some extent [17].

Flexibility in execution

The flexibility inherent in the concept allows for adaptation to varying conditions in different local contexts. As already stated, this has resulted in less focus on infrastructure in the applications that have been implemented in Sweden to date, compared to international BRT role models [4]. The initiatives have included a certain number of measures designed to give buses priority, such as bus lanes on certain sections deemed to be particularly critical, but have mainly achieved high standards in other aspects such as vehicles, service operation and bus stops [3].

The bus priority measures that have been implemented should not be underestimated, however; they are far from insignificant. Here, too, there is a great deal of flexibility and a wide range of potential measures. Bus priority can thus be adapted to different local conditions depending on the width of the street, the location of destinations and the impact on other modes of transport, for example.

The bus priority measures can be categorised into two main types: temporal and spatial priority [18]. Temporal priority means that the bus is somehow given priority when allocating time for different traffic flows at intersections. This can be done both at intersections without traffic signals, by giving priority to the buses' direction of travel, and at signal-controlled intersections, by means of signal priority. In turn, the concept of signal priority encompasses a variety of options, but all of them involve adjusting the signal phases in some way to provide better accessibility for bus services through the intersection. The different options are based on various technical solutions but can also be selected depending on the degree to which bus services should be given priority over other modes of transport.

Spatial priority relates to the allocation of space in the street environment and includes both bus stops – which can be designed according to different principles (such as bus bays, in-lane bus stops and bus bulbs) – and bus lanes. For many of us, bus lanes are probably the epitome of bus priority; and also in this case there are many design parameters to consider. The most significant parameter is the location of bus lanes in the street environment, where international expertise suggests that median-aligned bus lanes provide better priority than curbside bus lanes [2]. This also provides better conditions for physically separating the bus lanes from the other lanes by means of a curb or even a traffic island with trees or similar.

The downside of flexibility

The flexibility of the concept, as well as the design of its individual components, has probably helped to increase the chances of planned BRT initiatives actually being implemented. It may also have sparked greater interest in the concept when people have seen that it can be adapted to their own planning context, even if it concerns a relatively small town.

But flexibility also has drawbacks. Firstly, as already stated, it is associated with a certain degree of ambiguity and hence a risk of differing expectations among various stakeholders involved. Secondly, flexibility has led to inconsistent design of the BRT routes implemented in Sweden to date, using different solutions on different sections.

These sections may be relatively short, which may mean that several different design principles (such as mixed traffic, median-aligned bus lanes and curbside bus lanes) occur within just a few hundred metres [3]. In many cases, this is likely to result in poorer bus priority than if the design were more consistent [9].

Thirdly, the flexibility of the concept may in many cases make it more difficult to maintain high priority for bus services throughout the entire planning process [14]. Flexibility means a higher risk of compromises to bus priority at some stage; because of concerns about excessive consequences for cars, for example. For light rail, by comparison, it is technically more difficult to make frequent switches between different design principles, which paves the way for greater consistency along the route and, ultimately, fewer compromises with public transport priority [3] [14].

That said, it is perhaps becoming less and less relevant to make comparisons of this kind, as BRT in Sweden has developed in a niche of its own rather than as an alternative to light rail. There was frequent emphasis on this comparison a decade ago, and BRT was presented as a concept with the potential to offer a more rational solution than light rail investments. This rationality was based on a traffic engineering perspective, where BRT was ascribed the same capacity and service quality as light rail, but at a lower price and with less sensitivity to disruptions. On the other hand, light rail was attributed urban development characteristics that BRT was largely regarded as lacking [14].

A decade has now passed since the inauguration of the first *Malmöexpressen* service, sometimes referred to as Sweden's first BRT route, and several BRT-inspired routes have been added since. These initiatives all have in common the fact that urban development is a key motive, so there is no fundamental difference compared with corresponding light rail projects. On the other hand, completed BRT projects do not achieve a level of capacity or priority comparable to light rail. The fact is that research into the subject points to an inherent conflict between the arguments that BRT is able to offer the same capacity as light rail services and be an instrument of urban development at the same time [14]. The Swedish BRT projects implemented to date have focused on the latter.

This ambivalence in respect of capacity and priority versus urban development is possibly one explanation for the initial confusion with regard to BRT in Sweden. At this point, however, the sample bank starts to reach a critical mass and so it becomes possible to identify certain patterns [3]. These patterns, and other experiences from the initiatives implemented, may provide important lessons for the ongoing development of BRT in Sweden.

7 Demand-responsive public transport

Åse Jevinger

In recent years, public transport stakeholders have demonstrated an increasing interest in demand-responsive public transport; that is, bus services that are open to the general public and provide travel on demand. This increase in interest can be viewed as an indication of a shift from concentrated bus routes, with sparse bus routes in rural areas, to greater area coverage. By increasing area coverage, accessibility for the travellers can be improved. Moreover, thanks to technological developments in recent years, this type of service can be offered more efficiently than before. For instance, booking travel, which used to involve a phone call and perhaps even waiting in a queue on the phone, can now be done with ease using an app. The flexibility of demand-responsive public transport means that the service has the potential to resolve many problems; but that said, it has proven to be inefficient in many situations. Therefore, it is important to find an appropriate design and a suitable context to ensure the success of a demand-responsive public transport service.

Background

Traditionally, scheduled public transport, that is, transport that runs according to a fixed timetable, has been dominant in Sweden and elsewhere. However, scheduled public transport has been complemented by on-demand transport services (anropsstyrd kollektivtrafik) for several decades. On-demand transport is a generic term for transport that is provided only if someone has booked travel in advance [1]. There are several different forms of on-demand services, and they can be labelled differently depending on the type of service in question. Some common forms and names are flex traffic (flextrafik) local services (närtrafik), service trips (serivceresor) and booking-based services (beställningstrafik).

On-demand transport services can be restricted in various ways: in terms of where it is available and who is allowed to use it, for example. Mobility services

(färdtjänst) and medical travel (sjukresor) have typically been the most prominent on-demand services for specific groups of passengers, while local services (närtrafik) have been the most common kind of service open to all. Local services are usually designed to allow residents in areas with little or no traditional public transport to get to the nearest major town and so access services and other public transport. These services normally use minibuses or cars and are often quite limited in terms of area, pick-up and drop-off points, operating hours and prebooking, for example. For instance, local services in an area may comprise a taxi that runs scheduled trips on demand, where passengers who meet certain requirements (such as being registered as resident in the area) are given a limited number of trips per month to selected destinations [2].

In recent years, the term ‘demand-responsive public transport’ has begun to be used increasingly to cover on-demand services that are open to the general public and provide travel in the near future, which means that passengers do not need to book their travel a long time in advance. The term Demand-Responsive Transport (DRT) means that vehicles adapt their route depending on passengers’ specific transport needs at that particular time. Hence, the vehicles, usually small buses, do not stop at predefined places and/or times; instead, the current transport demand determines where and/or when the vehicles stop. Passengers usually book their travel via an app, and it is possible to book travel for individual passengers as well as for small groups. The service is open to all, and payment is made per person, not per vehicle. Unlike taxi companies, the operator aims to maximise ride sharing.

One of the reasons why demand-responsive public transport is being viewed as an increasingly attractive alternative to regular public transport is the technological developments in recent years that enable positioning and allow passengers to remain constantly connected. This makes it possible to maintain effective communication between the operator and the passenger during bookings, updates and changes, for example. Additionally, many public transport stakeholders are seeing an increasing need to find new solutions that can improve sustainability and cost-effectiveness, as well as increasing accessibility for various passenger groups in society. For instance, demand-responsive public transport has proven to be more economically sustainable than traditional public transport in some sparsely populated areas [3]; and from an accessibility perspective, demand-responsive public transport allows for shorter distances to stops and greater flexibility in terms of departure times. Unlike scheduled services, demand-responsive public transport offers the opportunity to reduce vehicle kilometres in times of low demand, as demand is known on account of passenger bookings. For the same

reason, the number of large vehicles can also be reduced, in favour of smaller and cheaper vehicles requiring less fuel.

By and large, it is hoped that demand-responsive public transport will help to make public transport both more efficient and more attractive. The latter may, in turn, help to reduce private car use. From previous studies in the field, it can be concluded that demand-responsive public transport has the potential to contribute to a range of improvements in terms of both efficiency and attractiveness, but that there are challenges in predicting in advance how well a particular demand-responsive transport solution will perform in any given context. On an international level, there are a number of examples of both ongoing and completed demand-responsive public transport services. The more well-known ones include MOIA in Germany, Flextur in Denmark and Bridj in Australia. Sweden, for example, has the X-linjen service in Säffle and Sunne, Paxa in Sundsvall and Sollefteå and Buss on demand in Ulricehamn and Kinna. The services implemented exist in various forms and contexts. For instance, both commercially driven services (such as MOIA) and services driven by public stakeholders (such as Flextur) are on the market at present. Many of these services are subsidised. Furthermore, some are aimed primarily at rural areas (such as Worcestershire on Demand in the United Kingdom), while others are located in urban areas (such as MOIA), or in both rural and urban areas (such as Hvv hop in Germany).

Many of the demand-responsive public transport services that have been launched over the years have eventually been discontinued, for various reasons. It may be difficult to draw general conclusions from these cases, but earlier research has indicated some general challenges and success factors. For instance, it has been found that demand-responsive transport services with low operating costs and simple routes (with many pick-up points and few drop-off points, for example) often have greater potential for success than services with high costs and complex routes (such as door-to-door services). Furthermore, a lack of knowledge of the passenger market has resulted in failed services in several cases. The various socio-economic and demographic characteristics, in combination with the specific travel needs of individuals and households in different parts of the world, influence the use and attractiveness of demand-responsive transport services. In particular, public acceptance of new types of travel services, which demand-responsive transport services often are, for the vast majority, can present a challenge.

> By and large, it is hoped that demand-responsive public transport will help to make public transport both more efficient and more attractive. The latter may, in turn, help to reduce private car use.

Thus, previous research shows that some of the most significant success factors for a demand-responsive public transport service are solutions that have low operating costs and are adapted to a passenger market that is receptive to this type of service. An efficient service with a high level of ride sharing can be achieved if the service succeeds in attracting a large number of passengers, and then, hopefully, the number of trips made by private car can be reduced. Attracting a large number of passengers usually requires a high level of service quality. However, in many cases there may be a conflict between service quality and system efficiency. A demand-responsive public transport service that offers door-to-door transport in 'real time', for example, where bookings can be made right up to departure time, provides the passenger with high service quality. However, this solution may result in an inefficient route in terms of both time and distance travelled. That is why it is important to create a good understanding of both the target group and the available design options and their impacts.

Design

There are a variety of design choices to consider when implementing a demand-responsive transport service, as reflected in the various forms of services that are or have been available on the market. Within the framework of the project Policy lab for public transport on-demand, which is run by K2 researchers, efforts have been made in 2023 and 2024 to identify various design aspects and map these against existing demand-responsive transport services [7]. From this work, it is thus possible to infer the design choices made for the various services. Previous research studies also identify potential practical as well as theoretical design choices for this type of service (see [4] [5] [6], for example). The results of these studies, including the work of the Policy lab project, indicate that in terms of vehicle type, minibuses are most common, sometimes in combination with cars, which may run on different kinds of fuels. Autonomous transport exists on a smaller scale but is predicted to play a larger part in demand-responsive public transport going forward. Having the vehicle driven by a driver impacts the cost, obviously, but also other efficiency-related factors such as downtime during breaks and reallocation during driver changes. However, having a driver may provide a sense of security for passengers.

7 Work conducted by Pernilla Björverud and Eva-Lena Eriksson.

To increase vehicle utilisation, the same vehicle can be used dynamically for different types of journeys. For instance, the same vehicles can be used for demand-responsive public transport in the evenings and at weekends, and for traditional medical travel during the daytime on weekdays. Another solution that is increasingly seen as interesting involves integrating demand-responsive public transport with special public transport, such as mobility services (färdtjänst). There are also studies that examine demand-responsive public transport integrated with parcel delivery [7]. These types of integration may, of course, influence vehicle design and equipment requirements.

Demand-responsive public transport can either replace timetabled public transport in a given area, introduce public transport to an area or coexist with public transport in an area. Coexistence may mean that the two services run entirely in parallel with one another, or that one complements the other; with the demand-responsive transport service taking passengers to a scheduled high-capacity route or to a hub for scheduled public transport, for example. This relationship may also vary at different times of the day. Transport to and from a public transport hub is one example of what is known as a many-to-one model; that is, the service runs from several pick-up points to a single drop-off point. Besides public transport hubs, shopping centres or natural areas, for example, could be used for such drop-off points. Return transport is normally offered, too. Another model involving multiple pick-up and drop-off points is known as many-to-many. Door-to-door transport is one example of this model. Similarly, there are also zone-to-zone structures whereby demand-responsive services transport passengers from one area to another and back again. Some services combine several different models: by travelling from an area to a central location in the morning, returning from the central location to the area in the afternoon, and travelling freely within and between the areas at other times, for example. Other services offer a more traditional model which involves the bus following a set route but runs only when needed; that is, if anyone has booked it.

Depending on the needs that demand-responsive public transport is intended to meet, the model for stops may also vary between services. In a door-to-door solution, the pick-up and drop-off addresses provide the stops for the service. Other types of stops can be divided into fixed and variable stops, where the fixed stops can be physically marked. Today’s scheduled stops are examples of physically marked stops. One option for both fixed and variable stops could be to mark the stops only in digital media, on a digital map in an app, for example. Unlike fixed stops, variable stops can be moved, often depending on where a bus can stop in purely practical terms and what would be most efficient from the

standpoint of the operator and passengers. In order to enhance route efficiency, the operator may also direct a passenger to a stop other than the one requested, regardless of whether fixed or variable stops are used.

In modern services, passengers usually book their travel via a dedicated app, or an interface integrated into the regular journey planner app. There are differences in how far in advance passengers need to book. A service that allows real-time booking, that is, the passenger can request departure 'as soon as possible', has less scope for efficient planning of route, driver and vehicle. That said, requiring more advance notice, a couple of hours, for example, may make the service less attractive to some passengers. Replanning the route to make a detour to pick up/drop off more passengers than initially planned, for example, may mean that the passenger's journey is not the same as the one indicated in the itinerary provided when they booked. One way to compensate for this could be to apply variable fares, where passengers could choose to pay more for journeys with little risk of change, or less if there is a greater risk of change. There are also pricing models that follow the demand for travel, resulting in higher fares when demand is high. A more common model is always to apply the same prices regardless of demand and the risk of changes. Travel guarantees may sometimes be issued in the form of different types of time limits so as to reassure passengers that not too many changes will be made. This may, for example, include maximum detour times, or restrictions on how late or early a vehicle may arrive to pick up, in relation to the booked time. In general, fares for demand-responsive transport services are often the same or slightly higher than for scheduled public transport. Some services allow travel with a monthly season ticket, which raises questions about how to deal with passengers who fail to turn up despite having booked a trip, and to what extent passengers opt out of more socially beneficial alternatives such as cycling and walking in favour of the service. There are various types of restrictions that can partially mitigate this type of problem, such as limiting the number of trips per day/week that one and the same passenger can book.

Booking a trip and subsequent interaction with the passenger via the app enables a range of services to be provided that can make life easier for the passenger. For instance, more precise arrival and departure times can be provided as the journey approaches, and guidance to the pick-up point can be provided in text or map form, for example (which may be particularly important if stops are variable). Other examples of services include updating the real-time position of the vehicle in question via a map in the app, the option of seeing the vehicle's planned route and stops along the way, or simply a photo of the vehicle and its registration number, which can provide peace of mind.

The above text shows examples of a few of the most important design choices that need to be made when implementing a demand-responsive public transport service. However, there are a number of design choices as well as other types of choices related to aspects such as procurement and communication, that also need to be taken into account during implementation.

Impacts

There may be different objectives for introducing a demand-responsive public transport service. It is often a matter of increasing accessibility in a particular area, as the demand-responsive transport service increases the public transport offering, for example, but it may also involve cost savings or environmental sustainability. Cost savings can sometimes be achieved if the demand-responsive transport service replaces a larger, scheduled bus with relatively low occupancy. Ecological sustainability can be achieved in the same situation, but also in cases where the service replaces private car use. Changes in accessibility, costs and ecological sustainability may therefore be important aspects to study in order to acquire an overall view of the effects.

Accessibility before and after the introduction of a new demand-responsive public transport service is dependent mainly on how the service is structured, the other transport services it may replace and the nature of the travellers. There are plenty of research studies on public transport accessibility, but only a small number of these focus on demand-responsive public transport. The ones that do, often demonstrate increased accessibility in the areas in which the service is implemented [8]. The studies also show that there are many different ways of measuring accessibility in public transport, reflecting a variety of aspects [9] [10]. These aspects can be roughly divided into temporal and spatial aspects; that is, transport accessibility in time and space. The results are often illustrated using maps of the area in question, with different shades of colour to indicate increased and decreased accessibility. It may also be of relevance to examine perceived accessibility, that is, how accessibility is perceived subjectively by passengers, as a complement to traditional, objective measures of accessibility.

Costs and environmental sustainability are related to some extent. If vehicles running on fossil fuels are used, fewer vehicle kilometres normally lead to both lower costs and lower emissions. Quite a few research studies examine the effects of replacing existing scheduled public transport with demand-responsive public transport, and the stops used for scheduled services are often retained in order to

facilitate comparison. With demand-responsive public transport, the bus will only stop at some of these stops (depending on demand), which means that vehicle kilometres and emissions are reduced [11]. In studies that instead examine demand-responsive public transport with more frequent stops, such as door-to-door services, vehicle kilometres and emissions may increase compared to scheduled services, in favour of the higher quality of the transport service (in terms of time and increased geographical coverage).

The results of various studies of the effects of demand-responsive public transport present a complex view which shows that a number of interacting factors have a part to play. In particular, it may be difficult to achieve a high level of ride sharing, which means that journeys made using demand-responsive public transport may generate more vehicle kilometres than if the journeys were made by private car instead (as the demand-responsive transport service also includes trips to/from pick-up/drop-off points with vehicles empty) [12]. A simulation study of Sjöbo with demand-responsive public transport integrated with scheduled public transport shows an increase in vehicle kilometres in relation to equivalent direct transport by private car [13]. However, another simulation study of the Gothenburg region shows that demand-responsive public transport can reduce vehicle kilometres if some drivers of private cars choose to switch from private car transport to the demand-responsive transport service [14]. These two studies illustrate the complexity of the many different factors that influence vehicle kilometres. In general, however, it can be seen that the opportunities for reducing total vehicle kilometres with demand-responsive public transport have been relatively limited in most studies.

However, an increase in vehicle kilometres does not necessarily mean an increase in emissions. A simulation study by Dytckov et al. [15] replaces scheduled bus services with demand-responsive public transport on the island of Lolland in Denmark, maintaining demand and comparable waiting and journey times. The results show that the demand-responsive transport service requires more vehicles and generates more vehicle kilometres, but fewer emissions are generated because the vehicles are smaller. The total costs of the two services are at the same level. The study also indicates the thresholds at which demand is so high that scheduled services would be more beneficial. Another potential effect of introducing demand-responsive public transport is that the total number of vehicles in society could be reduced. Each ride-sharing vehicle in the simulation study of the Gothenburg region as referred to above could potentially replace five private cars. The study also shows that different areas may be affected in different ways, as the number of cars in the study decreased for almost all road types, especially on the

major roads leading into or through the city, while the number of cars increased on roads in residential areas with no through traffic [14].

The introduction of demand-responsive public transport usually involves larger numbers of smaller vehicles, and therefore more drivers, in relation to scheduled public transport. Additionally, investments in hardware and software for transport planning are likely to be needed. However, the smaller vehicles are cheaper and require less fuel. Furthermore, they can also be used for other purposes, such as special public transport, at times of the day when they are not being used for the service. For a demand-responsive public transport service to be cost-effective, the final cost needs to be lower than the equivalent cost of alternative solutions, such as scheduled services. Of course, this is not always the case [16]. For instance, a study that uses mathematical modelling to examine the introduction of demand-responsive public transport in a number of villages in Hungary concludes that introducing demand-responsive public transport is justified in terms of cost in some of the villages, while in other villages it is better to maintain the current public transport system [17].

Of course, the cost of drivers plays a major role in the overall cost structure for demand-responsive public transport, particularly in relation to scheduled services. In the longer term, therefore, the development of autonomous vehicles could create a much greater competitive advantage for demand-responsive public transport. Thereby, there is potential to increase accessibility while enabling costs to be reduced.

Passenger perspective

The inclination of the intended target group to accept and start using demand-responsive public transport has proven to be one of the key issues for the success of this type of service. Of course, this inclination is largely dependent on the quality of the service and the ease with which passengers can interact with the service; in particular, how easy it is to book and receive updates on journeys. However, different target groups may have different needs and requirements, which means that the design and geographical area of the service may need to be adapted according to the intended target group. That is why it is important to gain as much of an understanding of the target group as possible. It is also important to remember that even if a service poses major cost challenges for the operator, it may sometimes fulfil other important requirements, such as accessibility to shops or healthcare.

The research literature includes a number of studies that attempt to identify the distinguishing features of the people who are most likely to use demand-responsive public transport. A study from the United Kingdom identified a number of characteristics in people who live in areas where demand for demand-responsive transport services is relatively high: low car ownership, low population density, high proportion of white people and high social deprivation [18]. Additionally, people with disabilities have been shown to be more likely to travel with demand-responsive public transport [19]. Men travel less frequently than women before retirement age, while no significant gender differences can be seen for pensioners [19]. Furthermore, demand-responsive transport services for commuting, as well as for access to entertainment, recreation and other modes of transport (such as airports or railway stations) have proven to be attractive to passengers [19] [20]. However, the success of these services is reliant on the fare for the journey and the availability of parking spaces, as they often compete with private car travel.

A research study by Jevinger and Svensson [5] conducted within the scope of the K2 project 'Towards integrated and adaptive public transport' examines passenger preferences and acceptance levels for different design alternatives in demand-responsive public transport. This study focuses on three different age groups: children and adolescents (aged 6–17), adults (aged 18–69) and older people (aged 70 and over). The results show that the age groups have similar levels of acceptance in many cases, particularly with regard to acceptance of delays and departure intervals. For instance, booking at least 30 minutes in advance is accepted by the majority of respondents, and most respondents also accept that a journey by demand-responsive public transport will take longer than an equivalent journey by car. These are factors that can affect the effectiveness of the service. Furthermore, Dytckov et al. [15] show that the larger the time window used for possible departure times in relation to passengers' preferred departure times, the fewer vehicles and the fewer vehicle kilometres are required.

Although different age groups have similar acceptance levels in many cases, Jevinger and Svensson [5] show that older passengers (aged 70 and over) differ in some respects. For instance, they are less likely to accept digital solutions, such as booking via an app or stops that are marked only digitally. They are also less accepting of changes to pick-up points, especially if they have to walk an extra 400 metres to reach the new stop. This can be compared with the results of the above-mentioned simulation study of the Gothenburg region, which examined various effects when the distance between stops was increased from 100 to 300 metres [14]. The study shows that vehicle kilometres decreased by about 7 per

cent while total journey time for passengers increased by about 32 per cent on account of the longer distance to walk. Overall, the two studies show that longer distances to stops may result in efficiency gains, but at the expense of service quality and passenger acceptance, which means that the number of passengers may decrease.

Jevinger and Svensson [5] also show that there are other design alternatives that both provide scope for different types of efficiency gains and are accepted by the majority of respondents (10-minute departure intervals, booking at least 30 minutes in advance, etc.) The study also shows that about half of respondents say they would use demand-responsive public transport every month or more frequently, while about 10–15 per cent of respondents say they would never use the service. It is difficult to identify specific target groups for demand-responsive public transport from the variables examined, but some characteristics of the people who say they would use the service can be identified. For instance, people who already use public transport, younger adults and people living in cities are more willing to use the service. The results of the study do not suggest that car drivers would be particularly inclined to switch modes of transport, from car to demand-responsive public transport. However, it is hoped that a demand-responsive transport service that attracts sufficient passenger numbers, such as people whose transport options were previously inadequate, can become sustainable over time and eventually attract new groups of passengers, such as car drivers.

In general, the research literature shows that people have an interest in this type of public transport [5]. Although previous studies provide some general answers on people’s preferences and differences between different age groups, stakeholders need to explore the specific passenger characteristics in the selected area for demand-responsive public transport. This can be done by means of interviews or surveys, for example. Additionally, it is important to be patient after introducing a new demand-responsive public transport service, as behavioural changes often take time [21]. It may also take some time for the operator to build up an understanding of the behaviours and needs of different target groups, which means that the design of the service may need to be adapted over time.

8 How rail service punctuality can be improved

Carl-William Palmqvist

Punctuality is repeatedly viewed by passengers as one of the most important factors and indicators in respect of rail services [1]. It is usually measured as the percentage of passenger trains arriving at the terminal station with a delay of five minutes or less. The rail industry joined forces in 2013 to set a target of 95 per cent of passenger trains arriving on time and remains committed to this target.

The 95 per cent punctuality target was probably set because it is a round number that is easy to remember, and it appeared ambitious but not unattainable. In Japan, the world leader in this regard, punctuality measured in the same way stands at around 98 per cent, and delays are perceived as a problem even there. Thus, there is no guarantee that everyone would suddenly perceive punctuality as a non-issue just because the 95 per cent level is reached: it would still be important to further improve quality. That said, 95 per cent would still represent a significant improvement on previous levels, and it is a necessary step towards achieving even higher levels.

Punctuality can also be measured at each stop: this is often referred to as en-route punctuality. This figure is usually a percentage point or so higher[8], but the measures are strongly correlated and so it makes little difference in practice. Similarly, there is often a desire to measure passenger punctuality, rather than train punctuality. Again, the measures are strongly correlated as passengers cannot be more punctual than the trains they ride on. Rather, adding the passenger perspective makes punctuality even more important, as there are then connections that are at risk of being missed, but that does not make achieving the target any

8 The reason for this is that delays tend to increase and punctuality tends to decline according to the length of the journey, which means that punctuality at stops along the way has not yet deteriorated as much as it will by the time it reaches the terminal station. Thus, taking these stops into account usually leads to a slightly higher level of punctuality than if they are not included.

easier. That is why this chapter focuses on the traditional definition in this respect. A major contribution to knowledge in this area was made in the K2-linked doctoral thesis [1] presented by the author of this chapter.

Punctuality trends in the 2000s

By the time the COVID-19 pandemic began, the punctuality target was almost reached: 94.9 per cent of trains arrived on time. The level has fluctuated by one percentage point or so both before and after that exceptional year, at an average of around 91 per cent. Figure 1 shows the evolution of punctuality between 2001 and 2023. It shows several periods of slow, gradual improvement over a few years, followed by a period at a significantly lower level, and then a recovery to normal levels. Some years stand out as clearly negative: 2010 was the worst, heavily influenced by an extreme winter that caused disruptions. 2011 was almost as bad, for the same reason. 2018 saw a clear drop in punctuality, caused both by a relatively (but not as extreme) cold and snowy winter, and then a very hot and dry summer. There has been a clear negative trend since the peak in 2020, but without the weather providing the same clear factor, and 2023 was close to reaching the previous low from 2010. Indications to date in 2024 are that the level is stabilising at around 88 per cent, rather than continuing to fall or bouncing back to a previous normal level. In other words, the industry still has a long way to go before the punctuality target can be viewed as having been achieved.

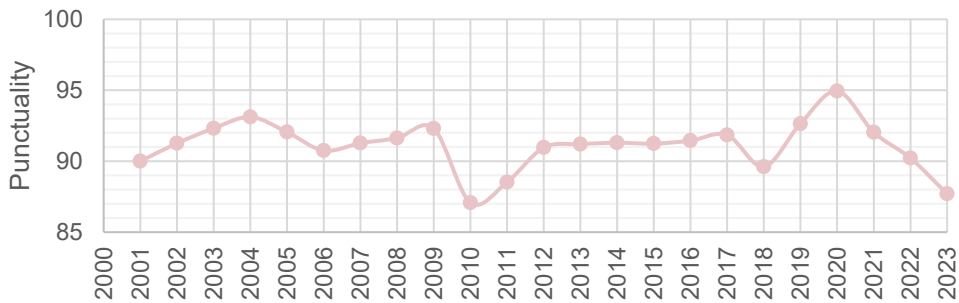

Figure 1. The evolution of punctuality from 2001 to 2023 refers to the arrival of passenger trains at the terminal station measured by RT+5; that is, the percentage of passenger trains delayed by five minutes or less on arrival at the terminal station. Own processing of data from Transport Analysis [2].

The longer the journey, the worse the punctuality

In general, it can be said that punctuality in Sweden decreases with the length of the journey. It is best over short distances (90–95 per cent), worst over long distances (70–80 per cent), and in between over medium distances (85–90 per cent). Of course, this is not a law of nature, but rather how things have been here in Sweden in the 21st century. In Japan, for example, the opposite is true: there, long-distance express trains are more punctual (>99 per cent) than local and regional services (approx. 98 per cent). There is such a spread in the number of trains over different distances that it is not enough to improve the punctuality of the trains that are already the most punctual: even long-distance trains have to approach 90–95 per cent punctuality for the target to be within reach. One reason for this in Sweden is that all trains share the same track. This means that long-distance trains must pass through several local and regional transport systems, thereby increasing the risk of extensive delays. In Japan, express trains, their long-distance trains, run on separate tracks and so do not have to interact with local and regional transport systems.

Most delays are small

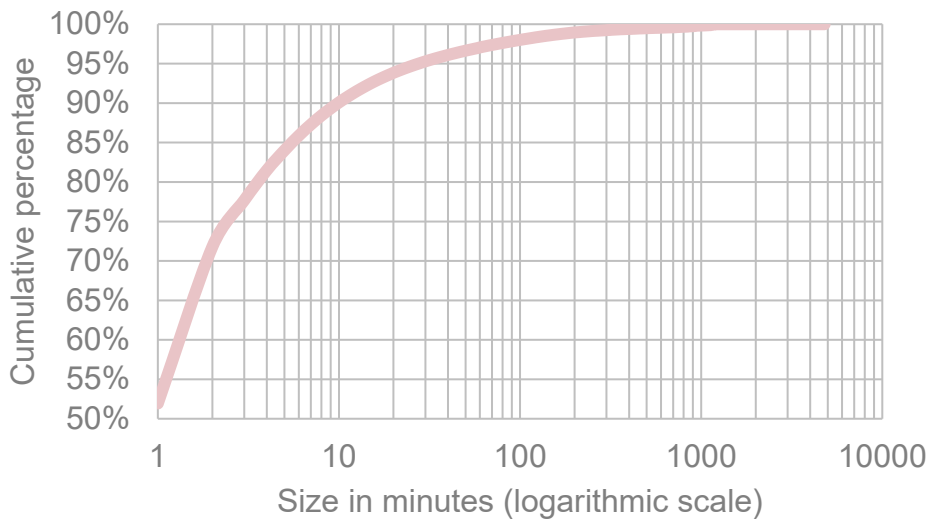

Figure 2 Cumulative distribution of train delays in Sweden between 2001 and 2020. The x-axis is shown on a logarithmic scale to illustrate the breadth of the distribution. Own processing of data from the Swedish Transport Administration's Lupp system.

A delayed arrival is often the result of several different delay events, and a degree of recovery of the delays. It is necessary to understand the events to get to the bottom of the problem. A delay event in this regard is a journey or stop that takes longer than planned. Other runtimes or stops can sometimes be faster than planned, leading to some recovery of the delay. Figure 2 shows the proportion of all delay time due to events of a certain size. The size is shown on a logarithmic scale due to the wide range of distribution. The largest recorded events have been approximately 5,000 minutes, which is more than three days. However, such major events are extremely rare, and the far left of Figure 2 shows that more than half of all delay time is accounted for by events of just one minute, and more than 70 per cent by events of up to two minutes.

What causes delays, and whose fault is it?

There is a well-developed and established system to identify and code the causes of delay events of three minutes or more. When these occur, the dispatcher has to enter one of more than 200 codes from a three-level system to indicate the reason for the delay. Figure 3 shows the distribution of coded delays at the most general level[9], for the period 2001–2020. This shows that 8 per cent of coded delays are due to dispatching, 31 per cent to infrastructure, 43 per cent to railway undertakings, and 18 per cent to accidents and other external factors.

9 The official statistics also include the category ‘Secondary delays’ and an additional marginal code. However, ‘secondary delays’ is a misleading code, as the system is based on attributing delays to the root cause as far as possible. For instance, a secondary delay following a primary delay caused by a point switch failure should be coded ‘Point switch failure’, not ‘Secondary delay’. Thus, the code ‘Secondary delay’ only includes cases where a train has been disrupted by another train, but the reason why the disrupting train was in the way is unknown. In other words, ‘Secondary delay’ in the coding is a euphemism for ‘Unknown cause’, and so it is not included in this figure.

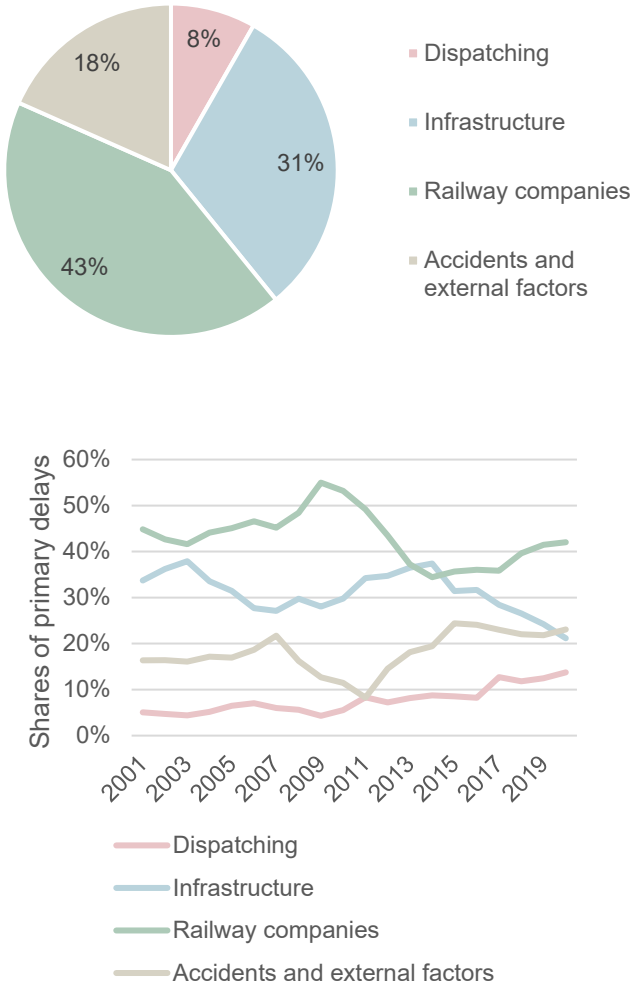

Figure 3. Above: Level 1 cause code for additional delays in the Swedish Transport Administration's Lupp system, 2001–2020. Below: Year-on-year fluctuations in the meanings of cause codes, 2001–2020. Own processing of data from the Swedish Transport Administration's Lupp system.

The proportions between the different causes of delay vary from year to year, as illustrated on the right in Figure 3. This figure shows that the percentage has been increasing slowly but steadily for Dispatching, while for Infrastructure it has fluctuated and declined slightly in recent years. The percentage for Railway Undertakings has almost always been the highest but has fallen slightly in recent years, and Accidents and Other External Factors has gradually increased and was

higher than Infrastructure in 2020. The Swedish Transport Administration, which is responsible for both Dispatching and Infrastructure, and Railway Undertakings are both responsible for around 40 per cent of delays, while around 20 per cent are due to external factors for which it is difficult to allocate responsibility. The problem is quite complex, therefore, and there is no one stakeholder or cause of the delays and lack of punctuality.

More trains in the system leads to more errors

The fact that infrastructure's shares of delays have decreased does not mean that the number of delays has decreased. Figure 4 shows how the number of failure reports per day in Ofelia (a system for tracking infrastructure failures, for the most part) has increased gradually year on year, almost perfectly correlated with the number of trains per year. This is not surprising; when infrastructure is utilised more heavily, it breaks down more frequently. To avoid this, infrastructure maintenance and renewal would have had to increase at an even faster rate than the traffic, but this has not been the case. Rather, the increase in traffic is crowding out necessary track works, and there are major problems with securing track time for maintenance. The relationship between rail services and track works was studied in detail in a K2-linked thesis [3] by Ivina, which resulted in a great deal of new knowledge on this relatively unexplored topic. Delays from Dispatching and Accidents and Other External Factors, from Figure 3 above, are also strongly correlated with the number of trains.

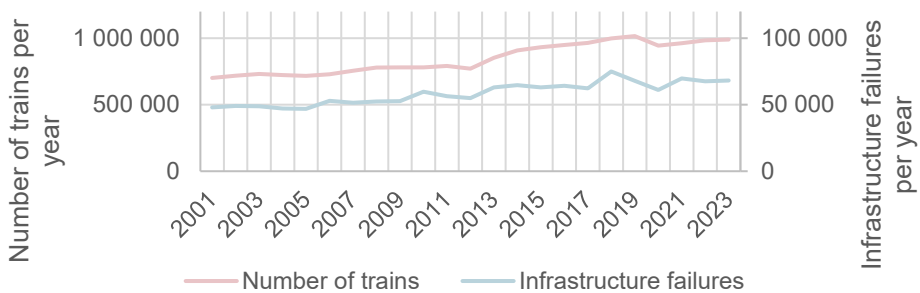

Figure 4 Correlation between the number of trains running and infrastructure failures. 'Infrastructure failure' here refers to the number of entries made in the Ofelia system. Strictly speaking, this also includes collisions with animals and the like, not just pure infrastructure failures, but these do not affect the curve to any significant extent. The figure is based on our own processing of train running data from Transport Analysis [2], and on infrastructure failures based on the Swedish Transport Administration's Ofelia system.

> Track works and related transport are the single biggest cause of delays; more so than catenary failures, switch failures, track failures, signal failures, unauthorised persons on track, or other causes that are more frequently heard about.

Delays at stops are common

It is difficult to work out exactly what causes the minor one or two-minute events. Instead, it is necessary to use other data and techniques to estimate what causes these minor delay events. For instance, around 40 per cent of train stops (when trains stop at stations) are delayed, although these delays are usually minor. This is because passengers often congregate around certain doors rather than spread out evenly along the whole train, because train staff wait for late passengers, or because stops are not planned or monitored very carefully, to name but a few reasons. A doctoral thesis [4] by Kuipers, funded by and linked to K2, made extensive contributions to better understanding and explaining these minor and very common delays during stops.

Weather often causes delays

Weather also plays a major role in delays. K2-linked doctoral student Ochsner studied this relationship in [5]. Delays increase in extreme weather in particular: if the weather is cold and there is a lot of snow and ice, if the weather is very hot and dry and there are fires, if there are storms or strong winds, or if there is very heavy rainfall and flooding. However, even without extreme conditions, there are links between temperature, snow and delays. Cold generally causes more delays than heat, but heat is also problematic; probably because it leads to a higher failure frequency in a number of different technical components, and because it is associated with a higher risk of fire. Although flooding is serious when it occurs, and has led to extensive delays, the correlation between delays and the amount of rainfall is weak. Strong winds can also disrupt services, but more often causing services to be cancelled as a precautionary measure than direct delays.

Delays spread easily

Delays spread easily and frequently between trains, which the K2-linked doctoral thesis [6] by Tiong studied in greater detail. Estimates from a K2-funded project [7] showed that one minute of primary delay initially affecting a train, leads to about two minutes of secondary delays on average because other trains in their turn are delayed by the lateness of the first train. The more frequent the services, the more secondary delays there are. Sometimes these are significant enough to be detected and coded by dispatchers, but usually they involve several trains being delayed by one or two minutes, which does not then appear in the official statistics. However, the lesson to be learned from this is that there needs to be even more emphasis on identifying and eliminating the primary delays so that they do not spread. If it is possible to eliminate one such minute of delay, this will prevent

a total of about three minutes of delay. If efforts were instead made to reduce the spread of disruptions and target the secondary delays, then preventing one minute of delay will save only that one minute. That is why tackling primary delays has a significant leverage effect, which increases as traffic density grows.

The more trains, the harder it is to maintain punctuality

When attempting to improve punctuality, it is necessary to bear in mind two things: 1) That there is not one problem and one solution, but many problems requiring many solutions. 2) That slow, incremental improvements are not enough – quick and decisive action is needed.

In general, there is a linear relationship between delays and punctuality, as long as the number of trains remains constant. This is most evident when we consider non-punctuality; that is, the percentage of trains that do not arrive within five minutes of their timetabled arrival time. At the time of writing (spring 2024), the punctuality rate stands at around 88 per cent, while the non-punctuality rate is therefore 12 per cent. If the aim is to achieve 95 per cent punctuality, non-punctuality must then be reduced to 5 per cent, which in relative terms is a reduction of about 60 per cent. To achieve this, the number of delays and delay time would need to be reduced by about 60 per cent, assuming no other changes to services. That is almost exactly the same reduction that would be needed to go from 95 per cent to 98 per cent punctuality.

Changes in the number of trains have a disproportionately large effect on the challenge of reducing the number of delays. In fact, having more trains in a timetable allows delays to spread more readily (see [7], for example). The reduction in the frequency of delays needs to be even faster if it is to be possible to go on increasing the number of trains while maintaining service quality. That said, if fewer trains run, there are fewer primary delays because there are fewer trains in the system and there is less wear and tear on the infrastructure; and there are fewer secondary delays because it is a little more difficult for delays to be spread between trains. This was evident in 2020, when the number of trains decreased slightly, and punctuality increased relatively substantially. Traffic in Skåne [7] was simulated as part of a K2 project to compare the 2019 timetable with a proposal for 2025, which included more trains. The results show that a relatively moderate increase in traffic greatly increased the difficulty of achieving the punctuality target. Instead of halving delays, a two-thirds reduction would be required, because the extra trains led to significantly more secondary delays.

In a way, this development is what has taken place in Sweden over the last thirty years or so. Traffic has increased by a few per cent almost every year, making it easier and easier for delays to spread. At the same time, there has been an increase in the number of sources of failure, an increase in the utilisation of infrastructure and a reduction in the time available for maintenance of both infrastructure and vehicles.

Four proposals to improve punctuality

Four proposals that have the potential to make a significant difference are presented below. These are big, powerful measures that would reshape the picture for railways. The industry does not agree on these measures, but in the author's opinion they are all reasonable and will be feasible in a few years' time. The industry's punctuality target and wider visions will not be realised without this kind of action and energy: it is not enough to make minor adjustments to timetables, add a few extra stations with passing loops, or improve boarding and alighting at stations, especially if rail services are to increase. These particular proposals may not need to be implemented, but measures of this type and order of magnitude *are* necessary. Nor is it the case that just one of the measures would suffice; even with large and powerful measures, there are multiple problems and multiple solutions are needed.

Remove many switches

Switch failures are the third largest known root cause of delays, after track works and catenary failures. Track works are discussed separately below; and unlike catenaries, switches are an optional component of railways. Switches are needed for trains to run; but the number of them, the types that are used and where they are located can be influenced very extensively. According to official statistics [8], the Swedish Transport Administration has around 10,600 switches and about 14,200 kilometres of track. In some other countries, primarily Japan, infrastructure managers have been gradually working to remove switches; and a more streamlined design of the infrastructure would make it perfectly possible to operate the same services with around half or a third of the switches currently in use in Sweden. Fewer switches mean fewer sources of failures, and resources for inspecting, maintaining and replacing switches can be concentrated on the ones remaining. This would make it possible to achieve significantly higher levels of reliability with the switches that remain.

In recent years, both the Netherlands and the United Kingdom have made a similar journey. This has not been systematically documented as of yet, but the general experience has been that maintenance has been reduced rather than redistributed to the remaining infrastructure. This means that switches fail at essentially the same rate as before, but now there are fewer opportunities to divert traffic. This is, of course, unfortunate, and not the intention. The reduction in the number of switches must be combined with a significant increase in ambition with respect to the switches that remain.

A related point is to choose to retain switches that allow relatively low speeds (around 60 km/h), or to replace existing switches with these types. This may seem odd, but there are two main reasons for this. Firstly, these switches are significantly more durable; partly because they are simpler in technical terms and have fewer moving parts that can fail, and partly because they are subjected to lower forces and therefore wear more slowly. Secondly, these switches are significantly shorter, and therefore easier and faster to replace, as well as being cheaper. If it is possible to completely replace a switch in four hours, it is much easier and faster to remedy failures that are starting to develop. It will then also be easier, and perhaps preferable, to regularly replace all switches at fixed intervals, perhaps every five to seven years[10], depending on traffic volume. When an old switch has been removed, it can be fully restored and then reused somewhere else. This means that the time-consuming work of carefully going through and repairing each component can be done safely during the daytime at a factory, rather than on site between passing trains. But for this to be possible, switches need to be relatively short and standardised. Curved switches, or switches that allow high speeds in the diverging direction, cannot be handled rationally and should therefore be phased out.

Replace the signalling system – fast!

Signal failures are another common cause of delays, and there are several different types of such failures. More worryingly, however, the signalling system is based on technology dating back to the 1960s and 1980s: components are not in stock and are essentially no longer manufactured. System components are already being

10 If two teams were replacing one switch per night each, every night for a year, 730 switches would be replaced in a year. I have heard that parts for about 700 switches per year are currently being purchased, while about 20 are replaced in their entirety. If the total number of switches were simultaneously reduced to around 5,000, just over half the current number, it would take just under seven years to work through all the switches in use. It would take just under five years with three teams doing the job.

cannibalised to keep it running, with entire components being taken from one part of the network to replace those that have failed elsewhere.

Almost the entire signalling system needs to be replaced, as it has reached and exceeded its technical service life. Faced with the same challenge, the whole of Europe has agreed on a new technology to replace the old one, harmonise systems from country to country and allow trains to travel across borders using the same signalling technology. However, the introduction of this new system, ERTMS (European Rail Traffic Management System), has been postponed, and the current plan is now to aim for completion in the 2070s. That will be far too late. The problems with signal failures will only increase at an accelerating rate unless the old system in its entirety is replaced quickly, within about a decade, or two at the most.

There is industry resistance to this shift as it requires on-board equipment and reinspection of vehicles, currently a costly measure, while opinions are divided on how much better the new system is. The willingness to adapt vehicle fleets is also dependent on the pace at which the Swedish Transport Administration will be implementing its shift. The railway undertakings' views here are understandable and justified, but that does not eliminate the problem. The industry needs to join forces and agree on a much faster shift, and possibly develop a national version of the on-board equipment so that costs are not unreasonable. Otherwise, these issues will escalate to the point where achieving good punctuality becomes impossible.

Shut down the railway overnight for maintenance

Track works and related transport are the single biggest cause of delays; more so than catenary failures, switch failures, track failures, signal failures, unauthorised persons on track, or other causes that are more frequently heard about. However, the railways have significant problems because not enough maintenance is done, and it is very difficult to secure and maintain time to do track work. This means that inspection findings are not addressed in a timely fashion, and that failures must be patched up with small, quick fixes instead of doing what is needed, resulting in substandard quality. Both factors contribute to the occurrence of urgent failures, which disrupt services and force maintenance personnel planning to carry out preventive maintenance to have to focus on corrective maintenance instead. This results in a vicious circle where time on the tracks constantly needs to be sought, and the maintenance schedule is perpetually behind.

A classic and effective way to overcome this problem is to shut the line at night and not allow traffic for a few hours, so that maintenance work can be carried out

at that time. This is the principle applied on Japanese railways, and more or less all metro systems. Traffic is so heavy during the day that it is impossible to carry out maintenance during the day. The track is completed closed to traffic when demand is lower from around midnight to four or five in the morning. That is when all maintenance can be done. This creates predictability, a sufficiently long time window, and maintenance speed and flexibility.

What makes this proposal controversial is that Sweden has a tradition of primarily running freight trains at night, as well as some overnight passenger services. However, in previous decades traffic on the tracks may not have been as dense, allowing time to be spent on the tracks between trains with relatively few timetable restrictions. In the current situation, with both a sharp increase in traffic volume and extensive problems with infrastructure and difficulties in carrying out maintenance, there is reason to reconsider the strategy. One compromise would be to keep one section open and another closed on alternate nights, so that freight and overnight trains have some opportunity to travel around the country every night. As far as the infrastructure is concerned, it would be best to completely halt services across the entire network every night. In return, all planned track work currently carried out during the day would be moved to the night, which would free up more capacity during the day. Delayed trains due to track works and infrastructure defects would also be reduced, creating further benefits from dedicating the nights entirely to maintenance.

Run fewer trains that are longer and faster

There is a clear correlation between more trains and more infrastructure defects, as illustrated in Figure 5 above. This is a natural and linear relationship, although it is not a law of nature – and it can be countered by measures such as better maintenance and reinvestment. What is not clear is that these delays do not increase linearly, but more than that. The more trains there are, the more easily delays spread from one train to another, and from there to another one, and so on. To counter this trend, other quality work and discipline in execution must increase faster than the growth in traffic. However, the punctuality trend – see Figure 1 above – clearly shows that this has not happened.

A clear way to improve punctuality, therefore, would be to run fewer trains. This would lead to less wear and tear on the infrastructure and, as long as maintenance resources are not reduced to a corresponding extent, greater infrastructure reliability can be achieved. Any delays that do occur are less likely to spread, making it easier to get the job done. As far as possible, trains should instead be longer so that they can carry at least the same number of people and the same

amount of freight. This is a clear streamlining measure and improvement, wherever possible.

At the same time, trains could travel faster than they do at present. This would help to increase their attractiveness and, in combination with improved punctuality, it is quite possible that overall demand and travel by rail could increase, despite slightly fewer trains running. In the long term, however, it is important to increase traffic volumes again, and investment in new railways is needed in order to cope with the new trains. But in the short term, running fewer but faster trains, and ideally longer trains, would be likely to yield benefits on many levels.

What have we learned?

Punctuality is by far one of the most important factors in the attractiveness of railways for both passenger and freight services. Punctuality fluctuated around 90 per cent in the 2000s; and after a crisis year in 2010, when it dropped to 88 per cent, a major industry collaboration was initiated with a view to reaching 95 per cent by 2020. By chance, a pandemic occurred, which resulted in reduced travel and service provision, which meant that the level in 2020 almost reached the target, but since then quality has fallen and the level is now (in 2024) back at 88 per cent.

Most delays are minor, up to a minute or so, but these accumulate over a journey and the longer the train's route, the worse its punctuality tends to be. Of delays where the cause is known, the Swedish Transport Administration accounts for about 40 per cent, railway undertakings for about 40 per cent, and external factors such as weather and unauthorised persons on the tracks for about 20 per cent. The more trains that run, the more failures and incidents there are, and the more easily delays spread. Having more trains will therefore make it harder to maintain good punctuality. Despite very extensive timetable margins, it is very difficult to recover from delays once they occur. The emphasis must therefore be on preventing delays in the first place.

Swift and decisive action is needed to address a wide range of causes to reverse the current trend and meet the industry's punctuality targets. Incremental efforts from year to year will not suffice; a great deal of energy and good sense is needed. A few major measures with the potential to contribute to this reversal include: 1) removing most switches and replacing the remaining ones with simple standard

types that are then maintained to a very high standard, 2) quickly replacing the entire signalling system with ERTMS L2, because the old system exceeded its technical service life a number of years ago and can no longer be maintained or replaced, and thus constitutes a ticking time bomb for the entire railway, 3) systematically shutting down the railway network for maintenance for four to five hours a night, every night, so that it is always possible to get out quickly and address everything that needs to be done, 4) temporarily running fewer but faster trains in order to increase punctuality, the standard of the infrastructure and passenger confidence. When punctuality stands at a consistent level of at least 95 per cent, traffic volumes can then be gradually increased again, under controlled conditions.

9 Collaboration opportunities and challenges – trend or necessity?

Claus Hedegaard Sørensen

Collaboration – nobody can oppose that. This is a common viewpoint. Society is complex, and we are facing major challenges – not least in terms of climate and other planetary boundaries. And these are problems that cannot be handled by individual stakeholders in isolation. That is why collaboration is necessary. This is not least the case for public transport, where a multitude of stakeholders, both public and private, are involved and have to work together in order to achieve good results. It also means that voices critical of collaboration are rarely heard within public transport. When criticism arises, it mostly relates to the fact that the parties focus too little on collaboration – that they do not make enough efforts when collaborating, or that they lack the necessary skills to conduct collaboration properly.

At the same time, anyone who has worked in a public or private organisation for a few years knows that organisational trends and fashions change. First, there is one way of organising that is the right one, with which all organisations and employees have to comply, and soon another way of organising is appropriate [1] [2]. These kinds of fashions also characterise public transport, and they characterise research in the field of public transport. This chapter asserts that collaboration is a good example of this.

The chapter looks at how focus on collaboration in Swedish (and international) public transport has changed over time, and how research has changed as well. The chapter concludes with a discussion of the implications for public transport stakeholders today.

What is collaboration?

What exactly is collaboration, and how does it differ from other terms such as cooperation or coordination?

There is little consensus on this issue among researchers, and they often emphasise different aspects of collaboration. Some focus on collaboration being formal, consensus-oriented and deliberative processes [3]. Others emphasise that collaboration is all about working together on tasks that the parties cannot complete as effectively on their own, and that they therefore work together in order to achieve specific, concrete results, even if they do not necessarily have the same goals [4]. Still others have focused instead on the fact that collaboration is something more than coordination, and that collaboration is characterised by a higher degree of complexity and long-term interaction between multiple parties [5].

Collaboration can be formalised and legally binding to varying degrees. Thus, collaboration can be based on a contract between parties: between RPTAs and public transport operators, for example. It can also be based on more informal partnerships where cooperation is not legally binding; and finally, it can involve the development of mutual understanding and the formulation of a common understanding of problems [4].

Collaboration in public transport is particularly interesting: firstly, because strengthening public transport is crucial for achieving sustainability and climate goals in the transport sector; secondly, because public transport in many countries is often governed by a public body but involves many other public and private stakeholders; and thirdly, because significant academic literature on collaboration has emerged in recent years [3]. But historically, how did the need for and focus on collaboration in public transport arise?

Unbundling and corporatisation

A series of public sector reforms took place, particularly in Europe, from the 1980s onwards. These reforms were inspired by Margaret Thatcher's rise to power as Prime Minister of the United Kingdom and were often implemented with reference to the economic difficulties in the public sector. The reforms were launched under the banner of *New Public Management (NPM*) and included breaking down public organisations into smaller units, often organised as companies and sometimes privatised. Competition for delivering products and

services came to dominate, and targets, performance measurement and management practices inspired by the private sector were introduced. A key argument was that the changes would make the roles of individual organisations simpler and clearer, promote efficiency and thus reduce costs [6].

Bus wars in the United Kingdom

While the kind of competition introduced in Sweden was off-road competition (that is, competition for contracts via procurement procedures), things were different in the United Kingdom (outside the London area):

'In the early days after deregulation there were a number of instances of aggressive on-the-road competition between operators providing services on the same routes. In some instances, this involved provision of excessive frequencies, continuous changes in schedules, with vehicles racing each other to pick up passengers at stops.'

NERA (2006) The decline in bus services in English PTE areas: the quest for a solution, p. 16

This type of reform became dominant, particularly in the field of public transport. Swedish public transport also saw this type of reform early on. As early as 1988, the organisation of Swedish railways was divided into two entities: one responsible for the tracks (Banverket) and the other for train operations (SJ), whereas SJ had previously been responsible for both. In local and regional public transport, the changes involved abolishing bus operators' monopoly on running specific routes. Instead, a commissioning system was established, with regional transport authorities acting as purchasers and bus operators running the services through procurement procedures. Transport planning by the transport authorities was thus separated from the actual work of running the services. This development strengthened coordination in public transport [3] [7]. These market-oriented changes in public transport were taking place throughout much of the world, generally enjoyed strong political support and were viewed as necessary and appropriate.

During that period, the issue of collaboration between public transport stakeholders largely remained unaddressed. The same was true of research, which focused more on the extent of market-oriented reforms implemented in different countries and the manner in which this was done [8] [9]. However, there were always sceptical voices, not least with regard to the radical implementation of market-oriented reforms that took place in the United Kingdom (outside London): the citation in the text box refers to this.

> A number of qualities are important for successful collaboration, including trust, openness, respect and inclusive dialogue. Collaboration is a learning process where progress is made one step at a time.

Collaboration emphasised

From the start of the new millennium in particular, there was greater emphasis on the negative consequences of the changes implemented. NPM-inspired reforms were not abandoned, but efforts were made in parallel with the introduction of market-oriented reforms to ensure greater governance, coordination and collaboration. Reforms with this focus have often been termed *post-NPM reforms*. Many other initiatives and concepts focusing on cooperation also emerged around this time, in both practice and research. These included public-private cooperation, co-production, collaborative innovation and meta-governance of networks. Also, greater emphasis on involving citizens in the development of public policy was stressed, and several of these concepts also included this.

Efforts to achieve collaboration also crept into public transport [10]. Collaboration is explicitly referred to early on in public transport legislation; in the Swedish Public Transport Act (SFS 2010:1065), for example, which came into force in 2012.

Any major investment in public transport requires collaboration involving several stakeholders. In local and regional public transport, in particular three relationships, gain attention, namely collaboration between:

5. The Regional Public Transport Authorities (RPTAs) on the one hand, and, on the other, bus and train operators, which sometimes form part of major international organisations. This often involves private ownership, but there are also examples of organisations that are wholly or partly owned by other states.
6. The municipality responsible for urban and road planning on the one hand, and, on the other, the RPTAs responsible for public transport planning.
7. Different authorities responsible for different modes of transport, such as public transport, cars, cycling, walking and shared modes of transport. This often involves authorities at different administrative levels, but it may also involve collaboration between departments within the same public authority.

The introduction of fast bus routes inspired by the Bus Rapid Transit (BRT) concept increases the need for collaboration between municipalities and public transport authorities as roads often have to be rebuilt in order to accommodate bus priority and dedicated bus stops, often in the middle of the road. Similarly, the need for collaboration with other modes of transport has increased; and become

more complicated with the advent of several shared modes of transport, such as shared bicycles, shared electric scooters and shared electric cars.

Of course, there are many instances other than those referred to where collaboration is needed; such as the initiatives for introducing a national ticketing system in Sweden and the transition to electric buses. There was also an urgent need for collaboration when COVID-19 arrived in Sweden, with dramatic consequences on public transport passenger numbers and health risks for both passengers and drivers. Similarly, redevelopment of stations involving many stakeholders with particular interests is also a typical situation in which collaboration plays a major role.

So how has research addressed the issue of collaboration in public transport? 'Collaboration' was a topic of research right from the time K2 began, and K2 researchers have contributed significantly to the international literature. This is reflected, for example, in a new international *Handbook of Transportation and Public Policy* [11], in which three chapters focus on collaboration and coordination: two of these written by authors affiliated with K2.

What insights does K2 research into collaboration provide?

It points out – among other things – that collaboration can take different forms. It may be both formal and informal, and the parties may be more or less loosely interconnected. A number of qualities are important for successful collaboration, including trust, openness, respect and inclusive dialogue. Collaboration is a learning process where progress is made one step at a time.

TEN TIPS FOR BETTER COLLABORATION:

1. A shared vision is a basic prerequisite, as is a shared understanding of common benefits, trust, commitment to the process and gradual results.
2. Ensure that all organisations affected are involved early on and establish clear rules for collaboration between different organisations. It is also important to ensure that there is a clear political mandate. Without a clear mandate, there is a risk that processes driven through collaboration will have an unclear status.
3. Make sure that 'difficult issues' are brought to the table early. Clarify who will be paying for what, for instance. It is also necessary to understand the conditions in terms of perspectives, roles and mandates that characterise each organisation.
4. Every organisation needs clear internal goals and clarity regarding responsibilities between units and departments.
5. You and your organisation need to be willing to compromise and help create good conditions for communication and understanding.
6. Conflicts and tensions between different organisations' goals, approaches and ways of working are a natural part of collaboration.
7. Bear in mind that all organisations bring different things with them in terms of their form and history.
8. Trust grows slowly, so be patient!
9. Collaboration may require significant resources for an organisation and can also be challenging for the people who represent the organisations. Collaborative processes also need to handle the fact that conditions may change at times. Built-in flexibility and adaptability are required. And remember: it might sometimes be better not to collaborate at all.
10. Looking after the interests of your own organisation while also helping to bring about collaboration in good faith is a challenge.

K2 (2019): Så kan vi samverka bättre, Kollektivtrafikforskning på 5 minuter (our translation)

Some organisations and people are better than others at collaborating, and there are specific cultures that promote collaboration. One important purpose of collaboration is to build a common identity and mutual understanding. The need for a central stakeholder with specific responsibility for collaboration, known as a meta-governor, has also been studied recently. It is also important to understand that conflicts cannot be avoided, and therefore what can be gained from collaboration should not be overestimated. Collaboration takes place everywhere in public transport; but at K2, particular attention has been paid to collaboration in connection with the establishment of new stations, public transport-oriented planning (Transit Oriented Development), innovation in public transport, Mobility as a Service (MaaS), and the introduction of bus rapid transit.

So, there is a wealth of literature – much of it produced within the K2 environment – on how to collaborate effectively and fruitfully in public transport, what

conditions are appropriate and what can be achieved through collaboration. One example is an information sheet published by K2 six years ago, presenting 'Ten tips for better collaboration'. A K2 publication focusing on recommendations on smart mobility, where collaboration was also emphasised, is another example. This is achieved by means of a series of questions that public authorities at different levels should ask themselves (see text boxes).

GENUINE PROGRESS REQUIRES COLLABORATION

A K2 report from 2021 on the governance of smart mobility contains a number of questions that may serve as a checklist for decision-makers and officials wishing to prepare their organisations for development of smart mobility. The authors have this to say about collaboration:

In our municipality/region, have we paved the way for dialogue and collaboration between companies that want to develop and offer mobility services and municipal/regional/state interests linked to different geographical contexts?

Is our region helping to coordinate the efforts of different municipalities in respect of transport and mobility in ways that will lead to more sustainable and cost-effective solutions in respect of land use and parking policies, for example?

As a government agency, have we taken on the role of 'meta-governor' or 'coordinator' in ways that pave the way for collaboration between private and public stakeholders at different levels?

Hultén et al. (2021): Att styra det nya. Samhällets styrning av och med smart mobilitet. K2 Outreach 2021:1, page 12 (our translation).

Limits to collaboration?

In Sweden, collaboration in public transport appears to be a strong ideal. In itself, it constitutes a kind of ideology embedded in institutions, politics and the thinking surrounding public transport [3]. Expressing criticism is almost like swearing in church. Asking questions about the benefits of collaboration has been described as heresy [12].

However, critical voices have become louder over time, and there are now people within the public transport sector who are dubious about the time and energy that collaboration requires and refer to 'collaboration inferno', for example [13]. There are complaints about how slowly things progress when working in collaboration, and the overloading often experienced by individuals working with collaboration has been emphasised [3]. The more critical tone can also be observed in research; mainly in analyses of sectors other than public transport, but research has also

been conducted by researchers affiliated with K2 on the limits to collaboration in public transport. The research has questioned whether collaboration does actually assist in achieving the goals of public transport [14], and a typology of negative impacts has been created [3]. The typology includes negative democratic and negative organisational consequences, as well as negative consequences for problem solving:

Democratic consequences

Goal displacement involves focusing on the collaboration itself as a goal, rather than focusing on the actual problem to be resolved. As collaboration is a strong ideology, it can therefore obscure the actual issues relating to aspects such as delivering better service, creating customer satisfaction and attracting more passengers.

The cementing of power structures relates to the fact that some stakeholders have significantly better access to data, knowledge, time and money, thereby allowing them to achieve more influence than others through collaboration. This issue is applicable to virtually all areas of society, but inequality in influence may become more prominent and at the same time less visible, particularly in the case of collaboration that may be more informal in nature and where the parties bring their own resources to bear.

The weakening of representative democracy relates to the fact that some issues vanish from the political agenda as they are expected to be dealt with in collaboration between officials. Thus, collaboration in public transport may also contribute to depoliticisation of issues that essentially relate to different groups' opportunities to have their transport needs met, and hence the distribution of resources in society.

Organisational consequences

Increased bureaucracy is the consequence of a new organisational layer of collaboration that constitutes an additional administrative burden on top of the existing organisations. This results in the creation of more complex and opaque structures for workers to comply with and manage.

Overloading relates to individuals who are particularly competent when it comes to collaboration and may therefore easily become overloaded. Collaboration is often reliant on individuals who are good at the task and already have contacts and a network to fall back on.

Consequences for problem-solving

Innovation is inhibited by the need for many stakeholders to reach agreement, which can easily result in decisions being dominated by the lowest common denominator. Not all decisions and new solutions can be implemented using consensus and the lowest common denominator as the starting point when it comes to the transformation of the transport sector, for instance, where public transport has an important part to play.

Slowness comes about due to the fact that the many stakeholders make it difficult to agree on solutions, which delays decisions and planning. This situation is often highlighted by stakeholders involved in collaboration in the field of public transport. One example is a national ticketing system, which has been in development for over 30 years; while COVID-19 is an example of how quick decisions can also be made through collaboration.

And finally, there is *stalemate* due to the fact that collaboration requires at least two stakeholders. However, there may be situations in which one of the parties simply has no interest in cooperating but benefits from conflict and disagreement. Both political parties and interest groups are extensively fuelled by conflict and disagreement as this helps to highlight the need for them.

LIMITS TO COLLABORATION

It is important to be aware of the negative consequences of collaboration.

Criticising collaboration should not be regarded as heresy.

Public transport stakeholders should always consider, carefully and critically, the nature of the content, the institutional structure and the interests of the various parties before engaging in collaboration. 'Don't do it unless you have to', as it has been said.

Sørensen, C.H. & Pettersson-Löfstedt, F. (2025): "Limits to collaboration in public transport: a typology", which is a chapter in Anthony Perl, Rosalie Singerman Ray & Louise Reardon, L. (eds): Handbook of Transportation and Public Policy. Edward Elgar Publishing Ltd.

So now what?

Society is facing an enormous transition if we are to avoid further exceeding of the planetary boundaries, including worsening of the climate. The transport sector in particular needs to be transformed. Going forward, we need to travel less, use far less polluting modes of transport when we do travel and carry on introducing cleaner technology. Some major changes have to be made, and many politicians,

officials, grassroots organisations and researchers are involved in deliberations on how best to create and promote transformation of the transport sector. There is no doubt that public transport has a key part to play if the sector is to undergo successful transformation.

The ideology of collaboration asserts that better, stronger collaboration represents a way forward. Collaboration involving many strong stakeholders can transcend silo thinking, identify the solutions we need and collectively help with implementing them. This is the way forward for both major societal challenges and other, minor issues in and around public transport.

However, the chapter also indicates that organisational trends and fashions in public transport and research are shifting. The emphasis in the 1980s and 1990s was on New Public Management and marketization of public transport, and there were few references to collaboration. There was greater emphasis on collaboration around the turn of the millennium. This wave impacted also on public transport and on research into collaboration at K2. Since then, questions about the potential of collaboration have increasingly been raised. Collaboration also has negative consequences, and there are limits to what it can contribute to and what problems it can resolve. Whether this critical view of collaboration will become a new wave is something that will only become apparent after a while. It is important to emphasise the fact that there are no watertight barriers between the different trends and fashions. Instead, they overlap and can be viewed as different ways of thinking and ideologies that are layered one on top of another.

However, the shifting view of collaboration provides public transport stakeholders with good reasons to be sceptical and ask critical questions about the current trends and fashions: Is marketization really the solution? Is collaboration really the solution? Does collaboration really have so many negative consequences? These are reasonable and necessary questions, and no one should be burned at the stake for asking them.

Collaboration is relevant and important in many contexts. However, there are limits to what collaboration is able to contribute. The contribution of collaboration is probably limited for the big and wicked problems which are caused by climate change and exceeding planetary boundaries, and which require radical transformation of the transport sector. The solution to these difficult problems is characterised by conflict and disagreement, and some people will have to give up the privileges they currently enjoy. If the aim is consensus and the lowest common denominator, collaboration can easily result in a stalemate that does not move us forward.

Often it is politicians who propose collaboration between officials, businesses and interest groups at different levels, probably due to the fact that politicians are also influenced by the ideology of collaboration. Another explanation could be that it is convenient. It is more convenient to let others come up with proposals rather than having to devise and propose unpopular solutions yourself as an elected representative. A certain degree of arm's length distance can be attractive to politicians. However, there is a major need for politicians at all levels to take on political leadership rather than asking others to resolve the problems.

In 2016, K2 published a report entitled 'Dömd till samverkan!' [Condemned to collaboration!]. [5]. The title can be understood in a number of ways. One interpretation could be that a public transport system with so many stakeholders makes collaboration inevitable. There is no other way (and this is probably the interpretation the author had in mind). Another interpretation could be that the ideology of collaboration is such a strong trend that no organisation or individual wanting to be taken seriously can disregard collaboration in respect of public transport. A third interpretation could be that collaboration is characterised by difficult and protracted processes with no visible results, in which case collaboration can be viewed as a harsh sentence to bear.

An attempt has been made in this chapter to illustrate how the perception of collaboration has changed, including in research. A critical and sceptical approach to collaboration and other new organisational trends and fashions appears to be a sensible way forward for both organisations and individuals operating in the public transport sector.

Public transport – a field rather than a subject

The growth of cities and regions during the industrialisation of the 19th century was reliant on the development of rail-based public transport. Drastically reduced journey times were then possible for passenger transport on land. There was interaction between urban planning and public transport planning. Clear focus on technology characterised development, not least when rail-based urban transport could be electrified. Tramways and metro systems were developed by major electrical engineering companies at the turn of the last century, and their design was characterised by the new building techniques of the era. This focus on technology has since accompanied the development of public transport throughout the 20th century. However, there has been a shift in the last 30 years. The negative impact of cars, how we want to develop our cities and regions, how we choose to travel and which groups of people can choose where and how to live require greater understanding, and not just from an engineering perspective. K2 is a clear example of how different disciplines and theoretical frameworks are necessary as a way of enhancing knowledge and understanding of people's everyday practices. Today, we want to plan for the development of attractive living environments where we are perhaps not forced to spend far too much time commuting. Close proximity, accessibility and consideration of limited resources will be key issues going forward, alongside how our limited resources can be distributed fairly. Citizens and decision-makers will also want to choose their paths. K2, with its multifaceted approach in this field of knowledge, is able to support these choices. The first decade has created a robust platform, and we are now well on our way to achieving our objective. As we continue to develop together over the coming years, there are strong opportunities for both the academic community and professional fields to both monitor and influence the development of our cities and regions.

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10 Procurement and contracts for regional bus services

Roger Pydokke & Helene Lidestam

Swedish public transport organisations have repeatedly recommended certain procurement procedures and contract structures. This chapter[11] aims to summarise the state of research with regard to some of the recommendations emerging in Swedish public transport. In Sweden, public procurement of regional public transport has been standard practice since the late 1980s. There are two main types of contract: production contracts and incentive contracts. Under production contracts, the regional public transport authority (RPTA) receives ticket revenue and the operator receives payment for bus kilometres and bus hours in particular. Incentive contracts are the common type used for large numbers of passengers. These have often involved production payments for bus kilometres and bus hours in combination with a payment per boarding passenger: the passenger incentive. Collaboration, the best combination of price and quality, passenger incentives and quality incentives are all contract elements identified by Partnersamverkan [29] and its predecessors as important for a functioning contract type.

Collaboration

The term ‘collaboration’ is used to describe desirable practices within organisations, between public organisations and between commissioning public organisations and private operators. In a trivial sense, collaboration is necessary in all these contexts. Obviously, communication is needed between organisations that are to achieve results collectively by executing their respective tasks.

11 This chapter reuses parts of Pyddoke (2024) Konkurrens på marknaderna för upphandlad kollektivtrafik [Competition in the markets for procured public transport], Swedish Competition Authority, Contract Research Report 2024:2.

What is not trivial is whether a specific form of collaboration really delivers additional net value greater than if the work were organised differently. Controlled experiments would be needed to find out whether this is the case. However, this can be costly and time-consuming. Simpler follow-up could be used to avoid the best method undermining the good methods. One way is to allow parts of the organisation to work with a more ambitious form of operation with more collaboration and let another part of the organisation work with a simpler, less ambitious form of operation, and then compare the results and costs.

A study of public transport in the Västra Götaland and Skåne regions, by Pyddoke and Thoresson [1], followed up on bus contracts that were regarded as being particularly successful examples of collaboration on bus services. Costs and results in these regions were compared during a period when both public authorities were of the opinion that they had increasingly applied collaboration with a period of less collaboration, both for bus services as a whole and for two individual contracts. The forms of collaboration were described as jointly staffed groups for analysis of outcomes and preparation of proposals for adjustment of the offering (lower-level officials) and for decision-making (senior managers).

Senior managers at the RPTAs found it difficult to specify what tangible benefits they expected. However, these senior managers were convinced that a positive spirit of collaboration would lead to greater creativity. The perception of the collaboration model was more distinct for officials at lower levels within the organisations. These officials were of the opinion that it was mainly a matter of reallocating capacity from routes with less demand to routes with higher demand. However, it was noted that these opportunities could diminish over time, and that the options for reallocating capacity within a contract could be limited. That said, these officials indicated that collaboration had been interpreted as meaning that a greater degree of planning would be delegated to operators. This had resulted in a lack of coordination between contracts.

A further implication of collaboration set out by officials is that it involves managing day-to-day disruptions to services where neither the transport operator nor the RPTAs are able to intervene. This may involve addressing temporary obstructions on the roads, such as construction sites encroaching on streets where the municipality can intervene.

Follow-up of statistics from the two public authorities shows that travel in Västra Götaland continued to increase (albeit with reservation for underestimates in previous counts of boarding passengers); and that it also increased in Skåne, but to a lesser extent than in Västra Götaland. However, this was accompanied by even

faster cost increases in both regions. The latter raises doubts about both the economic soundness and the sustainability of the development. There was stagnation in customer satisfaction and punctuality at or above target levels. An earlier study [2] indicated that contracts with greater emphasis on collaboration and where passenger incentives were introduced could not be shown, on average, to have increased passenger numbers.

Overall, the study concluded that application of the concept of collaboration was not without its problems. Although no causal conclusions can be drawn from the follow-up, it indicates that passenger numbers increased during the period studied, but that this cannot be attributed with certainty to the collaboration. Finally, costs increased faster than passenger numbers.

Most economically advantageous tender

Since 2014, the EU has recommended that Member States' procuring authorities should apply the *Most Economically Advantageous Tender* (MEAT) award method, rather than aiming for the lowest price. This has also resulted in increased application in Sweden, as well as the rest of Europe [3].

A theoretical advantage of MEAT is that the client can incentivise bidders to tender additional quality as long as the cost is below a certain value. If the client knows how much a quality dimension is worth but not how much it costs to produce it, the client can explain how more quality tendered will lead to cost reductions in the tender evaluation. This provides the operator with an incentive to offer quality in the tender as long as the cost is below the promised cost reduction. It is not worthwhile offering more quality when the cost of the measures exceeds the value of the enhanced quality. This can be applied when evaluating tenders if the tenderer undertakes to deliver the desired quality above a certain level. Additionally, a bonus can be promised that is equal to users' valuations for each additional unit of quality delivered.

In a survey of MEAT terms and conditions in public transport contracts in force in 2015, Ridderstedt [3] sums up the terms that were applied. Ridderstedt notes that there are few examples in the empirical literature of how MEAT requirements are applied in specific procured contracts. In one of these few examples [4], it was found that MEAT requirements were applied in many different ways, including ways that were unlikely to function as intended. The starting point for Ridderstedt's survey is that economic contract theory defines how effectively

MEAT requirements would need to be designed in order to produce the desired results.

Ridderstedt's main finding, as for Bergman and Lundberg [4], is that the current requirements in real contracts show significant differences in how MEAT requirements have been formulated, and that these are partly inconsistent with the recommendations of economic theory. Important implications from economic theory, according to Ridderstedt, are that there should be few quality dimensions subject to MEAT requirements rather than many, that they should be valued on a monetary scale, that they need to be possible to observe sufficiently clearly so that the parties can agree on the outcome, and that this observation can take place at reasonable cost. In contrast, Ridderstedt observes that several of the RPTAs use several scales, a large number of quality dimensions and vague criteria relating to bidders' plans and internal processes.

Ridderstedt argues that these circumstances may make it difficult to achieve effective fulfilment of goals. Instead, having many vague requirements may lead to increased costs for preparing and evaluating tenders. Moreover, it can create rivalry in describing qualities and processes that are difficult to verify and so cannot be used to demand changes. This risks weakening the incentives to endeavour to achieve the quality ultimately desired by citizens and passengers. He notes that having a large number of quality requirements may result in little emphasis on each, and that requirements for organisational quality do not necessarily affect performance quality. Ridderstedt therefore concludes that public procurement officers need better guidance on when and how they should apply MEAT requirements in order to achieve their public authority's goals and on how results and effective methods can be disseminated.

There has been very little quantitative empirical research into the relative benefits of applying the MEAT method. A study by Ridderstedt and Pyddoke [5] analysed both bus contracts procured at the lowest price and with MEAT in Västra Götaland, where the MEAT requirements included aspects such as organisational quality. The empirical question analysed considered whether the MEAT variants valid in 2015 that were applied in 18 contracts gave better results in terms of measured delay than corresponding contracts using the lowest price method. No statistically significant difference in outcome could be demonstrated.

> The studies consistently failed to find statistically significant higher increases in passenger numbers in contracts with passenger incentives.

Passenger incentives

Passenger incentives have been recommended by Partnersamverkan for a long time. These passenger incentives often involve the operator receiving a fixed sum of money for every passenger who boards one of the buses run by the contracted operator. Where passenger incentives have been applied, these have often been in the order of 30 per cent of the total payment. The remainder has been paid as remuneration for production. These passenger incentives have been analysed in a number of studies of Swedish public transport [6] [7] [8] [2]. These studies analysed data from contracts with and without passenger incentives in order to determine the impact of passenger incentives on passenger numbers. The studies consistently failed to find statistically significant higher increases in passenger numbers in contracts with passenger incentives.

There are several potential reasons for the lack of results. One key reason is that increased passenger numbers in a particular area or on a particular route may cost more than the incentive provides. One study [9], using average costs that were recent at that time, produced results indicating that the cost of increasing passenger numbers in a number of Swedish cities would have had to have been significantly higher than the passenger incentives at that time. Therefore, passenger incentives where the incentive times the number of boarding passengers equals 30 per cent of revenues would lead to only minor increases in passenger numbers.

Reallocating capacity within a contract does not cost more if the same capacity can create value in the form of increased passenger numbers. This would require the transport operator to be able (free) to actually reallocate capacity. However, such a gain can only be achieved once, unless another potential gain arises due to construction of housing or creation of jobs, for example. Analysts have pointed out that if a transport operator has several contracts, the transport operator might accept a reduction in one contract if that same transport operator were to receive an expanded mandate in another contract, as long as the net is positive.

Thus, there may be individual contracts where passenger numbers have increased, but the overall supply has not. The studies focus on investigating whether statistical differences exist, and not on the potential reasons for the absence of an average difference. However, there may be several reasons for the lack of impact. As mentioned above, one study indicated that most incentives were too small to cover the costs incurred by the transport operator in increasing passenger numbers. Another reason stated is whether the contracts prevent transport operators from amending their offering.

Quality incentives

Quality incentives refer to either bonuses for quality above a certain predetermined level or penalties for quality below that predetermined level. Common forms of quality incentives in public transport by bus relate to punctuality, service provision and customer satisfaction. These incentives have been structured in a variety of ways, but overall, there has been little systematic analysis of quality incentives. However, there have been a few research studies on public transport quality incentives and other areas, including one foreign study [10] [11] [12] [13]. These analyses indicate that whether quality incentives are having the intended effect is unclear and suggest that it has not been easy to get the quality incentives right. There is a risk of setting the incentive at the wrong level if the client is unaware of how passengers value different quality dimensions. If the level is too low, the measures will be insufficient and so the quality outcome will be too low. Conversely, if the level is too high, there is a risk of the transport operator doing more than is desirable and costs exceeding passengers' valuation of the improvement. Another risk indicated is that penalties may be imposed and bonuses paid for outcomes that are beyond the operator's control. In this case, all the operator can do is add sums to or subtract sums from the tender to cover anticipated expenses or deduct anticipated bonuses, respectively, without influencing the outcome in respect of services. The implication is that the client should therefore ensure it remains well-informed about what the operator is able to influence and the approximate cost of this, and to avoid penalties and bonuses for outcomes that the operator is unable to influence.

Given the fact that an incentive is included in the contract, it is also important for the operator to believe that the client will verify the quality and actually impose the penalties. The incentive effect of penalties may be undermined if there is reason to believe that the operator can 'talk their way out of' penalties. No major studies analyse the imposition of penalties.

A study by Pyddoke [13] analysed penalties for bus service quality in the Stockholm and Skåne regions, using data with varying availability from 2007 to 2017. The study found little in terms of verbal or written explanations at the RPTAs in respect of the intended impact of the selected forms of penalties and bonuses. The interviews showed that officials believed that passenger incentives would reduce the need for quality incentives, and that remaining quality incentives were necessary in order to ensure sufficient quality. The study also presented observations indicating that there may have been extensive failure to impose penalties. Both RPTAs record contractual payments, but neither states that

penalties or bonus payments are recorded by type. If this is true, it means that they are unable to study the link between quality and penalties imposed.

The study found that there was little change in quality outcomes over the period studied. In cities, however, punctuality is declining. This decline is thought to be due to increased congestion resulting from factors such as increased traffic, construction activities and hence greater congestion. The following conclusions were drawn:

- → Terms and conditions of contracts in respect of penalties should be public.
- → Reporting of quality outcomes and penalty payments should also be public and subject to regular audits.
- → Penalties based on the above data should be subject to regular evaluation.

Nature and scope of procurement procedures

Procurement documents are very comprehensive and detailed as they contain all mandatory requirements and a large number of less stringent requirements or preferences, particularly in respect of behaviour [14]. Lidestam [15] examined the scope and level of detail of requirements in different areas and analysed three years' worth of procurement documents. The results of the study showed that many requirements are detailed, particularly with regard to bus exteriors and bus sizes. Bus sizes and their impact on costs were analysed in greater depth in [16], where a mathematical model was used to investigate the environmental benefits of being able to adapt bus sizes to the number of passengers instead of predefining which bus sizes should be used.

The importance of environmental requirements was analysed more comprehensively in [17]. A content analysis of ten years of procurement documents was carried out, and the topic was also addressed in workshops. The purpose of the study was to investigate how an RPTA can support the process of creating more sustainable procurement procedures for bus services. The results showed that RPTAs have major opportunities to contribute to more Green Public Procurement by defining precise environmental requirements in procurement documents.

One hypothesis set out by bus operators and industry organisations is that the industry is looking for functional requirements rather than specific requirements. This was highlighted in WSP's report [18], which analysed the literature and conducted a number of interviews to demonstrate how specific requirements lead to high costs, estimated at over SEK 375 million annually in Sweden. Examples of how specific requirements can lead to unnecessarily high costs for public transport were also shown in a study by Camén and Lidestam [19], which examined the reasons for cost increases for bus services in Sweden. Nine different reasons for high cost increases in bus services were identified by interviewing RPTAs and bus operators, as well as stakeholders in industry organisations: contract length, specific requirements for buses, peak hours, working hours agreements, the procurement process, counterproductive political governance, accessibility, and age-related and environmental requirements for buses.

Many of these reasons were rooted in the procurement procedure and the process behind the procurement procedures. If tendering becomes more expensive for bus operators, bus operators will have to submit higher tenders in order to cover their costs. These higher tenders then lead to higher costs for RPTAs, and therefore, ultimately, higher costs for passengers and citizens in the form of increased ticket prices and/or increased taxes. An in-depth study was conducted in Lidestam et al. [20], which further analysed and ranked the factors behind the cost increases. The results of this study showed that peak traffic, specific requirements and age requirements for buses were the most important and most significant reasons for the cost increases. Maximum age requirements for each bus and maximum average age of the bus fleet have been analysed further and were presented at the Transport Forum in Linköping in 2024 [21]. This study mapped the extent of age requirements in procurement procedures and calculations of the increased costs associated with the application of the same.

The application of the Bus Nordic policy document [22] has also been mapped, and additions and exceptions have been studied further. The results of this study were also presented at the 2024 Transport Forum [23]. Bus Nordic is a policy document relating to the characteristics of buses. It is a joint document for the Nordic region as a whole, unlike the previous policy document, Buss 2014 [24], which related only to Swedish circumstances. Virtually all RPTAs refer to Bus Nordic, but most of them have made additions, exceptions or clarifications to its content. This risks undermining Bus Nordic as a policy document, which may impair confidence in its role as a leading guideline for the industry.

Bus operators are requesting greater flexibility in their contracts, while tender documents are tending to be more extensive and more detailed. Flexibility in contracts in general has been studied by Camén et al. [25]. This study mapped the degree of flexibility in different types of requirements in procurement documents for the 2008–2018 period. The study focused on the level of flexibility in the following categories: contract types, timetables, bus sizes, age requirements and application of standards. A number of interviews and complementary workshops involving industry stakeholders were also held. The results of the study indicated a fairly low level of flexibility. Hansson et al. [26] examined opportunities for innovation in procurement procedures and focuses on the three metropolitan regions of Sweden: Stockholm, Västra Götaland and Skåne. Interviews were conducted with six RPTAs and ten of the biggest operators in Sweden. The results reveal difficulties in defining the concept of 'innovation' in this context, and also in determining who is actually responsible for innovative procurement procedures: RPTAs or operators. Although both operators and RPTAs have the ambition to introduce innovations to procurement procedures, it is difficult to make progress or, as the authors put it in the title, an 'insoluble knot'.

Impact of contract requirements on costs and the number of tenders

Two studies [27] [28] have analysed data from the procurement of bus services by RPTAs with contracts valid in 2015. Since then, as far as the authors are aware, no compilation of the contracts has taken place. Vigren [28] studies factors that may influence the number of tenders in a procurement procedure. The analysis uses the following variables from the call for tenders: vehicle kilometres, number of routes, median route length, contract duration, combinatorial bidding, MEAT (evaluation according to the Most Economically Advantageous Tender), presence of incentives for passengers and quality, presence of environmental requirements in respect of fuel, whether the client provides depots that may or must be used, whether the client requires the winning tenderer to take over staff or other resources, the number of potential tenderers in the region (county), the number of simultaneous calls for tender, and population density. The study found no statistically significant effect of contract duration on costs in bus contracts in Sweden.

An average of 3.4 tenders had been submitted in the studied sample of bus contracts from 17 RPTAs (excluding Västmanland, Kronoberg, Västerbotten and

Norrbotten). The estimated model indicates that the number of tenderers could be influenced by at most 0.5 of the variables stated above, on average. Therefore, by varying the criteria studied, the number of tenders could – hypothetically – be increased by 0.5 in a tender, on average. Any additional requirements defined for operators – that is, the existence of environmental requirements for fuel, whether the client provides depots that may or must be used, and whether the client requires the winning tenderer to take over staff or other resources – reduce the number of tenders. These requirements reduce the number of tenders by approximately 0.4 each. The number of tenders was reported to be reduced by 0.8 if all these requirements were applied.

Null and void contracts and procurement procedures with problems?

A number of research projects studying cherished contract recommendations for public transport have raised doubts about their effectiveness. These are summarised in brief below:

A project on collaboration [1] shows that projects involving increased collaboration may have helped to increase passenger numbers, while another project [2] that analysed many contracts with increased collaboration were unable to identify any impact on passenger numbers. That said, costs have risen sharply in the regions studied, which appears to be unsustainable. There is no clear indication as yet of the effectiveness of collaboration contracts.

Two projects analysed the most economically advantageous tender. The first project [3] mapped the design of the requirements for Swedish contracts for bus services procured by regions. The results show a wide variation in the design and abundance of vague criteria and requirements relating to bidders' plans and internal processes. The second project [5] analysed data from an RPTA that used both lowest price and most economically advantageous tender. The outcomes were compared with regard to punctuality. No statistically significant difference could be identified.

Several projects (such as [2]) have analysed contracts with and without passenger incentives, whereby the operator is paid a fixed sum of money for each additional passenger boarding buses run by the contracted operator. None of these studies have found statistically significant higher passenger numbers in contracts with

passenger incentives. Few studies have analysed quality incentives, but those that have indicate uncertain results.

As regards procurement issues, studies [19] have shown that several reasons for high costs for bus services stem from procurement aspects. Despite the fact that functional requirements have been requested by the industry for a long time, many detailed requirements remain in place in many procurement procedures. These include age requirements, stipulating both a maximum age for every bus and a maximum average age for the fleet. Furthermore, Bus Nordic has evolved over the years (previous different versions of Buss2010); but research has also shown that while RPTAs refer to the document, many additions, exceptions and clarifications are made, thereby making it more difficult for bus operators to be able to relocate buses to other areas.

What do we know now that we did not know ten years ago?

Looking at public transport in general, it has delivered what politicians wanted most of all – more passengers travelling. However, this has come at the price of a sharp increase in costs. Neither procurement procedures nor renewal of contracts appears to have been able to influence the latter.

The most significant thing we know now is that controlling contract outcomes is not as simple a task as the authors of the early recommendations appeared to hope it would be. One factor that may be contributing to the increased costs is that despite wishes to the contrary, operators are still significantly limited in terms of what they can influence. Another factor is that this has been combined with a high level of revenue certainty, achieved by indexation of compensation corresponding to input prices, which has reduced incentives to cut costs.

We also know that follow-up has been lacking in significant areas. However, more and stricter follow-up would also cost more. At best, smarter follow-up may result in more lessons being learned about how requirements can be made more effective and how costs can be reduced. It may appear rational not to increase follow-up if politicians have wanted to limit client costs. However, this may prove to be a poor strategy. More follow-up could improve governance, but it may not lead to greater efficiency unless a smart approach is taken.

11 Electrification of public transport

Fredrik Pettersson-Löfstedt & Vendela Åslund

Electrification of public transport is a phenomenon both old and new. Electrification of the railways began early, and the first electrified line for passenger services was put into operation in Sweden by the end of the 19th century [1]. Today, Sweden is one of the countries in Europe with the highest share of electrified railways. About 80 per cent of the Swedish rail network is electrified, and over 90 per cent of trains run on electrified lines [2]. Other examples of long-standing electrified public transport include the Stockholm metro and 'old' tramway systems such as those found in Gothenburg and Norrköping. There are also long-standing examples of electric buses, known as trolleybuses, which were operating in Stockholm as early as the 1940s. The trolleybuses of Landskrona, which have been in operation since 2003, are a more recent example [3]. In Sweden, however, more trolleybus initiatives have been conspicuous by their absence. Since the early 2000s, many bus manufacturers have introduced electric hybrids: this can be viewed as a form of electrification.

Rolling out battery-powered electric buses

But when it comes to public transport electrification and research, the introduction of battery-powered electric buses has been the big issue over the last decade. A few battery-powered electric buses were operating in Swedish cities when K2 began, almost exclusively as test projects. The rate of introduction has been high over the last five years, however; and, as Figure 1 below shows, electric buses are now an increasingly common feature of the regular public transport services procured in many Swedish cities. At the time of writing, there are over 1,200 electric buses in Sweden: compare this to a total of around 9,600 buses providing urban or regional services (known as Class I and II buses) in 2022. Additionally, there are also more than 2,000 Class III buses, commonly known as touring coaches [4]. Almost all buses in Figure 1 are city buses. It can be concluded,

therefore, that although the number of electric buses has increased significantly in recent years, the transition is still at a fairly early stage and there is a long way to go before the entire Swedish bus fleet is electrified – which may not even happen.

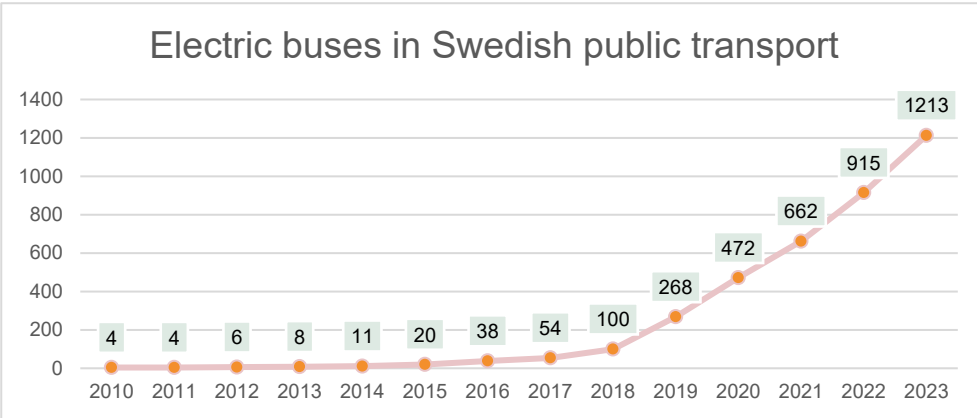

Figure 3. Electric buses in Swedish public transport [5] [6]

To put the figures in Figure 1 into further perspective, we can look to China, which has undergone a dramatic transition to electric buses. There were over 400,000 electric buses in Chinese cities as early as 2019. This means that the Chinese market accounts for about 95 per cent of all the world's electric buses [7]. From a European perspective, however, Sweden is quite advanced in terms of electric buses, which has made the Swedish context an interesting research subject.

Test and demonstration phase

An early K2 study mapped various electric bus test operations in Sweden and Europe [8]. This study showed that electric bus initiatives at that time varied a great deal in terms of aspects such as the choice of technology, the nature of the projects, the stakeholders involved and the objectives of the initiatives. Electric buses were often introduced outside regular procurement procedures. Bus manufacturers, technology companies, universities, research institutes, transport operators and power utilities were actively involved, and the emphasis was often on testing and demonstrating various technical solutions in collaboration with public stakeholders. Municipalities or regions usually took on the financial risk of buying vehicles and charging infrastructure. There were many examples of

municipalities acting as testing grounds, and investment in electric buses was viewed as a kind of experimentation linked to visions of a fossil-free transport system. Therefore, the objectives of this type of test and demonstration project were not necessarily to electrify the entire bus fleet in the city, but to learn about different technical solutions for the electrification of bus services [8].

Early examples of introduction to regular services

However, there were also early examples of electric buses being used more as part of regular public transport services. In Sweden, cities such as Ängelholm and Eskilstuna were early adopters of electric buses in this manner. Electric buses were also introduced to several UK cities at around the same time. These transitions were characterised not by emphasis on testing, development and learning, but on safe running and low costs. Unlike test projects, which focused more on experimentation, this meant that the most established technologies and suppliers were generally selected. Government funding in the form of subsidies, such as the Elbusspremien [electric bus premium] scheme and urban environment agreements in Sweden, or the Clean Bus Technology Fund in the UK, were important. Funding from national or EU research funding bodies also had a major role to play in this phase of the transition [9].

It can also be noted that at the time, there were great expectations that the upcoming transition to quiet and – during the operating phase – emission-free electric buses would help to bring about fairly radical changes in bus services by making it possible to operate services in sensitive environments, for example, where exhaust fumes and noise from internal combustion engines had previously presented an obstacle. The possibility of locating stops indoors was another example of such expectations [10].

> Electrification of bus services in a Swedish context also means that the role of procurement in the transition will be important. Electrification can be viewed as a new phase in a clear trend whereby Swedish regions are switching to fossil-free bus services.

Introduction on a wide scale – new issues in practice and research

Electrification of bus services in a Swedish context also means that the role of procurement in the transition will be important. Electrification can be viewed as a new phase in a clear trend whereby Swedish regions are switching to fossil-free bus services. The widespread introduction of biofuels such as biogas, ethanol and biodiesel meant that procured bus services were already virtually fossil-free by the end of the 2010s [11]. However, the shift to electric buses was a clear trend by the end of the 2010s, as evidenced by the inclusion of electric buses in new procurement procedures as an alternative to biofuels. One interesting example of this is a procurement process where the client defined a requirement for biogas buses, but the winning bid used electric buses instead [12].

Which technology is best?

Research into electric buses that was conducted in the 2010s focused extensively on issues relating to technology, such as the choice of charging strategy (depot charging, top-up charging or charging on the move, for example). Such studies [13] [14] often attempted to answer questions such as 'what is the best solution in terms of technology and charging infrastructure?'. The answer to this question depends on what is meant by 'best' – does it mean cheapest, for example, or most energy-efficient, greatest reduction in environmental emissions, or least impact on existing service arrangements [14] [15] [16] [17]? The results of various studies also showed that local context, such as urban structure, length of bus routes, type of service arrangements, operational requirements, funding model and the type of fuel being compared to electric power, have a major impact on what can be regarded as 'best'. It was also generally assumed at the time that technological developments would make batteries cheaper, and the price per kilowatt-hour of battery capacity was expected to continue to fall.

How to manage various challenges and barriers during the introduction?

Other studies focused on integration of electric buses into public transport services by answering questions about the pace at which electric buses should be introduced in order to minimise costs and energy use [18] [19], for example, or where charging infrastructure should be located [20] [21]. The results of such studies highlight the fact that the transition rate – that is, how quickly electric buses should be introduced – depends on the goals to be achieved (such as reduction of emissions in relation to costs) and the fuel from which the transition

is being made (such as from diesel to electricity, or from gas buses to electric). Of course, issues related to the locations of charging infrastructure are also highly dependent on local context and site-specific characteristics. In general, the results of the research in the late 2010s showed that electric buses may have lower operating costs than biodiesel and biogas, but that the investment costs for electric buses and charging infrastructure for them were higher. There was a great deal of emphasis on technical, but also institutional barriers [22] [23] to the transition to electric buses.

However, the increasing rate of introduction of electric buses, both in Sweden and globally, in the early 2020s indicated that many of the barriers to the transition appeared to have been lowered. This established an interesting fund and provided new ideas for further research into the transition to electric buses. An interesting question in the Swedish context, where bus services were already virtually fossil-free, was what provided the actual driving forces behind a transition to electric buses. The large-scale introduction also raised questions about how electric buses work for regular services, and how a large-scale transition can take place in the most sustainable and resource-efficient manner possible.

Have expectations for electric buses been met?

Reduction of exhaust emissions and noise from buses on account of electrification remains a major driving force behind the transition. As the introduction of electric buses now appears to be widespread, electrification per se has also become a reason for more and more cities to make the transition [24]; or, as one interviewee in a research project put it, ‘The whole world is electrifying!’.

As technology has developed, finance has also become an argument in favour of switching, as electric buses are expected to result in lower operating costs compared to diesel and biogas buses, for example. However, as more cities have introduced electric buses and operating experience has been built up, it has become clear that expectations of significantly lower operating costs have not been realised, mainly because maintenance costs for electric buses have been underestimated. Expectations that the cost of batteries would continue to fall have also failed to materialise [25]. Moreover, the variation in the price of electricity over the day and year affects charging costs. This can have a major impact on operating costs for electric buses, depending on the charging strategy selected and the time of day when buses are charged [26].

It can also be noted that the expectations that electric buses would pave the way for new urban and built environments by enabling indoor bus stops to be built or

allowing access to sensitive areas, for example, have been only partially realised. Electric buses have opened up new opportunities for urban development in places or along routes where air pollution and noise from buses have previously been a barrier to new housing developments, for example. However, to date the transition to electric buses has had a limited effect on routes through sensitive environments, for example, or new solutions such as indoor bus stops. In other words, hopes that electric buses would help to bring about quite substantial changes to bus services have not been realised as yet [10].

New challenges

Electric buses are now commonplace in Swedish public transport services. Running electric buses does not appear to be a major problem in itself once the services are up and running, apart from a few issues with fine-tuning and 'teething troubles' in the very early phase. However, it has been shown that problems with charging and reduced range can occur in cold winter temperatures [27] [28]; a challenge that is greater at more northerly latitudes, of course.

Although the running of electric buses does not present a major obstacle to efficient and attractive public transport, the preceding phase – the procurement of electric buses – presents a challenge for practitioners and is an interesting research domain. While there are some differences in how different regions or municipalities procure electric buses, they share a number of common issues or challenges. For instance, electric buses are assumed to have a longer lifetime than other buses, which means that the service life of the vehicles is longer than the contract period. The way this has been managed varies from city to city [12]. A further example relates to the management of responsibility for and ownership of charging equipment and depots. Who is to invest in, establish and own these installations also differs from city to city. However, there are indications that the transition to electric buses is contributing to a trend of increased public ownership, with regions or municipalities taking greater responsibility for the ownership of depots and charging infrastructure [12] [24].

Transition in a changing world

A number of major external events have affected the transition to electric buses over the past five years: the pandemic has impacted demand for public transport in general, conflict and war have affected supply chains and access to technology, high electricity prices have affected costs, and new guidelines have been developed that place increasingly stringent demands on environmental and social sustainability in the production of vehicles and batteries [29]. Last but not least,

funding opportunities have also changed. The Elbusspremien scheme – that is, state funding for electric buses – has been reformulated and is now available only for Class II buses intended for regional services, and not for city buses [30]. Moreover, what are known as urban environment agreements have been phased out. These urban environment agreements previously played a role in the transition by enabling joint funding solutions for charging infrastructure [31]. The conditions for the transition have been dynamic and changing, to say the least.

Despite this, the transition of Swedish public transport services has continued. By the end of 2023, about 9 per cent of Sweden's total bus fleet was electric, compared to 2 per cent just five years earlier [32]. Focusing only on city buses, the share of electric vehicles stands at almost 30 per cent due to the fact that almost all electric buses in Sweden are city buses. There is every reason to expect the transition to continue at a similar pace and scale as a number of upcoming procurement procedures include electric buses [33], and many of the regions have set goals for fully electrified (urban) services within a few years. Perhaps most importantly, the automotive industry is investing heavily in electrification, which means that – in the short term, at least – the technology that is capable of meeting 'zero emissions' requirements (which usually means emissions while travelling, not the entire manufacturing process) is electric buses. But while public transport has come a long way in the transition, new phases of the transition to electricity open up new issues. The electrification of regional bus and touring coach services (Class II and III buses) has barely begun, and many new challenges remain that need to be addressed.

It could also be said that electric buses have become a symbol of a green transition. This means that bus services are expected to be quiet and emission-free. Vehicles, batteries and the electricity used are expected to contribute to lofty ambitions of environmental, social and economic sustainability [24]. In other words, there are high expectations that electric buses will help achieve many different goals in society. That said, there are also major challenges in the continuing transition. Access to the right amount of electricity, in the right place, at the right time is a key challenge. In southern Sweden, where there are occasional shortages of capacity and power in the electricity grid, issues relating to the establishment of electric bus depots are an important consideration; not least because the electrification of cars and lorries, as well as industry, is viewed as central to achieving climate goals.

12 Digitalisation and public transport

Jan Persson

Digitalisation plays an important role for society and public transport as it can influence all dimensions of sustainability – social, ecological and economic. For instance, digitalisation can influence public transport resource efficiency, thereby making it possible to provide better service and save on resources, which includes reducing emissions. Furthermore, digitalisation can influence groups and individuals in different ways. While digitalisation can support passengers, it can also exclude people who are less used to using digital services such as buying tickets with a smartphone, or who are unable to use such services. As digitalisation is typically based on access to data, there is also a risk of violations of personal privacy due to information about individuals being created and stored without their consent. Digitalisation can also affect which stakeholders have access to data, and to what extent, which allows some stakeholders to gain competitive advantages over others.

In the field of public transport, digitalisation has perhaps been reflected most clearly in changes to digital passenger services. Examples of changes include:

- → manual sale of paper tickets has been replaced by electronic tickets on smartphone
- → static timetables on paper have been replaced with real-time display of vehicle position and departure times updated in real time in journey planners on mobile phones
- → new transport service variants have been introduced, such as demand-responsive public transport with the option to travel now and complementary transport services to public transport such as micromobility (for example, using electric scooters rented via apps);

For public transport stakeholders, new opportunities have also been created by collecting and analysing data based on ticket data, for example, or based on pick-

up and drop-off via APC (Automatic Passenger Counting). Computer-aided planning and optimisation of resources is also used, including timetabling.

From a historical perspective, digitalisation has involved automation of data via IT. A related earlier designation was ADB – Automatic Data Processing. More recent initiatives, such as the Swedish ICT Commission and the Swedish Digitalisation Council[12], also deserve to be highlighted together with digitalisation as a topic. As the boundaries between what is referred to as IT (Information Technology), ICT (Information and Communication Technology), computer-aided data processing and digitalisation are difficult to draw clearly, we choose here to view digitalisation as relating to the use of IT, ICT, computers or data with the ambition of improving in various ways. Digitalisation can also involve creating an understanding of a field or phenomenon by collecting and using digital information via digital tools, for example.

K2 has conducted research related to the development of digitalisation in public transport in slightly different ways: directly linked to the development of information technology; linked to the impact of digitalisation on individuals and society, or to the development of transport services that are highly dependent on digitalisation; and by using data made possible by digitalisation. Critical perspectives on digitalisation have also been included in the research. K2 has thus contributed to understanding, and probably to stakeholders making more informed choices in the developments linked to digitalisation that have taken place and are still taking place.

Examples of how K2 has contributed knowledge in areas related to digitalisation are presented below. The review indicates a broad scope and considers the following areas: travel support systems and information for passengers, information on travel and passengers, and new services and the transport system. The future in the form of artificial intelligence and challenges with digitalisation are also highlighted.

12 https://digitaliseringskommissionen.se/om-digitaliseringskommissionen/

> Autonomous shared vehicles can have a positive impact in terms of reduced vehicle kilometres, as long as ride-sharing is achieved during the journeys and the trips replace private car journeys. However, without ride-sharing, these vehicles have a negative effect.

Travel support systems and information for passengers

Digitalisation has played an essential role for passengers on account of travel apps of various kinds. The fundamental difference compared to earlier printed timetables is that travel apps can provide real-time information, which is particularly relevant when services are disrupted. They can also provide information based on the passenger's situation (context, that is), such as their location or any special needs they may have. At K2, research has addressed what is relevant for travel support systems to know about passengers in order for the digital tool to provide relevant support, such as suggesting new travel routes in the event of delays [1]. Typically, one underutilised context is the ability for the travel support system (the smartphone, that is) to know which departing bus or train the passenger is actually on. It has also proved difficult to efficiently identify explicit buses or rail carriages in the system, which is required for more refined digital travel support that, for example, allows guidance for boarding with wheelchairs.

Research at K2 also showed that the exchange of information between passengers and the transport operator provides opportunities for the operator to improve information services for passengers by acquiring intelligence about the passenger's situation and intentions, which provides a basis for replanning and managing replacement services in the event of disruptions, for example, at both an aggregate and an individual level [2]. In general, the more information a transport operator has about its passengers, the better service it can provide. That said, it is important to bear in mind that passengers may not want to share information such as their actual final destination.

K2 has also conducted research into the type of information and packaging that best supports passengers [3]. This has been done on the basis of a real-time map of the positions of public transport vehicles and relevant opportunities based on the passenger positions. Users of such a real-time map should also be able to 'fast-forward' to see where they might be at a later time if they use any of the vehicles illustrated in the moving digital map.

Digitalisation has enabled developments in ticketing that extend beyond cost efficiency for operators, but have increased opportunities for passengers in the form of new payment solutions (such as Swish) and ticket types (ten travel days in a 30-day period) and linked opportunities such as digital ticket lending and capping (so that passengers do not pay too much even when they use several single tickets in one period, for example). Investment in IT systems, such as

ticketing systems, can be quite significant. It may therefore seem that a socio-economic analysis should be included in the event of any such investment, where social benefits are set against costs. However, there are examples where such considerations are not made [4].

One relevant aspect of digitalisation is its potential to influence travel behaviour, for example related to various information services as mentioned above. It may also involve digitalisation in order to influence travel behaviour, explicitly promoting sustainable travel. For instance, research has looked at how smartphones can be used for this purpose [5]. The results indicate a need to personalise information so that it is relevant to the context, and that feedback to individuals is important. Such insights can be used when designing digital services to encourage sustainable travel.

Researchers at K2 have also highlighted the opportunities offered by digital communication with passengers, finding that such communication can help to improve the customer experience and so increase travel. However, there are challenges with digital communication, and these differ depending on the different groups of passengers; the challenges being greatest for older people [6]. The potential of digital information has also been highlighted for passengers using transfer points, where it has been found that there is potential to provide digital support to passengers at transfer points. For instance, observational studies showed that people already appear to rely heavily on smartphones at transfer points [7].

Another example of research related to the opportunities offered by digitalisation and its impact on different groups has focused on the perspectives of older people and demonstrates that if digital services (digital locks and digital information boards) are used, for example, the technology can improve matters for this group by providing better accessibility and health [8]. There are also examples of summaries on digital travel support systems for passengers with varying needs [9]. The summary highlights factors such as challenges in this area, such as the quality of digital information and the fact that few/no journey planners are fully satisfactory from an accessibility perspective.

Information on travel and passengers

Digitalisation also provides new opportunities to gather information on travel. For instance, Public Participation Geographic Information Systems (PP-GIS) in the form of a map-based online web survey can be used to collect information. Such a method can provide information on perceived public transport safety, as has been done at various locations in Malmö [10]. Another example is investigating

everyday mobility during COVID-19. where PP-GIS was able to provide richer information when data was collected [11] . In this case, it showed the increased need for access to walking and cycling infrastructure and the need for green spaces.

Digitalisation has also enhanced understanding of travel by using smartphones to collect data on travel similar to a paper-based travel diary, but with the advantage of creating more precise data on aspects such as time and location. Such collection also enables passenger-related questions to be asked directly in relation to passenger context, such as their chosen route. This has been used to analyse travel linked to waiting times [12] [13], and to estimate travel route selection parameters, which in turn provides more of an understanding that can be used in planning models or planning principles. In these cases, passengers have installed an app that collects both GPS data and user input.

One possible overlooked effect of digitalised services in respect of mobility is that such services themselves can also provide opportunities for more data and relevant data on travel. For instance, data from electric scooters can be used to estimate whether electric scooters are primarily a complement or a competitor to public transport by studying the starting points and destinations when they are used [14] [15]. The results indicate that electric scooters can be both a complement and a competitor, but to different extents depending on factors such as distance to public transport, which can be taken into account in planning.

Digitalisation and transport services

Digitalisation also enables more efficient integration of mobility services, as envisioned with MaaS (Mobility as a Service), an area in which K2 has conducted research [16] [17]. MaaS aims to make it possible for passengers to easily combine different modes of transport for seamless travel. The integrated services are combined in a digital interface (typically on a smartphone). This research into MaaS also indicates clearly that there are often obstacles to digitalisation. For instance, it can be difficult to set up simple systems for passengers so that they can use all relevant mobility services. More than integration of services in an app may also be required. New types of offerings such as subscriptions for multiple mobility services are also needed if MaaS is play an important role. Collaboration between different stakeholders is key, therefore. Such collaboration can take place in slightly different ways, and with slightly different roles for public stakeholders [16].

Since K2 began, several mobility services which are largely dependent on digitalisation have emerged or been revitalised. For instance, we have seen the development of electric scooters that are ordered, monitored and planned using digital services. Another example is demand-responsive public transport (DRT: see the other chapter and project example[13]), which is clearly based on digitalisation. DRT is a demand-responsive service open to all, where passengers have to book their travel in order to leave now or later. The vehicles adapt their route to enable ride-sharing as far as possible, and can be viewed as a cross between a taxi and a bus. In DRT, digitalisation is highly relevant for communication with passengers about updated pick-up times, for example, and also for service optimisation. Optimisation is key to achieving ride-sharing effects and potential coordination with other services for the vehicles, such as mobility services. Furthermore, digital tools such as simulation tools are needed in order to analyse the impact of DRT [18], particularly in respect of new variants of the DRT service and regarding higher travel volumes that are absent from implemented services.

Digitalisation in the form of sensors and the interconnection of various IT systems enables more comprehensive and efficient collection of data on the transport system. For instance, it is possible to continuously collect arrival and departure times for trains and perform analyses that can enable a better understanding of the causes of a lack of punctuality [19] and trends over time, and also to improve delay forecasting [20]. Furthermore, analyses can be performed of how delays are affected by variations in weather and passenger numbers.

Digitalisation offers new opportunities in the form of autonomous/self-driving vehicles. Research at K2 does not include research into the development of autonomous vehicles per se, but looks at potential impacts and challenges that may arise. For instance, the needs of visually impaired people have been brought into focus with the introduction of autonomous vehicles [21]. Different use cases have been specified in the research to better understand needs and potential solutions to support travel with autonomous vehicles for visually impaired people.

Autonomous vehicles – or, rather, their use in the form of ride-sharing or as robot taxis – have also been studied from the urban and societal perspective. A simulation study of Gothenburg, Mölndal and Partille has studied effects relating to the need for the total number of vehicle kilometres and vehicles [22]. This study clearly indicates that autonomous shared vehicles can have a positive impact in

13 https://www.k2centrum.se/en/policy-lab-public-transport-demand

terms of reduced vehicle kilometres, as long as ride-sharing is achieved during the journeys and the trips replace private car journeys. However, without ride-sharing, these vehicles have a negative effect. In fact, the adverse effects in terms of increased vehicle kilometres may be greatest in suburban areas such as residential areas.

A chapter on digitalisation should also mention the fact that digitalisation makes it possible to avoid travelling, for example thanks to various digital remote working services. K2 has not focused on remote working, but it is nevertheless relevant to understand how the opportunity for remote working can influence travel among different groups, which should reasonably affect transport planning. After all, the COVID-19 pandemic provided an opportunity – which has been used in some studies – to analyse how different groups changed their travel on account of aspects such as different opportunities for remote working, [11] [23].

Artificial intelligence and new technology

Travel support systems (in the form of travel apps) can potentially be improved by the use of machine learning. This was demonstrated using a travel app where historical context information was used [24]. In this case, the travel support system uses machine learning to learn to predict which train departures passengers are interested in receiving information about (before they are requested). A review of research into AI and public transport shows that machine learning (and AI in general) has the greatest potential improve the passenger experience, for example through enhanced travel support/decision support systems, as well as by enhancing service quality and providing better insights into passenger behaviour. There are also examples of how AI is being used for other roles, such as streamlining the transport system [25].

There are a number of ongoing trends related to AI and machine learning systems that are likely to have a major impact on public transport. One trend is that analysing and processing data using AI offers potential efficiency gains, but also new opportunities to understand data, particularly from the transport system, including covariances with, for example weather data and event information. AI and data can also help to predict future public transport disruptions, albeit typically in the form of increased probability. These probabilities are often relatively small

and therefore rather questionable to act upon in order to create added value, at least according to the results of the AI-enhanced mobility project [14].

There have been strong expectations that AI will enable the rapid and widespread introduction of autonomous vehicles, which has not occurred as yet. Quite recently, however, the technology has proven its worth on a slightly larger scale, at least in some contexts (such as Waymo in San Francisco [15]). As autonomous driving technology is rolled out in the transport system, the cost structure for vehicles is changing and the greatest potential for savings should be found at points where driver costs are highest relative to other costs – in smaller vehicles, that is. Thus, it is reasonable to expect mobility services such as taxis and demand-responsive services (including demand-responsive public transport) to see an increase in competitiveness relative to other mobility services. Mobility services based on vehicle sharing, such as carpools, may also evolve and become more attractive as vehicles can move to passengers independently. Thus, there is likely to be pressure on public transport to both utilise autonomous technology to save money, and to reasonably adapt to the development of autonomous vehicles within various mobility solutions. Autonomous vehicles with low ride-sharing levels may well lead to reduced sustainability, as is also illustrated by simulations [22].

Looking back, it is quite clear that travel apps from Google, for example, or from regional public transport authorities have altered the way in which we use public transport. At the very least, it is reasonable to assume that the introduction of journey planners has resulted in routes using public transport being planned closer to the departure time, for example, making the planning more dependent on the current service situation and any delays. At present, it may be suspected that many people find identifying a route – that is, how to get to a place by public transport (provided that the option is available) – to be fairly unproblematic. Looking ahead, a likely trend is that travel apps will provide more context-based travel advice and support. Besides location and special needs, this support may be based on information such as past behaviour and (indirectly) expressed wishes.

Imagine that you have previously sent a message to a friend about meeting up for a coffee sometime and searched for a particular type of bicycle online. It is not utopian to imagine that AI, in the form of a personal assistant (if you want to and grant it permission), could proactively suggest a destination and route for a coffee on the basis of your the friend's ability to travel, the predicted occupancy of the public transport route in question (including the availability of demand-responsive

14 https://closer.lindholmen.se/projekt/prediktering-av-storning-i-kollektivtrafiken

15 https://waymo.com/waymo-one-san-francisco/

travel with a ride-sharing option) and the stock levels of the specific type of bicycle in a shop. This example highlights not only a ‘possible’ future scenario, but also a common trade-off between our personal privacy (what digital information we feel it is fine to share, with which stakeholders and for what purposes) and the benefits that the individual may perceive. Historically, there are quite clear indications that people will sacrifice their privacy in return for benefits to some extent, but how this will evolve in the future is unclear. Thus, an important consideration for public transport planning is to be prepared for the possibility that travel will be guided not only by people’s immediate travel needs and preferences, but also by ‘digital assistants’ to some extent. Utopian, perhaps, but already aspects such as social media trends (AI-driven to some extent) are having an impact on our behaviour, so from that perspective this kind of future scenario is already here.

Historical and future challenges

There are some obvious problems with digitalisation that have been demonstrated historically, such as the fact that introducing IT systems can be much more costly than the cost estimate that existed at the time the decision to introduce them was made (and unclear societal benefits for the IT investment as referred to above). Additionally, some system functions may be inferior to what they were in the previous IT system that was replaced. These challenges also apply to the development of travel apps, where researchers who have monitored such developments have identified significant challenges for public stakeholders in maintaining control over such apps [26].

In this chapter, we have also pointed out that different groups and individuals have different abilities and opportunities to use digital services, which may create a kind of exclusion. Another relatively obvious challenge and concern with digitalisation is linked to the personalisation of transport services, such as MaaS solutions and demand-responsive public transport, which often involve passengers/citizens sharing personal preferences or address information on where they want to go and when. Access to passenger data may make it possible to identify regular visitors to a mosque, for example, at least with a degree of increased probability. However, it should be mentioned that there are a number of different methods for reducing this type of privacy issue, such as pseudonymisation or simply not storing more information than is necessary.

Another challenge is that increased personalisation of mobility services (enabled by digitalisation), such as demand-responsive public transport, context-based travel support systems and micromobility solutions, leads to more varied and uncertain travel offerings and their quality. It may vary over time (throughout the day and from day to day) and be reliant on other passengers' journeys. In the case of demand-responsive public transport, for instance, the waiting time and journey time for a passenger may be reliant on parameter-driven real-time decisions built into the digital systems, as well as being dependent on how many other passengers are competing to travel at about the same time. One challenge, therefore, is to plan mobility on the basis of defined goals through various parameters in digital systems as well, which requires new knowledge compared to the traditional way of planning on the basis of the number of bus or train departures from a stop per day.

The conclusion of this chapter states that digitalisation technology offers significant opportunities for sustainable travel. However, 'forward-looking' analyses are required in order to understand which areas society should regulate, incentivise or subsidise in order to harness the benefits of digitalisation while also avoiding the worst pitfalls.

13 New public transport services

Karolina Isaksson

New public transport services have become a key issue for public transport over the last decade or so. *New services* in this chapter include examples such as digital information, journey planning and payment services, but also various types of sharing and ride-sharing services that can form part of or complement existing public transport. The chapter highlights the issues and perspectives on new public transport services that have characterised K2's research over time, from the start-up and establishment phase to today. Links are also made to research from other contexts. Overall, the emergence of an increasingly diverse research domain is depicted.

Early ideas on the opportunities offered by digitalisation

When K2 began in 2013, one of its first tasks was to define a specific research agenda. The starting point was a Future Search Workshop at Luftkastellet in Malmö, which gathered more than 70 people from research, public transport operators and public authorities responsible for transport and urban planning, as well as consultants, industry organisations, politicians and civil society organisations. Proposals for prioritised focus areas for K2 research activities were developed over three days.

One of these areas focused on new public transport services, although 'new services' was not the term used at that time. However, there was interest in questions about how digital technology could be used to further develop public transport and make it more attractive to passengers. One theme related to the development of travel planning services – preferably with payment functionality. Another possible application discussed related to information services aimed at supporting passengers in the event of delays, for example. There were also ideas

about using digital technology to gather knowledge about passenger behaviour and preferences. A further question concerned how public transport in rural areas could be strengthened by means of greater coordination of school transport, travel to work, mobility services, medical travel and leisure travel. It was assumed that information and communication technologies could reinforce the links between different services and help to optimise routes or enable new types of demand-responsive traffic to be implemented. There were hopes of more 'seamless' travel, where digital services would be used to strengthen the whole journey perspective and use public transport more efficiently.

The process of defining K2's research focus did not take place in a vacuum. This was a time when interest in digital technology and its potential to streamline and optimise the transport sector, including public transport, was gaining ground. New concepts for shared travel were established globally, including new types of bicycle-sharing systems and new ride-sharing services, Uber being one of the most widely discussed. On a national level, Samtrafiken, working in collaboration with Storstockholms lokaltrafik (SL) and what was then the Viktoria Institute, had launched Trafiklab in order to develop the work (individually and jointly) of public organisations and private public transport operators with travel information and open data. Travelhack was a recurring event that resulted in concrete ideas and proposals for apps that were intended to make public transport more attractive. At KTH Royal Institute of Technology, research was also conducted into how real-time information could be used to increase bus service regularity in cities [1].

Other initiatives focused on testing and developing new sharing services. In Gothenburg, the UbiGo pilot project was launched in 2013 to design and test a new type of mobility service combining public transport, carpooling, car hire, bicycle sharing and taxis in a single offering. Households participating in the project were given access to an app where they could make bookings and activate trips using the modes of transport that were included [2]. UbiGo, which was a continuation of the pilot study *Den flexible trafikanten* [The flexible road user], gained attention and helped to increase interest in potential applications for digital technology in the field of passenger transport, which also provided important input for K2's research agenda.

A research domain in the making

A total of five major research domains were designated when K2's full operational phase began in 2015. One of these related to information and communication technology and its potential to strengthen public transport. Other major initiatives were launched in parallel at national level. The strategic innovation programme

Drive Sweden aimed to drive the emergence of digitalised and shared mobility solutions for a sustainable transport system. A further initiative was the government's collaboration programme for *Nästa generations resor och transporter* [Next generation travel and transport], which led to what was known as the *KOMPIS project* (Combined Mobility as a Service). Pilot projects were launched within the framework of KOMPIS to strengthen learning about what combined mobility could involve in practice.

MaaS on everyone's lips

A great deal of interest was focused on developments in Finland, where the potential of digitalisation to develop public transport and sustainable travel was high on the agenda during those years. In 2014, the Aalto University student Sonja Heikkilä had written a master's thesis for the City of Helsinki, which coined the term *Mobility as a Service* (MaaS) [3]. According to Heikkilä, MaaS should be understood as a system where mobility operators provide a range of mobility services that passengers can access easily without having to deal with lots of different ticketing and booking systems themselves. In her thesis, she painted a future scenario of more flexible and personalised travel offerings, which were assumed to be a way to maintain the attractiveness of public transport for existing passenger groups, while also enticing car drivers to switch to more sustainable travel practices.

The ideas expressed by Heikkilä in her paper were also expressed in other contexts during these years, including the UbiGo project referred to above. While the ideas were not unique, the concept of MaaS caught on quickly and for several years became the buzzword on everyone's lips in discussions about new public transport services.

Strategic analyses and future forecasting

In 2015–2016, K2 initiated a number of studies of different types of services that were deemed to have the potential to strengthen the public transport offering to passengers. This included the development and use of real-time data to be used in situations when public transport services were disrupted, for example [4]. However, a significant part of the research involved mapping and concept clarification. One example is a strategic outlook on integrated mobility services that was conducted by researchers at Chalmers University of Technology and the Viktoria Institute in collaboration with K2 in 2016. One of the aims was to clarify the relationship between some of the various concepts that flourished during those years: combined mobility, mobility as a service and integrated mobility services

[5]. The analysis highlighted a number of completed or ongoing projects relating to combined and integrated mobility from countries such as Sweden, Germany, the US and Austria. It was noted that different projects had led to different results; and that some had been extended and undergone further development, while others had been discontinued following a brief trial period. The causes were not analysed in detail, but funding and regulatory issues were identified as important issues. The overview led to recommendations to work further with pilot projects and to develop clearer concepts and frameworks in order to facilitate in-depth analyses and evaluations.

In 2016, K2 initiated a project aimed at analysing changing conditions for future public transport, focussing on trends and counter-trends. The project report included a chapter that discussed issues related to intelligent transport systems and digitalisation. Inter alia, it was highlighted how new services based on open data can facilitate rapid decisions for the individual and strengthen the opportunities to combine different travel options, as well as comparing them on the basis of time, cost and other aspects such as health and the environment [6]. New services were primarily referred to as a strengthening force for existing public transport and other forms of sustainable travel. However, other analyses highlighted the fact that much was still unknown about the impact of new services on public transport and emphasised the need for more empirical evidence so that firm conclusions could be drawn [7].

Greater interest in institutional frameworks

During these years, there was also an increase in interest in different types of barriers or challenges that could be expected to affect the implementation of integrated mobility services. In addition to technical issues, focus began to shift towards regulatory frameworks and other types of institutional factors. The fact that these issues began to attract attention in the Swedish context was largely due to the analyses that were now being completed by the UbiGo initiative in Gothenburg, to name but one example. Further analyses on institutional frameworks for integrated mobility services were conducted by researchers at Lund University, Chalmers University of Technology and Trivector between 2016 and 2018 [8] [9]. One specific issue that received increased attention during this period was procurement. A trial was conducted in the Västra Götaland region to find out whether MaaS could be procured as part of public transport. However, it was concluded that MaaS was still too new and immature a phenomenon to be suitable for public procurement [10].

> Technological development per se is not what makes a difference, but rather how new technology is applied in specific social and political contexts. Opportunities for enhanced resource efficiency and sustainability do not materialise all on their own.

Further empirical research and a more diverse picture

Research into new public transport services entered a more empirically oriented phase in the 2018–2020 period. A number of Swedish pilot projects were taking place in order to test and learn more about new public transport services, including those linked to Drive Sweden and KOMPIS. Most of the pilot projects took place in urban environments. One example was the *Modern mobilitet i Barkarbystaden* [Modern Mobility in Barkarbystaden] project in north-west Stockholm. This pilot project included trials of MaaS and driverless shuttles [11]. There were also projects testing combined mobility in rural environments, for instance *KomILand*, which was conducted in western Sweden [12]. Attempts were also made with services to reduce the need to travel. One example was a local workplace hub that was designed and tested as part of the *Mistra SAMS* research programme (Sustainable accessibility and mobility services), where K2 participated as a partner [13]. New services also emerged during these years in an unregulated and unplanned form, such as the hundreds of blue-and-green EU bicycles that flooded the streets of Stockholm in the summer of 2018 but vanished after just a few months. The appearance of shared electric scooters in several Swedish cities in the late summer and autumn of 2018 was a more lasting phenomenon. Both the pilot projects and the commercial mobility services provided new experiences.

Critical approaches

During this period, K2's research developed a more multifaceted understanding of new public transport services. The optimism that had characterised the early discussions was complemented by more explicitly critical understandings and approaches to new public transport services. The K2 projects developed during these years were inspired by the problematising discussions that had also started to develop in the field of international research. Studies were published that asked more fundamental questions about what the ongoing shift to a transport system with increasing elements of digital services could mean for the development of society as a whole and for the possibilities of achieving societal goals of long-term sustainable development [14] [15] [16]. Critical analyses were made of MaaS and the way in which the concept is grounded in the notion that mobility services should be designed to be optimal for the individual, as this does not necessarily overlap with sustainable development at a societal level. Additionally, risks were highlighted with an increased element of digitally supported mobility services under private management, as this could mean that public planning stakeholders

would find it more difficult to gain access to passenger data and other data that would be needed for strategic transport planning and social planning [17].

At the same time, empirical research from the US and elsewhere showed that new ride-sharing concepts such as Uber and Lyft had led to increased use of cars (increases in both the number of trips and the number of passenger kilometres), and that this was true even in areas where public transport was well developed [18]. Swedish scenario studies indicated that there was a genuine risk of similar effects here, too. A K2 report dated 2019 highlighted the fact that digitally supported ride-sharing, sharing and journey planning services could not automatically be expected to promote public transport and other forms of sustainable travel, but could just as easily lead to increased car use, depending on a number of interacting factors and trends in the field of automation as well [19]. It became clear that issues relating to new public transport services needed to be understood and analysed from a broad sustainability perspective, taking into account both environmental and social dimensions, and that there was a need to develop knowledge on governance and planning linked to new services.

What could new services mean for passengers?

Studies were also conducted that related to passengers' perspectives on new services. Examples include analyses of the possibilities of using a combination of information on passengers' geographical positioning, preferred destination, other contextual information and real-time data to develop more advanced travel information that could reinforce the exchange of information between passengers and service providers in the event of unscheduled disruptions [20]. In other contexts, it was noted that issues relating to gender and equality had thus far been conspicuous by their absence as perspectives in pilot projects and research into integrated mobility services, and proposals were developed for how such perspectives could be strengthened going forward [21].

Different perspectives on governance and planning

A number of research projects focused specifically on governance and planning. A key concept in these studies was 'smart mobility', which was used as an umbrella term linking several different phenomena such as intelligent infrastructure, automation, connected vehicles, electrification and new types of shared and combined mobility services [16]. Analyses were made of various potential development pathways in a future with greater elements of 'smart mobility' and MaaS, and the potential consequences for public transport. One example was an article by Smith et al. dated 2017, which discussed three possible scenarios for the

development of MaaS in public transport: a market-driven scenario, one in which public stakeholders play a leading role, and a third that was a mix of the first two. The authors drew attention to the various implications for public transport authorities in the different scenarios: while the market-driven scenario mainly involves enabling third-party ticket sales, the scenario with strong public leadership would mean that public transport authorities themselves would integrate different services and taking greater operational responsibility [22].

Between 2018 and 2020, comparative analyses were also conducted of approaches to MaaS and autonomous vehicles in different cities and countries as a potential part of future public transport [23]. Several studies examined how public stakeholders perceived their room for manoeuvre in relation to MaaS and other forms of 'smart mobility'. Comparisons between Sweden and Finland showed that the approach at the national level was of major importance. In Finland, there was a clear national agenda that involved new legislation to promote the development of a more service-based transport system. The regional public transport authorities did not feel that they had a particularly great deal of room for manoeuvre. They had to adapt to the new conditions, which for them mainly involved acting as partners to private service development companies. In Sweden, the national level had not selected such a clear way forward, which left more room for manoeuvre for the regional public transport authorities to explore possible futures with MaaS. In operational terms, however, public transport authorities found there was limited room for manoeuvre as national regulatory frameworks remained unchanged [24] [25]. Other studies highlighted significant differences between various cities and countries in terms of how active roles public stakeholders at various administrative levels had chosen to take on (or perceived they had the opportunity to choose) in order to steer the innovation and development of new public transport services [26] [27]. 2020 saw the publication of a doctoral thesis on MaaS which was based on extensive empirical analyses both in Sweden and internationally. This thesis developed proposals for governance approaches to make MaaS a clear contribution to a more sustainable transport system [28].

Overall, the studies led to new insights and more critical discussions about situations and contexts in which public transport stakeholders were perceived as providing considerable scope for private companies to set the agenda for the development of future mobility [29]. A number of analyses, both national and international, reiterated the need for more deliberate governance and planning approaches by public stakeholders [29] [30] [31] [32].

From ‘new services’ to broader analyses of future mobility

The emerging empirical evidence and more multifaceted picture provided inspiration for K2’s new research focus for the 2020–2024 period. In the field of *Future Mobility*, new knowledge was to be developed on the opportunities and challenges of new digital technology, as well as the relationship between traditional public transport and new mobility services. This involved broader focus for research into new public transport services. What had previously been described as research into ‘digitalisation’ or ‘integrated services’ now became linked to issues relating to behavioural change, collaborative governance, business models, and impact on public transport provision and physical environments, such as the design of transfer points [33].

Greater emphasis on micromobility

Analyses of different types of mobility services have remained a prominent part of K2’s activities in the early 2020s. This has included further developments of previous studies on information services that can be used to support travelling during service disruptions, and research into digital services in order to influence customer satisfaction. According to the studies, digitally conveyed travel information can enhance public transport as well as the passenger experience in several respects. However, it has been pointed out that this involves costs and other challenges (such as ensuring that complex travel information is conveyed correctly). The studies have also made clear that different groups of passengers have different circumstances for absorbing digitally mediated information, thus stressing the need for targeted adaptations for specific groups, and the remaining need for analogue travel information [34] [35].

One issue that has received particular attention in recent years is micromobility; that is, different variants of light electric vehicles such as shared bicycles and electric scooters. Experiences from the 2018–2019 period showed that new mobility concepts – in particular electric scooters – can be introduced quickly and have a major impact on travel behaviour and the traffic environment. And while new mobility services have been perceived as positive additions by some, they have also posed problems in the form of physical barriers, accidents and sometimes even competition with pedestrians, cyclists and public transport, for example.

Research conducted within K2 as well as and in other environments has included analyses of possible ways of designing and managing micromobility services so that they can complement public transport or otherwise contribute to sustainable mobility. For instance, Fearnely [36] discusses the potential of steering electric scooters by means of geofencing or zoning, or by requiring electric scooter companies to share data and cooperate with public policy and planning organisations. Research has been conducted under the auspices of K2 in order to understand both the temporal and spatial reasons as to why electric scooters are sometimes used as a complement and sometimes have become a competing mode of transport to existing public transport. Research indicates that there are opportunities to manage electric scooter systems, for example, so that they become a complement that reinforces public transport. However, this requires public governance to be designed on the basis of deep insights into both the public transport system and other local characteristics in the cities or other geographical areas in question [37].

Other studies have focused on methodological approaches for evaluating different types of bicycle-sharing schemes [38]. Critical analyses have also been conducted, that discuss different types of values related to mobility and different modes of transport that are promoted by different types of bicycle-sharing services. For instance, Koglin and Mukhtar-Landgren discussed in a 2021 article what will happen to the understanding of cycling if it is increasingly viewed as part of public transport. They noted that bicycle-sharing services are often permeated by norms around fast and efficient commuting to work or accessibility for tourists, rather than meeting the needs of other groups (such as the unemployed, older people, students), and highlighted the need to address tensions between ecological and social dimensions of sustainability [39].

New services for rural areas and small towns

Another theme that has become an important part of the research into new services relates to mobility concepts for rural areas and small towns. Some of the research projects conducted in recent years, within both K2 and other research environments, have involved compiling and further developing results from pilot studies and early MaaS trials in rural areas. Attention has been drawn to both residents' experiences of the services and various types of organisational and institutional challenges linked to factors such as uncertainties about responsibilities and mandates [40] [12]. Essentially, those who have been involved in these types of projects tend to think that MaaS can benefit the environment, local development and the private economy. In many cases, the pilots and trials

from these years were impacted by the pandemic, which have made it difficult to draw firm conclusions. However, the projects have led to new types of dialogue and collaboration on sustainable accessibility among residents and community stakeholders in rural areas, which has been perceived as important. Other research projects have focused on exploring possible concepts for demand-responsive public transport. Analyses have been made regarding opportunities and impacts of replacing existing bus routes in rural areas with a high-capacity route complemented by demand-responsive services [41]. In 2023, a new research project was launched within K2, which focuses on comparing the performance of demand-responsive services from different geographical contexts. This project is expected to lead to more in-depth insights into how these types of services could be included as part of regular public transport, and what is required for them to help reduce emissions and increase resource efficiency and social equity.

Research into experiments and pilot projects

Issues relating to governance, planning and organisational matters have remained important parts of the research on new services and future mobility. In recent years, this has often been done with emphasis on experiments and pilot projects. One example is the research project *Innovationsarbetets organisering: Att lära från pilotprojekt och testlabb* [Organising innovation: learning from pilot projects and test labs], which focused on exploring the criteria for organisational learning in innovation processes [42]. Another example is the project *Att realisera ny mobilitet – samverkansprocesser som formar framtidens kollektivtrafik i städer* [New mobilities in the making – collaborative processes that shape future urban public transport], which explored forms of collaboration between public and private stakeholders in the development and implementation of MaaS and driverless shuttles. One of the key findings of the latter was that the ways in which private and public stakeholders at different administrative levels choose to collaborate during pilot projects often have a lasting impact on responsibility and influence in the further planning of future public mobility [11] [43]. The project also discussed new governance challenges arising from the increased use of digital platforms, including the fact that these often operate on a different scale compared to the scale applied in local and regional public transport planning [44].

Stronger emphasis on social justice

In recent years, K2's research into new services and the future of mobility has also taken on stronger emphasis on social justice. Examples include research into how new services such as MaaS, demand-responsive services, shared micromobility or

digital journey planners can take into account and meet the needs and circumstances of different groups and locations [45] [46]. One thing these studies all have in common is the fact that they provide insights into how new services and micromobility could enhance sustainable and equitable access for more people, but that this is dependent on how the services are designed, how they are priced and how they are integrated with public transport and the transport system as a whole.

New services are no longer new but still require attention

Twelve years after the launch of K2, 'new services' in public transport form an integral part of mobility for many people and are included as part of the operations of both public and private stakeholders operating in the public transport sector. New services are no longer 'new' but something that many of us have gotten used to and take for granted, regardless of whether we think of digital journey planners, mobile ticketing or access to different types of shared mobility services.

The retrospective provided in this chapter highlights a number of different phases and changes of direction in K2's research over the years, from the optimistic expectations in the early years, through the years involving extensive public pilot projects, to a situation in which new services have indeed been established but where private car use remains high. Today, the debate on new services is characterised by a presence of more critical perspectives on the possibilities offered by digital technology, and significantly more developed and nuanced reasoning on possible impacts in respect of the environment, climate and social justice.

Many new insights have emerged during the first twelve years of K2's activities. Perhaps the most central insight is that technological development per se is not what makes a difference, but rather how new technology is applied in specific social and political contexts. Opportunities for enhanced resource efficiency and sustainability do not materialise all on their own. Active and conscious governance approaches are required, along with adaptation to spatial, economic and social criteria. This, in turn, requires insight into the everyday lives and the circumstances faced by people who live or spend time in different types of places. Similarly, an understanding is needed of both governance conditions and the ideas and logics that permeate processes and contexts in which new services are shaped.

Finally, there needs to be a political will to drive development of the transport sector in a sustainable direction, alongside an ability to envision and engage with both risks and opportunities that follow in the wake of new technology.

14 Innovation capacity of public transport

Dalia Mukhtar-Landgren, Mats Fred, Lina Berglund-Snodgrass & Alexander Paulsson

Each year, considerable global investments are directed toward innovation processes that seek to advance automation, electrification, and digitalisation within the mobility sector [1]. In the Swedish context, these investments originate both from industry actors and from extensive government-led innovation and research programmes. Concurrently, rapid technological advancements – coupled with increasing demands for operational efficiency and the urgent need for more sustainable transport systems – are exerting significant pressure on public transport authorities (PTAs) to adapt and evolve. This pressure is often perceived as to necessitate not only an accelerated pace of innovation but also an enhanced institutional capacity to engage in transformative processes. For PTAs, this involves the development of internal innovation strategies, such as modernising ticketing infrastructures or transitioning to electric bus fleets. Equally important, however, is the need to assume a (often proactive) role in external collaborations and multi-stakeholder initiatives. These collaborations may involve varying degrees of engagement, including examples such as participating in pilot projects with automated vehicles, testbeds in new housing districts featuring mobility hubs, or policy labs around emerging planning concepts like the 15-minute city.

Against this backdrop, new ways of organising have emerged in PTAs in Sweden over the past decade. This is partly a result of general institutional changes in Swedish innovation policy, which is shifting its focus from products to processes [2]. Contemporary innovation initiatives often have the explicit aim of breaking up what is seen as rigid and sectoral public organisations and 'opening up' public sector organisations by encouraging new, more collaboration-based processes. In this context, many PTAs are seeking to strengthen their ability to innovate by developing what we refer to as *innovation-producing governance arrangements* – organisational arrangements developed by stakeholders with the aim to support and encourage innovation. Drawing on the literature on public sector innovation, this chapter

describes three different innovation-producing governance arrangements. These are (i) internal processes (including innovation procurement), (ii) platform organisations, and (iii) pilots. We also discuss which types of innovation capacity PTAs are developing through these different organisational solutions.

Innovation-producing governance arrangements

An innovation-producing governance arrangement is a delimited organisation developed with the aim to support and encourage innovation. Examples include pilots to test a new technical solution, developing new collaborative models or setting up new internal units and processes. The concept *governance arrangements* [3] conceptualises governance as a relational process and an arrangement of stakeholders and material entities or artefacts directed towards a specific goal [4]. Artefacts, such as an app, an EU-application or a specific regulation, are important elements in these arrangements as they can provoke, encourage, or hinder action [5]. Governance arrangements are continuously shaped and reshaped between the stakeholders and artefacts involved: For examples, a MaaS app or a mobility hub creates specific (and temporary) relationships between different stakeholders, as well as specific ways of working (workshops, webinars). Over time, a certain distribution of roles, identities and mandates are developed in the governance arrangement. This theoretical perspective is often used in organisational research when researchers do not want to be constrained beforehand by given hierarchies or assumptions that cooperation is entirely governed or constrained by given relationships (such as mandates, authority or responsibilities between the municipality and the region). In practice, we know that mandates and authority are very important, but they are only *one* part of the relationship between stakeholders.

Based on this brief discussion, we now turn to three innovation-producing governance arrangements that have emerged in Swedish PTAs over the past decade. Each of these arrangements is distinct from the others, making them well-suited for comparison. Our focus is on how they, in different ways, lead to, build up or hinder organisational capacity. Before exploring these governance arrangements in more detail, we will first explain what we mean by the concept capacity.

> Long-term contracts like these provide security and economies of scale, but they also risk leading to lock-in effects and reduced flexibility and opportunities to engage in innovation.

Organisational capacity

Organizations rely on, and develop, various capacities to fulfil their different goals. Organisational capacity can be described as the ability to develop and achieve set goals by requiring, developing, or managing resources [6]. In this context, resources refer both to financial resources and competences. Indeed, knowledge and collective learning are often described as the starting point for building organisational capacity, and this includes everything from learning through evaluation and dialogue to learning from collaboration. It also involves anticipating and managing change and developing solutions and processes to achieve their goals [7]. For politically governed organisations, like PTAs, innovation capacity also involves the ability to implement political goals, decisions and priorities in accordance with the norms surrounding the public sector [8], where issues of both democracy and efficiency are key.

Different types of innovation-producing governance arrangements shape different types of organisational capacity, including different notions of what resources and knowledge are important to develop. For instance, while collaboration is an important innovation capability in pilot projects or platforms, strategic management and coordination are important for internal work processes. Let us begin with internal processes.

Internal processes

Public transport is subject to continuous improvement, sometimes referred to as everyday innovation. Working methods and services are then developed within the scope of the contracts that public transport authorities have with transport operators and other stakeholders. One example to this end is public procurement. Bus services, for example, are procured on contracts that run for about ten years. Long-term contracts like these provide security and economies of scale, but they also risk leading to lock-in effects and reduced flexibility and opportunities to engage in innovation. That is why many larger PTAs have attempted to design procurement procedures in such a way that transport operators submitting bids are rewarded for demonstrating innovation capacity. However, studies at K2 have shown that these ambitions are difficult to put into practice, as PTAs then have to be able to evaluate innovation capacity objectively [9].

Similarly, many PTAs have sought to move away from traditional procurement procedures, which historically included several detail-driven demands on transport operators, towards functional procurement procedures [10]. Functional

procurement procedures focus on the function; that is, *what* transport operators should be doing, not *how* it should be done. Not only are functional procurement procedures assumed to provide transport operators with more freedom to design mobility services; they are also assumed to increase the freedom to innovate. This has proven difficult in practice, not least because the 'mobility service' function is multifaceted and sometimes difficult to define. Public transport does not just involve transporting people from one place to another as efficiently as possible. Equity, accessibility and sustainability in urban planning are also aspects that should be considered or included in the 'mobility service' offered by public transport authorities. It is also unclear whether transport operators choose the most innovative solution or just the cheapest one when they are allowed free choice of how to design their mobility services [11].

Some PTAs have begun developing their own innovation-producing governance arrangements due to the uncertainty associated with procurement procedures and potential lock-in effects. Besides the pilots and platform-based arrangements that will be described in greater detail below, a number of major PTAs are also running their own innovation projects. While pilots and platforms are 'open' to different stakeholders and often financed by external funds and governed by external requirements, the internal governance arrangements are intrinsically aligned to the organisation's own goals. But even if they are internal, these governance arrangements are often organised at some distance from regular operations; in separate entities, in different buildings and with different types of skills; despite the fact that they are expected to develop innovations closely linked to operations. One example to this end is the development of apps.

When travel apps were first introduced to public transport, they were procured as ready-made technical solutions provided by large tech companies on the market. As a rule, these were generic 'white label' apps developed by companies that specialised in designing travel apps. The branding of the procuring PTA was added to the app, and a few adjustments could be made to adapt to the region in question. Travel apps have become more complex as more features have been added to them, not least the ability to buy tickets. Instead of relying on the market, PTAs started to explore the possibility of building internal capacity and developing combined travel and ticketing apps themselves. A common payment and ticketing standard was also developed in parallel for all public transport authorities in Sweden.

It is interesting to compare the two Swedish PTAs Skånetrafiken and Västtrafik, as they had similar processes for developing their respective ticketing apps while

differing on some crucial points. At Skånetrafiken, consultants were hired for what was referred to as the development lab. The selection and onboarding of consultants was important in the app development work. Skånetrafiken only brought in the skills that were deemed necessary to resolve a particular issue when developing the app. The development lab was not based at the head office in Hässleholm, but at Malmö Central station, in close proximity to their passengers. Västtrafik had a similar process, however, they did not engage consultants, but recruited entirely new competencies to their organisation, including SCRUM masters[16] and UX designers[17]; both common roles in the field of software development. In doing so, they departed from established processes that otherwise often centred on procurement. By recruiting the required expertise, Västtrafik was able to build in-house capacity to carry on working on digitalisation and further develop the ticket app by adding new functionalities, for example. This way of organising app development has subsequently been highlighted as a success story and now serves as a model for digitalisation throughout the entire Västra Götaland region. As a result, organisational capacity for digitalisation was built, although this was not the initial aim. Both Västtrafik and Skånetrafiken initially had the idea of building their own capacity in order to develop an app, and in this respect, they turned to UX designers, SCRUM masters, IT architects and app developers. Their idea was to build capacity to develop apps, but they also saw how the organisation was being equipped with a new type of capacity that had consequences beyond what was initially intended. As new staff were recruited and embedded in the organisation, new skills were built up and the organisation articulated new goals in a new area: digitalisation [12].

Externally funded pilots

We have been witnessing an increase in externally funded pilot projects in Swedish public transport during the past decade. Västtrafik has run pilots on bus-on-demand and ride sharing, and Skånetrafiken and Östgötatrafiken have worked with MaaS pilots. There is currently growing academic interest in pilots as a method, and at K2, a considerable number of studies have been conducted of pilots and trial initiatives in areas such as autonomous vehicles, demand-responsive transport, digitalisation and smart mobility. Pilots are often viewed as examples of a broader trend related to trials or experiments [13]. Here the aim is generally to

16 Scrum is a popular agile method for the development of software in particular, where the role of Scrum master involves coaching change processes within specific teams.

17 A UX designer, or user experience designer, works from the perspective of users – in this case, passengers – to design products and services that meet their expectations, behaviour and needs.

test a solution on a smaller scale, and then to evaluate it and scale it up if the results are deemed positive (although there is a tendency to view 'scaling up' as a natural part of pilots, thereby 'forgetting' the step of asking whether this is something we even want to achieve!) As learning is a key aspect of experimentation, the concept of 'learning by doing' serves as a central legitimising logic for the funding of pilots. The idea of *disseminating* knowledge is every bit as strong as the idea of *generating* knowledge. Thus, an important organisational capacity that is required and potentially developed by working with pilots is the ability to work in a knowledge-intensive way; both in terms of developing new ideas, learning (evaluating) from examples presented by oneself and others, and working on scaling up.

How can externally funded pilots be understood as innovation-producing governance arrangements? Pilots, like projects, can be described as temporary and collaboration-based organisations that exist 'outside', and sometimes also 'in-between' organisations: between private and public organisations, for example, or between public organisations at different levels [14]. PTAs can play very different roles in pilots. Often, they are approached by private companies, consultants, or other public organisations (such as municipalities) wishing to test a new solution; but sometimes the PTAs themselves are the project owners and active drivers of the pilot. The role of the PTA may therefore vary from being an active party in self-funded pilots with relatively few participants, to being a more passive participant in a reference group in an EU project run by an external stakeholder. In the latter case, the purpose of participation may be to gather business intelligence, to gain knowledge of ongoing projects in the region, or to influence developments in a particular area.

Pilots are paradoxical as they often are regarded as open, flexible and experimental, while they at the same time are described as a form of bureaucratic iron cage controlling involved actors through GANTT charts, pre-determined deliverables and milestones: artefacts that also impede flexibility, experimentation and the room for manoeuvre [15]. Externally funded project and pilot arrangements take on a certain hierarchical logic where a manager leads the work and the involved stakeholders have more or less room for manoeuvre. In cases of external funding, the arrangement is also restricted to the requirements of the funding agency. The tendency to define excessively specific requirements – and so leave insufficient room for manoeuvre for local and regional stakeholders, for example – has been noted in research on innovation projects [16]. In 2017, for instance, the Swedish innovation agency Vinnova announced funding "to support the growth of combined mobility services by enabling the testing and validation of

these services under real conditions and with real customers", where potential applicants were to test not only the solution but also its business model [17]. In this call for proposals, the design and goals of the pilot were largely determined by external demands from the funding body, in terms of both *what* was to be tested and *how*. Studies have shown that overly narrow calls for proposals affect the capacity of public stakeholders to make use of knowledge from projects in a way that is appropriate for their own organisation. One risk of narrow calls for proposals is that they leave insufficient room for public stakeholders to reflect on how shared mobility, in this case, should be understood in relation to their own region's objectives. We have spoken to planners and strategists in both municipalities and regions who described their frustration with pilots where there is focus on a specific innovation, trend, technology or function and how it is evaluated without being put into a broader context: "they [the stakeholders running the pilot] talk about [a specific smart mobility service], but I have to think about the general transport needs in the area" [15].

One important organisational capacity in relation to pilots is the ability to balance internal goals with the expectations set through various national innovation programmes, platforms and calls for proposals. However, the PTAs internal goals also need to be balanced against those of other organisations, including municipalities. But organisational capacity in this context is not only about effectiveness or collaboration with different stakeholders; it also involves ensuring learning and relevance. Working with pilots always includes a 'local translation process' to 'fit' the pilot into regular activities and the overall objectives of the organisation. This challenge has also been highlighted in studies of 'projectification' in the public sector. Here, the literature refers to *active ownership* [18] – the proactive and engaged involvement of project owners or key stakeholders in decision-making and resource allocation to ensure alignment with strategic objectives – as a way of building organisational competence for avoiding 'teflon projects' where insights and knowledge gained in a project do not stick in the organisation. One key aspect in this context is the capacity to coordinate and align the pilots internally so that they interconnect and form a coherent whole.

Platforms

Innovation platforms are collaborative organisations that are often found at the intersection of the private and public sectors. They may vary in nature, but their overall aim is often to improve the innovation capacity of the public sector [19]. The emerging literature on innovation platforms describes them both as intermediaries facilitating collaboration between different types of stakeholders

[20] [21] and as meta-organisations generating and leading collaborative projects and networks [22].

Platforms can be initiated ‘top-down’ through government initiatives (such as Drive Sweden, Viable City) and ‘bottom-up’ at the initiative of municipalities or regional stakeholders (such as the case of Innovation Skåne), for example. They are mainly financed by external funding through government innovation initiatives and research programmes, sometimes in combination with membership fees (such as Gate 21) or ‘core funding’ from interested parties (such as Lindholmen Science Park). The, often self-assigned, tasks of the innovation platforms include activities such as, developing visions and roadmaps, monitoring calls for proposals and sharing best practices. Based on this, the platforms formulate and create innovation agendas and support stakeholders in their efforts to achieve them. Platforms can also develop different models for learning or scaling up; or otherwise attempt to find ‘recipes’ for organisational solutions to problems encountered by public stakeholders in their innovation work. Part of this may also involve packaging and presenting new services such as mobility hubs and delivery robots, but also new concepts such as collective mobility or mobility-as-a-service. Interviews with representatives of innovation platforms reveal that some stakeholders are described as pioneers, while others are viewed as followers. Pioneers are described as early adaptors to new trends or technologies, aspects that innovation platforms can capitalise on and highlight as best practices that in turn can inspire other stakeholders to follow. In this way, the platforms create a context around an innovation agenda in which PTAs, as well as other stakeholders, can be included.

Newsletters, websites, workshops and events are key artefacts in innovation-producing governance arrangements of this kind, and they work by creating connections and relationships between stakeholders. Similarly, project funding or collaboration processes can also offer an opportunity to ‘put stakeholders together in the same room’. A relatively new example is the ShiftSweden innovation platform. Over a ten-year period, it is aiming to bring together and mobilise government and regional authorities as well as civil society organisations, the business community and research institutes around the agenda of making the transition “... to attractive and accessible living environments for all by ‘ integrating the built environment and mobility into an ecosystem, creating new value through circular business models, and creating competitive alternatives to private car travel”. Like other platforms, ShiftSweden aims to offer everything from resources for testing and demonstrations to events and newsletters. By subscribing to newsletters or participating in workshops and being connected to

such a platform, public transport authorities and others are given the opportunity to seemingly follow developments without having to make major investments, take risks or actively participate in projects themselves.

What organisational capacity is built up through these platforms? As in the example of the pilots, it becomes crucial to be able to assess, relate and potentially translate trends to align with the existing needs and interests of one's own organisation. Moreover, what policy researchers describes as 'nodality' (being a node in a network) is essential. Nodality involves not only positioning oneself in key locations in order to gather information but also presenting one's own organisation as a future-oriented and attractive stakeholder and partner in innovation contexts. This can include everything from having logos featured on various platform websites to participating in workshops where new knowledge is gained, opportunities to showcase activities are provided and networking with potential partners is possible. In this respect, a number of PTAs have developed organisational capacity by providing some of their staff with the time and space to devote themselves to this. For instance, Västtrafik has a designated coordinator for work with the Electricity innovation platform. The ability to cultivate personal relationships and networks is an important skill in this context. In an interview with a representative of an innovation platform, the work is likened to "building a bank of friends that you can work closely with. And if you find successful combinations, it's not unusual to keep applying for projects together".

Innovation platforms often work on the basis of a portfolio approach, funding and/or managing complementary projects within a programme area. Coordination and ensuring learning between ongoing projects is particularly important so that solutions are not developed that cannot be 'connected' or 'scaled up'; for instance, if a municipality's digital solutions for shared mobility services cannot be connected to public transport authorities' digital solutions. Over time, public transport authorities have developed an important capacity both to prioritise the projects in which they choose to participate actively, and to coordinate projects internally so that they align more accurately with one another and are linked to the overall goals of the organisation.

Public transport innovation capacity – what do we know?

The purpose of this text has been to discuss the innovation capacity of Swedish public transport authorities by examining three different forms of innovation-producing governance arrangements. We began with the internal innovation work and then zoomed out to discuss pilots and platforms. Here, we have been particularly interested in exploring the PTAs' ability to adapt and develop organisational capacity to manage innovation.

The PTAs have begun to develop knowledge of how to navigate and strategically use the various arrangements for their purposes. Several PTAs have set up dedicated innovation units and established long-term links with strategic partners in the academic community and industry. As one of our respondents noted in a discussion about innovation and the future of travel: "We know what we want, and we know that we need to work with others to achieve those goals". Like many organisations, PTAs are engaged in continuous development to ensure that buses, trains and boats arrive and depart on time, using resources as efficiently as possible. However, major innovation initiatives are sometimes undertaken internally, which requires different resources and skills. When these initiatives are embraced and become part of the organisation, governance arrangements change, and new organisational capacity emerges, while other skills may perhaps disappear.

When *Skånetrafiken* and *Västtrafik* chose to develop apps internally, organisational capacity in terms of new knowledge and skills was developed in tandem. From this, new procedures for development emerged within the authorities, particularly in relation to digitalisation. Building organisational innovation capacity in this way – close to their regular operations and organisation – has in both cases resulted in rapid decision-making and flexibility in development work, but it has also resulted in a change in the composition of skills and expertise. UX designers, Scrum masters, IT architects and software developers now make up a significant proportion of the workforce, and in both cases, this has had an impact on the way in which the organisations work; not only on innovation, but also on development in more general terms. The wider and longer-term implications of this change remain to be seen, as the challenges of working on the basis of a coherent strategy and coordination between initiatives are not always less extensive for internal work than for external and pilot-based processes.

Participation in innovation platforms is an innovation-producing governance arrangement that instead lies slightly outside the regular work of PTAs. The platforms provide an opportunity to participate in contexts involving other (innovative and/or successful) public transport stakeholders in a manner that involves little risk or cost for the authorities. In this way, they serve as an innovation-producing arrangement through which resources and expertise can be pooled (economies of scale). In this regard, the PTAs are provided with an overview of potential development avenues that may also potentially strengthen their capacity to prioritise; which, in the context of innovation, relates to where and how resources are to be used. However, innovation platforms have a certain 'pro-innovation bias' – that is, a tendency to see almost all innovation as beneficial – and their staff can be very quick to jump on board with the 'latest thing'. So, in this regard, the PTAs need to translate innovations and fads into regional objectives and assess its relevance.

Pilots are often institutionally closer to the ordinary operations of the organisations than platforms. Some pilots are run in-house, while others are funded externally and are more collaborative. PTAs sometimes participate solely for the purpose of keeping up to date with developments, but sometimes there is a willingness to try something new and eventually implement it on a wider scale. Regardless, there is often an organisational, but also an ideational, distance from ordinary operations when piloting something that differs from 'business as usual'. The impact of working with collaborative pilots on organisational capacity is dependent on the role of PTAs: very different skills are required and developed if they lead the pilot, or if they are just a part of a larger reference group. Here, a variety of K2 projects across various innovation processes – from BRT to demand-responsive travel – has demonstrated a great deal of variation in terms of capacity and learning.

Active participation in various innovation-producing governance arrangements over the past decade has allowed many metropolitan PTAs to start developing a strategic ability to choose which pilots to participate (and, therefore, invest) in, and which to leave be. This may also be based on a general 'project fatigue' and greater scepticism towards projects that are initiated with unclear links to the organisation's goals. With more purpose-driven innovation efforts come organisational proximity, which facilitates learning and scaling. However, there is a risk that familiarity leads to risk aversion, preventing the kind of disruptive change that may be necessary for a sustainable transition. This phenomenon is sometimes referred to as the radicals' dilemma, where actors face the challenge of balancing, on the one hand, efforts for deep, transformative change that requires disruptive innovation with, on the other hand, more incremental step-by-step

initiatives close to ordinary operations. The former can be greatly innovative but risks alienating existing structures and supporters, while the latter may be less ‘radical’ and transformative, but holds a strong potential of being accepted or adopted in ordinary operations [23]. Therefore, innovation capacity might ultimately involve navigating between adventurousness and stability in the transition to more sustainable transport.

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