TRANSPORT REVOLUTION
– THE FUTURE OF ACCESSIBLE
PUBLIC TRANSPORT IN
URBAN AREAS

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HELGE GIDSKE NAPER
SHARED MOBILITY, AUTONOMOUS VEHICLES AND MOBILITY AS A SERVICE OFFER NEW SOLUTIONS TO INCREASE FLEXIBILITY AND ENABLE MORE TRAVEL OPTIONS ON THE USER’S TERMS.
Public transport is crucial to the liveability of any city. It helps reduce pollution, fosters a sense of community for people travelling together, encourages active lifestyles, reduces injuries and fatalities cause by car accidents, and requires less land use than road infrastructure. The private car is beginning to lose its position as the dominant means of transportation in urban environments.

Accessible and efficient public transport requires a balance between design for short distance to the nearest stop, and short travel time offered by high capacity lines. This report examines how to achieve this balance and how new transport solutions can add to it.

The historical evolution of our cities and steady growth in the number of cars has strongly influenced the way public transport systems, and access to these systems, has developed. In a modern and sustainably designed city, public transport must be accessible for all people.

“A CITY WITHOUT EFFICIENT PUBLIC TRANSPORT IS A CITY THAT REGULARLY GRINDS TO A HALT.”

As a crucial part of any city, public transport needs to be accessible to everyone, regardless of social group or physical capability. But in many European cities public transport remains unavailable to some residents and visitors, and some choose not to use public transport because it does not meet their needs. How do we make public transport accessible – and beneficial – for all?

Providing access to efficient public transport for all types of users requires striking a balance between installing sufficient numbers of stops to reduce walking distances and reducing travel times on high capacity services. The way cities originally developed and the role of cars in society have had a decisive influence on the development of, and access to, public transport systems.
Accessibility refers to people’s ability to access goods, services and activities. When discussing public transport, accessibility can be categorised into two main perspectives. On the one hand, accessibility is characterised by the time and cost associated with reaching various destinations from a given origin. On the other hand, accessibility relates to the effort needed to understand the transport system, walking to stops or stations, barriers when entering and exiting vehicles, and the cognitive effort needed to understand and pay for rides. Europe’s most effective public transport systems deliver on both these accessibility aspects. They are easily understood by users, have few physical barriers, and are effective and affordable.

The development of shared mobility and new technology, such as self-driving cars, is likely to affect the way we use our public transport system. The mobility services of tomorrow may, and should, provide extended accessibility.

III. 1: An example of good urban design: street with a tram and pedestrians in Freiburg, Germany. Travelling on public transport typically involves some walking distance.
2. ACCESS TO PUBLIC TRANSPORT
URBAN STRUCTURES ARE A RESULT OF AVAILABLE TRANSPORT OPTIONS

Public transport is a cornerstone of sustainable urban development. The way a city is built influences the way people travel. The opposite is also true: citizens’ travel patterns influence the development of cities and their attractiveness as places to live and work.

An urban structure is mainly a product of the dominant transportation system in place during the city’s most important period of growth. This can be illustrated by looking at the size of urban areas that make up different cities. Illustration 2 shows the areas of Atlanta and Barcelona. The cities have similar sized populations, but as Atlanta expanded during the era of the private car, it covers a huge urban area. Barcelona was founded and grew as a city much earlier, in an era without cars. This contributed to Barcelona’s very dense city centre.

III. 2: Atlanta and Barcelona have similar populations, but the size of the urban areas and emissions from the transport systems differ significantly. Newman & Kenworthy 1999

ATLANTA

Population: 5.25 million
Urban area: 4,280 km²
7.5 T CO₂/ha /an (public + private transport)

BARCELONA

Population: 5.33 million
Urban area: 162 km²
0.7 T CO₂/ha /an (public + private transport)

“CITY PLANNERS ARE DESIGNING MORE COMPACT CITIES DUE TO GROWING CONCERNS ABOUT CLIMATE CHANGE AND AIR QUALITY, RISING FUEL PRICES, AND TRAFFIC CONGESTION.”

It is widely accepted that high population densities are essential for sustaining cost-effective public transport. Put simply, high infrastructure costs need to be shared between a large number of users to make individual trips affordable. Urban sprawl generally makes today’s public transport solutions ineffective and expensive. This is evident when looking at the geography of neighbourhoods and districts within many cities. The probability of having public transport located nearby is strongly correlated to the urban population density of a neighbourhood or district.

Attempting to stop and reverse urban sprawl is therefore one of the most important measures to provide better access to public transport, given today’s typical solutions for public transport.

THE DEVELOPMENT OF PUBLIC TRANSPORT: A BUMPY ROAD

Rail-based public transport was critical for the growth of industrial cities during the 19th century. Prior to industrialisation, cities were still small and compact. Rail-based public transport developed during this era was therefore built for short distances and with no competition from the private car. Labour was cheap and the cost of running these services was considerably lower than it is today. This created a public transport system characterised by short distances between stops and low travel speeds.

The private car started to become the preferred form of transportation in the middle of the 20th century. This facilitated the growth of cities beyond the current network of public transport, making private transportation preferable to public transport and creating a self-generating cycle of urban sprawl and car dependence. In order to compete in terms of travel time, public transport needed to increase its travel speed. To adapt to the changing structures of cities and to passengers’ demands, public transport was therefore developed to facilitate longer travel distances in urban areas. This also led to longer distances between stops, shorter travel times, and reduced operating costs.
The result of this development in transportation modes and city structure is a mix of fast, effective new routes and old time-consuming routes with low travel speeds. This is illustrated by looking at average distances between stops for various routes in specific European cities (illustration 3). Short average distance between stops (Lisbon, Oslo) is often due to the line having a long history with few structural changes, while a distance of 500–800 metres between stops (Metz, Barcelona, London, Bergen) is typical of new, more effective systems.

III. 3: Average distance between stops on various transport lines in European cities.

III. 4: Modern tram in Barcelona (left) and old tram in Lisbon (right).
PROXIMITY TO PUBLIC TRANSPORT NETWORKS

If the walking distance to the nearest stop takes as long or longer as the entire trip (by bus, for example), this can be perceived as an obstacle. It may also result in the user choosing another means of transportation. In general, users tolerate walking longer distances when the entire trip takes longer than the time it takes to walk to the nearest stop, as illustrated in illustration 5.

Acceptable walking distances and journey times also depend on who you are. In general, the distance an adult is prepared to walk (assuming the alternative is to use the car) is 500 metres. But the walking speed of healthy adults is not the only factor. While an adult typically takes six minutes to walk 500 metres, the elderly and children typically take 11 minutes to walk the same distance. What is regarded as an acceptable distance to walk will therefore differ depending on who the traveller is.

“TWO ASPECTS THAT SHOULD BE TAKEN INTO CONSIDERATION BEFORE DESIGNING A PUBLIC TRANSPORT NETWORK ARE THEREFORE: WHO WILL BE THE TYPICAL TRAVELLER, AND WHAT IS THE EXTENT OF COMPETITION FROM OTHER MODES OF TRAVEL.”

The “passenger market” of a station or a stop is defined by the citizens living and traveling in its surrounding area. Station location has a major impact on walking distances, and thus also on the passenger market surrounding the stations. This is particularly true for stations outside city centres. In such cases, however, it is often possible to reduce barriers around stations to increase the surrounding passenger market, which may not be as easy in a city centre where demand for space is that much greater.

One common way to develop a traditional public transport system is to create a network of main corridors and service routes. Main corridors are typically served by modern trams or high capacity buses, while smaller buses typically run on service routes. Effective main corridors comprise several routes and offer high-frequency departures. Service routes supplement main corridors, covering a larger, less dense area and having less frequent departures. In the absence of service routes the network would be less accessible, especially for people who have difficulty walking long distances or riding a bike to the station (in areas where car parking options are limited). This type of interdependent system therefore offers a high degree of accessibility for several different groups of users, while still providing options for reasonable travel times to destinations relatively far away.

III. 6: The classic public transport planning dilemma: How to satisfy everyone.

The bus is not an option because it stops all the time and takes all day to get anywhere. Richard, Environmental Consultant

The bus is no good for us because it is too far to walk to the bus stop, and it doesn’t make enough stops. Knut, father
ACCESS TO PUBLIC TRANSPORT VEHICLES
While walking distances to stops have different effects on accessibility for different types of users, all users benefit from easier access into the vehicles. Wide doors and low steps not only reduce the time vehicles spend at stops, they also significantly improve access for the disabled and those travelling with prams and buggies. In Europe, 12–14 per cent of the population is disabled, and the percentage of people with disabilities is expected to increase in future.4 Disabilities vary greatly in severity, but most disabled people have a relatively low degree of disability. Solutions facilitating ease of use for all users should therefore be prioritised in public transport systems. And as it is much easier and cheaper to achieve full accessibility at the design and construction stage, rather than trying to modify infrastructure at a later stage, it should be focused upon in the early phases of new projects.

Ill. 8–10 (above left and right and below left): Vehicles with good access. No stairs and easy wheelchair access. Example from Metz, France.

Ill. 11 (below right): Public transport must be accessible for all travelers.
UNDERSTANDING THE TRANSPORT SYSTEM
Understanding a transport system is key to achieving good access. Networks must be designed to be easily understood by users.

III. 12: Despite the size and complexity of the London Underground map, the network is easy to understand, even by those who are unfamiliar with it.

III. 13: New technology can make it easier for travellers to use public transport.
“TRAVELLERS WHO DON’T UNDERSTAND A SYSTEM WILL NOT USE IT. THIS REDUCES THE PASSENGER MARKET AND INCREASES OPERATING COSTS AS COMPARED WITH AN EASILY UNDERSTOOD NETWORK.”

Network planning and design are important factors in all public transport. A simple network with a clear line structure which is easy to learn and remember for all citizens needs to be planned and created for long-term use, as in Reims in France (Illustration 14). Complex network design typically reduces public transport’s share of journeys made.

Key network aspects include number of routes, departure frequency, and interchanges. A limited number of main routes and related resources help travellers understand networks. Frequency is a considerable timesaver and, combined with interchanges, an important factor in reaching various destinations from a given origin.
Clear, accurate maps, together with digital tools such as apps offering users real time information, also promote accessibility. However, such tools are unlikely to entirely compensate for a complicated physical structure.

III. 15: Main Homme de Fer tramline interchange in Strasbourg. The interchange is marked in the urban space and helps create mental maps of the tram network.

III. 16: Solutions facilitating use of public transport for all travelers should be prioritised in public transport systems at the early stage.
3. NEW SOLUTIONS AND TECHNOLOGY IMPROVING MOBILITY
Today, there are several options for people wanting to get to public transport stops or stations that are not within close walking distance. These include bikes, e-bikes, taxis and cars. However, these options all present challenges in terms of physical accessibility as well as monetary and environmental costs. Services that transport citizens to high capacity routes are usually costly to run and fail to appeal to all potential users. Effective and accessible transport systems need better solutions with high capacity service enabling people to get to their nearest station.

“It is important to note that we expect the concepts of shared mobility, mobility as a service, and autonomous vehicles to considerably disrupt the transport sector, while also having the potential to provide access to mobility for all in modern urban areas.”

**Shared Mobility and Mobility as a Service**

Shared mobility refers to the shared use of a vehicle, bicycle, or other mode of transportation. It is a transportation strategy that allows users to access transportation services on an as-needed basis. Shared mobility includes a variety of transportation modes such as car-sharing, bike-sharing, peer-to-peer ride-sharing, on-demand ride services, and micro-transit. To varying degrees, these can supplement fixed-route bus and rail services. While the first sharing solutions took place between defined sharing partners, through peer-to-peer platforms, we are now heading towards shared mobility on a new level, partly aided by the use of digital technology.

“Mobility-as-a-Service (Maas) integrates services from several mobility providers into one single service.”

Maas is typically packaged as an app or other digital platform and provides services from public and private mobility providers. Users can pay for a trip using a mobility solution that fits their needs at a specific time and that takes them more or less seamlessly all the way to their desired destinations.

Shared mobility has existed for many years. While traditional public transport can be viewed as a form of shared mobility, nowadays the term generally refers to the sharing of private vehicles. These forms of shared mobility are well established in society. Car-pools, for example, take multiple travellers in cars owned by one provider, and digital platforms are used to hire privately owned cars (or hire out your own car). Although carpooling has existed for over 50 years, it is only in recent years that shared mobility has seen considerable growth. This is primarily due to the increased digitalisation of society. Location data gathered by smartphones and other devices are key to sharing mobility solutions effectively – for example, to easily find an available vehicle in a nearby area. The increasing use of technology in everyday life has made us comfortable using apps and other digital platforms to share vehicles effectively. People have also become increasingly used to paying for services by phone. This reduces barriers to accessing shared mobility solutions on the go. Together, these societal changes create a situation that paves the way for further development of mobility sharing solutions.
The changes that stimulate the use of shared mobility also facilitate the use of mobility as a service on a large scale. Several European cities currently offer MaaS solutions, with various packages of public transport, car-sharing, car hire, cab, rent-a-bike and/or walking. Vienna, Helsinki and Hannover are examples of cities where MaaS solutions are already in use. Illustration 17 shows the offer per city, with different transport forms that are combined in a single payable service.

<table>
<thead>
<tr>
<th>MaaS solutions per city</th>
<th>Vienna</th>
<th>Helsinki</th>
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<tr>
<td>Public transport</td>
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<tr>
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<td>Cab service</td>
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<tr>
<td>Bike sharing</td>
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Ill. 17: Mobility-as-a-service (MaaS) solutions in some European cities. The asterisks indicate shared mobility transport forms.

Ill. 18: Location data gathered by smartphones and other devices are key to sharing mobility solutions effectively.
SELF-DRIVING VEHICLES AND MOBILITY AS A SERVICE
Self-driving vehicles typically use a combination of sensors, cameras, radar and artificial intelligence (AI) to sense the environment and navigate without human interaction, with different levels of automation. They are also known as autonomous vehicles, driverless vehicles and robot vehicles. Many such systems are now evolving in terms of technological and market maturity and may disrupt the transport system as we know it.

Self-driving vehicles have been operating for many years in rail systems in closed areas, separate from the main rail system. These systems have proven highly reliable and shown potential to increase capacity and safety and reduce operating costs. The focus today is to start using self-driving vehicles in our cities and have them operate on the same streets we drive on in our traditional cars. A new bus line operated by autonomous vehicles was recently opened in Stockholm. Line 549 will act as a service route and connect passengers to bigger and faster buses. This is the first line in the world to be operated by autonomous vehicles and fully integrated into a traditional public transport system.5

It is not yet known how quickly fully autonomous vehicles will start being phased into transport systems, although several studies indicate a time frame of 2020–2025.6 Barriers vary from country to country, but typical obstacles include a lack of specific regulations, low consumer acceptance, lack of local tests, and lack of infrastructure (such as charging stations, high-quality roads, and high-speed mobile data networks).

While the evolution of autonomous vehicles is to a large degree independent of that of shared mobility, they are often mentioned together. Studies have found that, in a worst-case scenario, autonomous vehicles will generate more traffic. But integrating shared fleets of autonomous vehicles with conventional public transport can improve the future for urban areas – providing affordable, sustainable and convenient mobility options to all citizens, including less mobile persons, the elderly, children, and people living in suburban or rural areas. Studies have shown that transport systems adapted to accept wheelchairs result in a much lower price per passenger than today’s typical solutions that rely on standard taxis that serve citizens with physical and cognitive disabilities.

It is vital that new technology and services complement, rather than replace, well-functioning public transport routes, or walking and biking to local stops and stations. The quality of urban spaces will not benefit from an increase in space requirements due to large fleets of autonomous vehicles, not even non-polluting units. Increased congestion issues when replacing mass transport with smaller units can lead to longer travel times and reduced access to cities (see illustration 20). When done correctly, mobility services of the future may offer a level of mobility flexibility that is hard to imagine today. It will be easy to combine modes of transport, to vary the package of transport forms used from day to day, and to combine individual and collective solutions. We believe that new services have the potential to blur the boundary between public and private transport.

III. 20: Small autonomous units require far more space than conventional rail-based transport.

Mobility services, including autonomous solutions, that connect to larger mobility hubs may become an important part of efficient transport systems. This will offer mobility at low cost to new parts of the population, given the cost savings potential from using autonomous vehicles in lieu of today’s more costly alternatives. At the same time, autonomous vehicles could supply larger and faster routes with more travellers, presenting possibilities for public transport systems with fewer stops and faster travel times.

INNOVATION AWARD FOR UNIVERSAL DESIGN

The light rail “Bybanen” is the winner of the Innovation Award for Universal Design in the transport category. The aim of the award is to acknowledge innovative solutions that anyone can use. A universal design was a fundamental requirement for the development of Bybanen. It is the first rail line in Norway universally designed with a focus on traveller accessibility. Bybanen offers an equitable transportation solution – public transport for the mountains. It makes public space, otherwise hard to reach, accessible to all Bergen residents and visitors.

A NEW STANDARD FOR COLLECTIVE TRAVEL IN WESTERN NORWAY

The city of Bergen’s light rail is now the preferred means of public transport for the mountains, and has changed the city landscape for travellers. Highly accessible mobility solutions and a universal design improve inclusion, equal opportunities and equality. This also sets a standard and provides a good example of new, user-focused mobility solutions for future travellers.

Bergen’s light rail system is the backbone of the city’s public transport, 20 kilometres in length and with 27 stops. Phase 4 (10 km in length) is under construction and will open in 2022.9

9) www.bybanen.no
MOBILITY SOLUTIONS – EXAMPLES FROM SWEDEN

THE LATEST MOBILITY SOLUTIONS FOR SWEDEN
Electric scooters (or kick bikes) help you minimise your carbon footprint and reduce your greenhouse emissions. This service, available in Sweden, is connected to an app. Scooters are booked via smartphone, and users pay only for the time used. Scooters can be picked up and dropped off all over the city, so travellers are not limited to predetermined routes.

The test run for self-driving buses is the first step in the Swedish government’s initiative to create “In Real Labs” for future travel and transport. Autonomous vehicles have been operating on public roads for a period in Kista Science City.

Self-driving shuttle buses share the road with pedestrians, cyclists and other vehicles in Stockholm. These little shuttles set an innovative example for multimodal urban transport, serving as a role model in the near future for smart cities in Europe.
4. CONCLUSIONS AND RECOMMENDATIONS
Accessible public transport is vital for the city and its inhabitants. High capacity transport makes our cities accessible in an affordable and efficient way. High capacity transport options are found in dense parts of our cities and thus offer access to many people. Service lines complement the public mass transport system and make less dense areas accessible. Shared mobility, self-driving cars, and “mobility as a service” can go a long way towards achieving accessible door-to-door mobility solutions for everybody.

After studying examples of successful public transport planning around the world we can conclude that:

- Urban structures are related to available transport options, and people’s accessibility to public transportation is related to the density of the city. Stopping and reversing urban sprawl is one of the most important measures to provide better access to public transport, given today’s typical public transport solutions.
- With today’s transport solutions it is difficult to provide good accessibility for everybody. Accessibility through public transport is closely linked to the time and cost associated with reaching various destinations from a given origin. In a larger city, an accessible public transport system provides short travel times and has reasonable operating costs, although often with longer distances between stops. This conflicts with short walking distances for users to the nearest stop, which is another important accessibility criteria.
- New technology and mobility services increase our options for mobility and may come to blur the traditional separation between public and private transport. Shared mobility, self-driving vehicles and “mobility as a service” can offer new solutions to take you from your doorstep to highly efficient transport options, thereby improving your accessibility to mobility.
- It is vital for the functioning and attractiveness of our cities that new technologies and services supplement, rather than replace, well-functioning public transport lines or walking and biking to stations.

I just love public transport – fast and effective!
Åse, Sales Manager
To accelerate the development of accessible mobility we have the following recommendations for policy makers, city builders, and aspiring suppliers of the mobility services of tomorrow:

- Analyse and identify local barriers to the development of shared mobility, self-driving vehicles and mobility as a service. Some barriers, like national regulation, will have to be handled by governments while others, like infrastructure, can partly be solved by local policy makers.

- Urban planning should always be done with transport supply in focus, since good planning may significantly change the need for public space used for cars. With the mobility solutions proposed in this report, urban planning should consider that transport supply may also significantly increase the possible travel range for citizens living in areas outside a reasonable walking distance from highly effective public transport lines.

- To gain citizen acceptance, new transport solutions should be introduced in steps, starting with areas that are currently not well served by public transport. But rapid and large-scale implementation will improve attractiveness of the system and reduce operation costs.

- Regardless of the business model chosen for operating the transport system, local policy makers should take measures to limit exclusive occupancy of shared vehicles. System efficiency may otherwise suffer. They should also make sure that the vehicles that operate the system are accessible for those with impairments and special mobility needs.
5. ABOUT THE AUTHORS
SARA POLLE is a human geographer and group manager for Sweco’s Norwegian mobility team and an expert on sustainable mobility and urban development. She is professionally engaged in a wide spectrum of mobility projects. Sara is a key consultant for Oslo municipalities’ sustainable “car-free” urban development and a contributor to Sweco’s Urban Insight. In the Norwegian Public Roads Administration, she graduated as a process manager and led a wide range of road and street planning projects. Sara always looks for new methods and opportunities for further development, selecting and designing methods that help activate participants’ creativity and ensuring a high level of innovation.

HELGE GIDSKE NAPER has worked as a strategic planner and project manager since 2002. Helge is an expert at strategic-level research and has excellent methodology skills. His work focuses on sustainable urban transport, with an emphasis on public transport. Through visualisation and emphasis on clear reasoning, he ensures good processes and involvement of all those involved in the projects in which he participates. Since 2011, Helge has been an external examiner at the master’s programme APL 360, Planning for Sustainable Urban Regions, at Aas University (NMBU).
6.
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Urban Insight is an initiative launched by Sweco to illustrate our expertise – encompassing both local knowledge and global capacity – as the leading adviser to the urban areas of Europe. This initiative offers unique insights into sustainable urban development in Europe, from the citizens’ perspective.

The theme for 2018 is Urban Move, describing various facets of sustainable mobility and accessibility.

In our insight reports, written by Sweco’s experts, we explore how citizens view and use urban areas and how local circumstances can be improved to create more liveable, sustainable and mobile cities and communities.

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