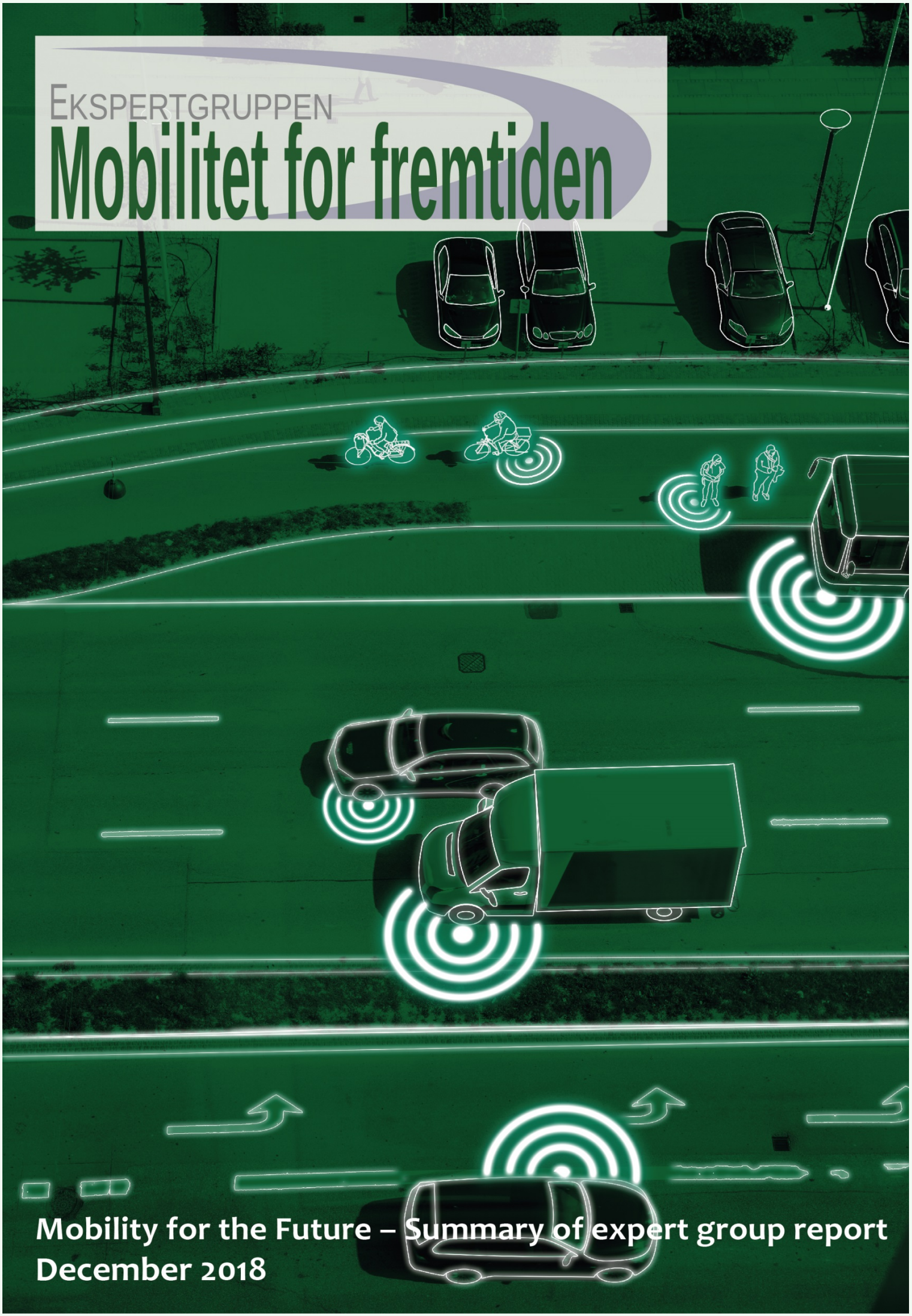
EKSPERTGRUPPEN

Mobilitet for fremtiden



Mobility for the Future – Summary of expert group report

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Contents

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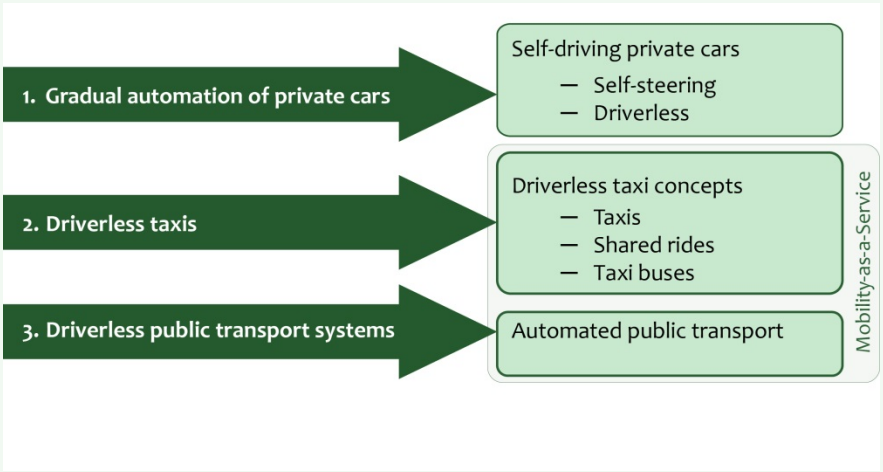
1 Summary

WE CAN EXPECT INCREASING TRAFFIC VOLUMES AND SIGNIFICANTLY MORE CHALLENGES WITH CONGESTION IN THE FUTURE. AUTOMATION CANNOT BE EXPECTED TO SOLVE IT. *Increased wealth and population growth will increase the demand for transportation. Along urbanisation this will lead to significantly increased congestion, especially in and around the largest cities. Presumably neither car sharing nor automated vehicles will decrease these problems.*

- A projection toward 2030 indicates a 16% overall growth in the national passenger car use compared to 2015, while the growth for road freight is expected to be about 12 %.
- The increased amount of traffic generates an increased pressure on existing and planned road capacity. In the same period, congestion will increase by two-thirds, which is far more than the growth in traffic.
- The growth of traffic and congestion will have large geographical variations. The growth will be higher in and around the largest cities and on the overall road network between the cities. This is also where the problems of congestion already are most severe. The parts of the railway network that have the highest utilisation today will also experience increased pressure on its capacity.
- This development is mainly due to a growing population and economic growth. The geographical differences largely stem from continued urbanisation. The population is expected to grow the most in the larger cities and decrease in more remote areas despite a general growth in the population. Changes in the population age structure will only have minor impacts on the general picture.

Future perspectives for the transport system in light of automation and new business concepts

Three different paths of development can be distinguished within the automation of passenger transport, each of them related to different business concepts. The first path continues the current business concepts followed by car manufactures that sell and lease private cars. The second path is attached to new car-sharing schemes where investments and operation of cars are shared between the users. The third path focus on automation of buses and trains aimed at what can be defined as *the provision of traditional public transport services*.



The implications of automation for the user

IT IS THE FUNCTIONAL CONSEQUENCES OF AUTOMATION THAT ARE OF INTEREST TO THE ROAD USER AND AFFECT TRANSPORT BEHAVIOUR. *In this perspective it is important to differentiate between two levels of self-driving features with different degrees of impacts for transport behaviour and thereby for the transport system.*

- ***Self-steering:*** *Driving does not need the driver's attention. Thus, the driver can make better use of travel time.*
- ***Driverless:*** *The car drives without a driver. This makes it possible to transport persons without a driving license and to call a car and return it.*

The self-steering features can be limited to parts of the road network and by weather conditions, speed and traffic conditions, etc.

- It is uncertain how advanced self-steering features need to be, before the driver really can use travel time for other activities. It is also unclear how much it will lower the inconvenience of commuting for driver , and how much it will affect transport behaviour.
- On the other hand it will undoubtedly revolutionise the transport sector when cars in the long run will be driverless on all roads and under any weather conditions. If cars can pick up users and park themselves remotely, it will create possibilities for completely new and unforeseeable ways to use cars. The consequences on transport demand and the need to adapt the transport system can potentially be huge.
- Users of public transportation already have many of the perks from automation, since they are not behind the steering wheel. But driverless buses will reduce operation costs significantly, which will provide economic means scope that potentially can be transferred into higher service.
- For Trucks, automation can provide large cost savings for road haulage, as wages for drivers are pivotal to total transport costs. Driverless Trucks can also reduce delivery time over longer distances, as they are not subject to the regulations on driving time and rest periods.
- Cheaper freight transport and shorter delivery times over long distances will increase the heavy goods road transport. This will most likely primarily apply in a European perspective through changed supply-chains, and localising of terminals and industry production as well as increased specialization.

Uncertainty on the speed of technological development

There is vast uncertainty and disagreement on how fast automatization will take place. Some large and influential companies have announced that they already expect to offer commercial, driverless taxi rides by 2019 in some American cities. Other more sceptical experts estimate that fully autonomous cars will not be available on the market for 'ordinary' car buyers before 2030. The difference in time perspective is to some extent related to varying commercial potential of the three aforementioned development paths.

WIDESPREAD USE OF DRIVERLESS, PRIVATE CARS IS PROBABLY WELL INTO THE FUTURE. BUT THERE IS A HIGH UNCERTAINTY AND LACK OF CONSENSUS ON THE TIME PERSPECTIVE. *Self-driving features are gradually reaching the market. However, they will probably at the earliest make up for half of all driving around 2030-2035. Fully autonomous driving private cars require a level of automation that is unlikely to be introduced before 2030. Probably, driverless cars will only constitute half of all driving distance around 2040-2045 and maybe much later.*

- Different levels of self-driving features will gradually be introduced on the private cars market. It will take many years from the introduction of the technology to the market until it becomes common use on roads. This is caused by two factors:
  - Prior experiences from introduction of new technologies indicate slow market penetration, unless they are promoted politically. The penetration time depends on the car buyers' assessment of the benefits of self-driving features against the cost of the technology.
  - Dispersion in the car fleet happens slowly due the long life-span of cars.
- A high value-based tax on vehicle registration means a slower spread of automated private cars compared to countries with low or no value-based taxes on cars.

DRIVERLESS TAXI CONCEPTS WILL PROBABLY BE INTRODUCED EARLIER THAN DRIVERLESS PRIVATE CARS. *Automation of vehicles for taxi services is developed as driverless from the start. This is due to the fact that gains on operational costs can only be achieved when the drivers' wage is saved.*

- At the same time, technological challenges are smaller to a commercial vehicle fleet within a limited geographical area. Combined with the cost reduction incentives, this will probably mean a faster breakthrough than for private cars in large cities.
- Especially in the larger cities the spread of sharing concepts can reduce the penetration period for automated vehicles, as sharing implies that cars can be used more intensely and therefore have a shorter life-span.

DRIVERLESS BUSES WILL PROBABLY ALSO BE INTRODUCED BEFORE DRIVERLESS PRIVATE CARS *for the same reasons as driverless taxis. In addition, driving along known and repeated routes gives the opportunity to adapt infrastructure to automated vehicles and in other ways prepare the interaction with other traffic modes.*

- Driverless minibuses are already on the market and can be used for niche assignments. However, the buses do, as of yet, only drive slowly and are expensive to operate, so technologically, it will take a while before they can be employed on conventional, scheduled bus routes. When the technology is ready, the size of the bus should be a minor issue. The large bus manufacturers are also developing and testing automation of larger buses.

INTRODUCTION OF DRIVERLESS TRUCKS CAN HAPPEN WAY FASTER THAN PRIVATE PASSENGER CARS. *A substantial part of the freight transport volumes on roads takes place over long distances mainly on the motorway network. On these routes, driverless operation is least complicated and the saved costs will be a strong incentive for operators.*

- The competition within the road haulage business is a strong driver toward the automation of trucks as the potential gains from saving the driver wages creates clear incentives to be a first mover. Therefore, fast transition in the truck fleet can be expected once driverless technology is feasible and economically available on the market.

Updating of decision support tools

At the moment it is difficult to estimate the future perspectives of automatization and new business models. This applies both to how fast they will be widespread and to the extent of their consequences. This creates increased uncertainty on the long-term benefits from investments in the transport sector, which should be reflected systematically and consistently in the basis for decisions for future projects.

- Technological breakthroughs and business models relying on sharing economy gives cause to continuously updating the decision support tools in the transport sector:
  - First, economic appraisal methods of analysis must be further developed to be able to assess the consequences of alternative scenarios for automation to each project.
  - Landstrafikmodellen (the Danish national traffic model) and other traffic models should correspondingly be able to illustrate the expected behavioural consequences from new and changed forms of transport, including new taxi concepts and the possibility for drivers to utilize travel time with self-driving cars in the future.

Geographical differences due to size of city, population density, and distances

Automatization and new business concepts have clear synergies but the opportunities and consequences for mobility and the transport system is fundamentally different across geographical areas. City size, population density and travel distances are central factors leading to differences in the challenges to the traffic system, the roles of the various modes of transport, and in how traffic will affect urban development. In the following sections the insights are structured in four main areas:

- City centre within the four largest cities
- The suburbs around the four largest cities
- Other cities and rural areas
- Between cities

There will be some overlap, as insights that characterize one area also have some significance to other areas, typically because the distinctions between the four areas are not concise but rather gradual.

Between cities

Almost all of Denmark's about 45 cities with more than 15,000 inhabitants are connected to the motorway network, which as a result is used for a major part of long distance trips in car. Outside the cities, high levels of traffic and congestion is mainly found on

the motorway network between the larger cities and on the approaching roads to Copenhagen. According to traffic projections this will also be the case in 2030. The train has its primary strength compared to the car on these stretches, especially between East Jutland, Odense and Copenhagen.

National infrastructure investments are pivotal to the Danish state transport policies, and they are of decisive importance for the long-term quality of the whole transport system. The long life-span for transport infrastructure implies that decisions over the years will have impact many decades into the future. That is why also societal tendencies and changes in technology, which evolves over a very long time period, will influence the economic return on today's infrastructure investments.

Demand and capacity on the overall road network

AUTOMATION OF PRIVATE CARS WILL MAKE DRIVING MORE ATTRACTIVE AND CAN REDUCE THE MARKET SHARE FOR PUBLIC TRANSPORTATION

More people will choose the car instead of public transportation when they have the opportunity to utilize their time better while travelling. This will probably be worth most on longer trips and on the overall road network where comfort is the highest. It is expected that self-steering abilities will be available here first.

- When time can be used for other activities, the importance of factors that contribute to a comfortable ride will increase. This leads to strengthened requirements on roads design and increases the attractiveness of motorways.
- Self-steering features will increase the tendency toward higher growth in traffic on motorways. They will attract a greater share of traffic in private cars, even if the trip will become longer, and more people will choose the car in preference to train or bus.
- Self-driving cars equipped with driver assistant systems that keep the car in its lane (LKA, Lane Keeping Assist) can increase the capacity of motorways as it allows for reduced lane width. When the market share of cars with LKA is adequate, some motorways can be rebuild to have more lanes with 1 or 2 LKA-lane in each direction. The potential benefits from preparing for this possibility should be considered in future motorway projects.
- Platooning of trucks, i.e. electronic linking, should be considered a transitional technology toward driverless trucks, and hence it is uncertain whether this technology will reach significant application.
- Driverless trucks have a big economic potential and will consequently have a fast breakthrough when they are marketable. At first driverless trucks are primarily expected to be limited to motorways. This will possibly create needs for facilities in addition to the motorways where drivers can enter the vehicle and drive the first and last part of a trip.

The role of long-distance trains in the future

THE STRENGTH OF LONG-DISTANCE TRAINS WILL IN THE FUTURE BE TO OFFER HIGH SPEED ON LONG TRIPS BETWEEN THE LARGEST CITIES. *This can be of importance to the choice of train material and timetable strategies. In the long term, competition from driverless cars and automated long-distance buses can make it less relevant to have long-distance trains on regional and local railways. This can reduce the profitability from further electrification outside the main lines.*

- In the long term, the costs from operating driverless long-distance buses will be reduced considerably compared to the already relatively low prices on commercial bus routes. This may reduce the relevance of trains on stretches with modest passenger basis attached with high costs per passenger-kilometre.
- On these stretches, the profitability from electrifying trains will be reduced by automation and new business concepts. These investments have a long horizon for return that goes far into a future with self-driving cars.
- Battery powered train operation is now technologically possible and within a few years, it can be expected that existing diesel-electric locomotives can be rebuilt to run on batteries. Within 5-10 years, battery-operated trains can become an advantageous economic alternative for secondary railway lines.

The largest cities

The largest cities are characterized by high population density. Public transportation and bicycling are important parts of the transport system and road congestion is a serious problem. Space is scarce, making parking areas a particular challenge, and rail-based transport with high capacity contributes to an efficient use of space. The interplay between city- and traffic planning is of huge importance to the liveability in cities. The impact on traffic flow is crucially depending on the balance between the forms of transport. This characterization especially applies to Copenhagen and decreases with city size.

In the short run: The struggle for space in city centres

CAR SHARING CONCEPTS INCREASES MOBILITY FOR URBAN DWELLERS WHO WOULD OTHERWISE NOT HAVE A CAR. *These users will increase traffic, while those users, who refrain from owning a car because of car sharing, will drive less. The combined impact can go both ways. Therefore, increased use of car sharing will not necessarily reduce congestion within cities.*

- Business concepts for car sharing depend on a high concentration of users and that the users do not need the car on a daily basis. But even today in the largest cities, the part of car-sharing is very limited when compared to both the total car fleet and to the overall amount of trips and traffic.
- Concepts based on both private cars and commercial fleets are gaining ground, mainly in the largest cities. Cities will also in the long term be the primary area for car-sharing.
- Access to car is generally important for mobility, also among many citizens in city centres even though they mainly use bicycles or public transport for local transport.

CAR-SHARING CAN REDUCE THE NEED FOR PARKING SPACE. IN THE LARGEST CITIES, THIS CAN REDUCE THE TIME LOOKING FOR PARKING OR MAKE SCARCE SPACE OPEN FOR OTHER PURPOSES. *Digital platforms and new business concepts give easier access to shared cars.*

- Most urban dwellers prefer to have a private car instead of a shared car, as it gives greater flexibility and lower variable costs per kilometre. This is why there still are many long-term parked private cars on public roads. The extent of so-called weekend cars is, among other things, related to the fact that the price of resident parking permits is much cheaper than the market price on parking spaces.
- Higher prices on resident parking will make some car owners, who have a limited need of driving, give up their private car. With a shared car as an alternative, the disadvantage of giving up the private car is reduced, which increases the effect of parking prices.
- If the higher price on residential parking mirrors the value of the released parking spaces, it will be an overall socio-economic gain. The increased costs for those maintaining their car will be counter-balanced by a corresponding public revenue.

HIGH CLASS PUBLIC TRANSPORT AND BICYCLING WILL IN THE FUTURE BE EVEN MORE IMPORTANT FOR MOBILITY IN CITIES, *as traffic, congestion, and scarcity of urban land generally are expected to increase substantially. Especially in the capital, rail-based traffic can relieve the road network, by virtue of high capacity and accessibility. However, automation will strengthen BRT (Bus Rapid Transit) as an alternative to extending the light rail systems in the larger cities and their suburbs.*

- Self-driving BRT combined with battery-electric operation will be able to give a more smooth travel and thereby higher comfort close to be similar compared with light rail. The saved wage costs at full driverless operation will be relatively more advantageous to BRT than to light rail.
- Automation of S-trains along the up-coming replacement of rolling stock increase reliability and provide for higher frequency and better material use.

In the long run: Driverless cars – privately owned or taxi concepts?

DRIVERLESS TAXIS AND CAR SHARING CONCEPTS CAN BECOME A REAL ALTERNATIVE TO PRIVATE CARS IN THE LARGEST CITIES.
Smartphone based on-demand business models will probably be realised before driverless, private cars, as leading companies claim they can offer these services in some American cities within a few years. These concepts will improve the mobility for users, but will not in itself limit traffic or congestion in cities; it will probably be the contrary.

- Driverless private cars and taxis will in the long run increase the demand and create more traffic and potentially significantly more congestion in cities. Compared to cars with a driver, they will 'patiently' position themselves before and after picking up passengers, even when the speed is very low due to congestion. On the other hand, the possibility for cars to reposition themselves will reduce the need for parking spaces, where space is scarce.
- The automation of taxis has clear commercial incentives as the saved wages from drivers will reduce costs significantly compared to today. With a high rate of utilisation, prices can get so low that they can replace short trips in cars within cities on a large scale.

- For urban dwellers with a low annual mileage, it can be an advantage to replace the private car with various taxi concepts, as occasional long trips out of town can be done with car-sharing services, which could be an integrated part of the concept. The advantage, compared to todays shared car services, will be that they can arrive to the user directly, after which the user can take over the wheel. This concept may arrive before driverless private cars.
- The business models and digital platforms in new driverless taxi concepts can also be used for shared automated mobility services that range from shared taxi rides to individualised public transport services. A large market share for this type of services has the potential to significantly reduce the amount of parked cars, traffic and congestion in larger cities. This can be promoted by general economic policy measures targeted at limiting congestion, e.g. road pricing differentiated by time and place.

MOBILITY-AS-A-SERVICE (MAAS) IS STILL AT THE DEVELOPMENTAL STAGE, BUT ONCE FULLY DEVELOPED, IT WILL BE A SUBSCRIPTION ACROSS ALL MODES OF TRANSPORT. *The challenge to developing MaaS solutions is first of all to create an organisational and economic set-up that is attractive to all stakeholders, i.e. users, the public transport operators, private operators and last but not least, the MaaS-operator.*

- The boundaries between car-sharing, car-pooling, driverless taxi concepts and traditional public transport are becoming fluid. The synergy between them can be improved through integration into MaaS solutions, which can be adjusted to the needs of the users. The benefits will primarily accrue to the users of public transport as they will receive easier access to complement their needs with shared cars, car-pooling, taxis and city bikes. For the small share of car owners in cities who consider ending up their car ownership, this convenience can become decisive.
- To promote MaaS solutions it can be necessary to support the organisational framework. This would be a matter of establishing an open and reliable access to updated timetables and real time data on delays together with a price structure and an open opportunity to undertake resale of tickets.

Suburbs around the largest cities

The suburbs around the largest cities cover the surrounding urban areas, where space is less scarce but activities are closely tied to the inner city. The tie to the inner city is especially relevant as concerning commuting. In the morning and afternoon hours congestion is a huge problem on arterial roads to the city, on the ring roads and in some local urban centres. Congestion is estimated to increase substantially in the future, as the share of car travel is particularly high in the suburbs. As in the city centres, it will be even more important to have high-class public transportation in the most significant transport corridors to relieve the pressure on the roads. However, the distances between the train stations are longer and travel patterns more scattered. This is why efficient access and egress traffic and station adjacent urban development are key challenges.

- Self-driving cars will reduce the inconvenience of tailback driving at ring and radial roads in relation to commuting. This will further increase traffic and congestion in peak hours.

The challenge of bringing passengers to and from public transport

DRIVERLESS CONCEPTS CAN ALLEVIATE THE CHALLENGES OF BRINGING PASSENGERS TO AND FROM PUBLIC TRANSPORT CORRIDORS AND INCREASE STATION CATCHMENT AREAS. *Driverless taxi concepts can increase the catchment areas for stations and other high-class hubs by offering more efficient and flexible access and egress transport (first mile/last mile) than conventional buses on regular routes. This also applies for driverless private cars that would not have to park at stations. A change in the design of stations will be needed by increasing the capacity for pick-ups and drop-offs and reducing the need for park-and-ride infrastructure.*

- In the long term, automated bus operation has the same economic potential from saved wages to drivers as taxis have. This provides economic opportunity to increase frequency and/or have more direct routes over the whole day at low marginal costs.
- Self-driving buses in regular route is technologically simpler than driverless cars, which can make them to be introduced earlier. However, a real market breakthrough is determined by whether the total costs will be lower than for regular buses with a driver.
- Today, precursors to automated buses as self-driving minibuses are already up and running in demonstration projects in other countries. They are still in an early stage of development, leaving the question about cost level under normal bus operation unanswered. However, the crucial limitation is that the minibuses can only drive at a very low speed, which until now only have made them useful for niche markets at very local transport such as airports, hospitals or university campuses.

ATTRACTIVE URBAN DEVELOPMENT CAN BE PROMOTED AROUND IMPORTANT STATIONS BY INTEGRATING NEARBY AREAS *with the purpose of developing urban hubs that support daily activities besides transport.*

- Driverless cars can support public transport by providing better solutions to first and last mile transport and by increasing the station catchment area.
- Stations, which are important public transport hubs with a high passenger base, can make the choice of public transportation more attractive by reducing the overall daily need of transport by integrating other daily urban activities, such as shopping. The concentration of urban development around transport hubs can support public transportation and contribute to create lively and attractive urban environments.
- Divided ownership and roles have until now been barriers to holistic thinking, but a shared responsibility for stations – as will happen for the electrified railway network of Copenhagen – and new types of public-private partnerships can support a holistic development.

Other cities and rural areas

The majority of the Danish population live outside the largest cities and their suburbs, and the majority of daily transport takes place in these smaller cities, towns and rural areas. Private cars will probably also in the future be the primary way to have access to car transport, and the car will still be the dominant form of transportation. However, only a few places are expected to experience critical problems of capacity apart from the motorways between the largest cities.

CAR-POOLING ON SHORT TRIPS ARE RESTRAINED BY THE RULES FOR COMMERCIAL PASSENGER TRANSPORT AND TAX LEGISLATION *Car-pooling services are almost limited to longer trips. On short and middle distance trips, the allowed payment is not sufficient to offset the inconvenience of coordination, additional travel time, etc. Making these trips more prevalent can increase mobility for people without access to a car especially outside the larger cities and at times with little or no public transport services.*

- Car-pooling services have been growing steadily in the last years but they still make up a very small share of overall transport. The trips are mainly between larger cities across the country.
- The gains to mobility could already be improved today by increasing car-pooling on short and middle distance trips. The economic incentives for the driver can be increased through changed legislation allowing higher payments for car-pooling on shorter trips. For private car-pooling, these payments should in practice be tax-free but only up to a certain daily amount in order to avoid untaxed taxi driving.

CARS ABLE TO DRIVE DOOR-TO-DOOR WITHOUT A DRIVER WILL IN THE LONG RUN REVOLUTIONISE THE TRANSPORT SECTOR. *The possibilities for mobility will generally be increased, but especially new groups of users without a driver's licence will get the opportunity to use cars on their own, e.g. children and young people. This will reduce the need for local public transport and the argument for providing public transportation as a public service obligation will weaken. The benefits will probably be greatest in smaller cities and rural areas.*

- Driverless cars will in particular be able to make a difference in small cities and rural areas where the supply of public transport is limited. The improvement to mobility for children and young people will reduce the logistic difficulties for families to settle in these areas.
- In the long run new driverless business concepts with flexible demand responsive routes will in many cases both be a cost-efficient and service improving substitution to route-based bus operation. This applies not least in the areas where the passenger base for public transport will become smaller as a consequence of driverless cars and continued urbanisation.
- Automated bus-operation in middle-sized cities will have similar perspectives as within suburbs, meaning savings to bus-operation and/or better spatial distribution along with higher frequencies over a greater part of the day.

More efficient use of the transport system

THERE SEEMS TO BE HUGE UNREALISED OPPORTUNITIES TO MAKE BETTER USE OF THE TRANSPORT SYSTEM'S CAPACITY THROUGH OPTIMISED TRAFFIC MANAGEMENT AND MORE EFFICIENT ORGANISATION, AND USE OF REAL TIME DATA ABOUT TRAFFIC. *Commission works have repeatedly called attention to this potential. It is unclear whether the lacking realisation of this potential is due to organisational barriers or lack of attention on or visibility of the existing gains.*

- Better instalment and management of existing controlled junctures can without major investments improve traffic flow and speed for cars and buses on some stretches.

- The accessibility and regularity for buses can be prioritised by communication between bus and traffic lights, though it has to be held up against the overall accessibility for all road users.
- Coordinated traffic management and optimisation of signals across administrative border as well as sharing of data can improve the traffic information and dealing with interruptions in the operations.
- Open access to real time data on public transportation can already in the short term contribute to the improvement of traffic information across all modes of transport. This can be supported by requiring integrated IT and open data in contracts with operators.
- The size of the benefits from establishing a public digital road map is uncertain. There is no doubt about the importance and value of precise, detailed, and updated digital maps in relation to automation, among other things. But experts in the area have different views on the role of public authorities, as large international businesses have great commercial interest in investing in this area.
- Experts within the field also have very different views on the importance of car-to-car communication (V2V) and car to infrastructure communication (V2I). The need for investments in V2I infrastructure alongside the overall road network is currently uncertain. Neither V2I nor V2V are estimated to be a precondition for automation to take place, even though there in the long run will be a synergy. It would be an advantage for Denmark to wait launching V2I infrastructure and instead follow the development in the EU and other international forums. It is further relevant to contribute to development of international road standards and road equipment that support V2I technology and self-driving cars.

TRAFFIC-RELATED GAINS FROM ROAD PRICING WILL BECOME GREATER IN A FUTURE WITH INCREASED CONGESTION, AND TECHNOLOGICAL DEVELOPMENT WILL MAKE THE IMPLEMENTATION EASIER. *Congestion is particularly expected to increase in the largest cities and on the road network around them. Automation and driverless taxi concepts in a broad sense will contribute to mature the technology for time and place dependent road pricing and reduce the transaction cost of running a payment system.*

- A restructuring of car related taxes from registration tax to time- and place dependent kilometre based road pricing is widely acknowledged as in principle the appropriate regulatory approach. The introduction should in practice be dependent on whether or when it is socio-economically profitable, after taking into account the cost of investments, running expenses, and the technological risks.
- The transition to road pricing, with prices that mirrors the overall costs and burdens to society from each mode of transport, will make the driver change routes and times of driving, leading to a better utilisation of the road network capacity. It will also increase the incentives to use public transport along with bicycling and walking, car-pooling in private cars, and in the long run also driverless taxi concepts.
- In the long run widespread use of driverless vehicles may make extensive regulation of access to roads necessary, e.g. high payments, in order to avoid a traffic collapse in the largest cities during peak hours.

Distribution and e-commerce

THE CONSEQUENCES FROM E-COMMERCE ON THE TOTAL TRANSPORT AND TRAFFIC WILL PROBABLY ALSO IN THE FUTURE BE SMALL EVEN THOUGH E-COMMERCE IS EXPECTED TO INCREASE. *The growing amount of e-commerce gives opportunity to optimise and consolidate the distribution and thereby counter the impact of smaller deliveries to the total traffic. Freight traffic on road is expected to grow as a result of increasing e-commerce.*

- E-commerce has become widespread and is growing steadily, as it is involving more groups of goods, such as groceries and convenience goods. The significance of e-commerce to the overall freight traffic on roads is estimated to be small.
- Current experiences show that e-commerce on shopping goods only has replaced passenger transport to a very limited extent. With the increasing e-commerce on convenience goods the effect might become larger.
- Automated distribution is probably further out in the future than automated freight transport on long distances. However, there are certain areas where automation soon will gain ground:
    - Small self-propelled robots (ground drones) with low speed will potentially in a few years' time be able to deliver packages, mail, and goods. The adaptation to other traffic is not clarified and there may be consequences to traffic, which then would require regulation.
    - Drones for airborne delivery of packages are technically possible today. The challenges in relation to safety, surveillance, and noise, among other things, would require regulation of the airspace and will probably make drone-deliveries on a large scale unrealistic in densely populated areas. Express delivery of light goods such as medicine or spare parts would be the most evident deliveries for using drones, not least in sparsely populated areas.

The climate change challenge and its consequences to the transport sector

TRANSITION OF PRIVATE CAR TRANSPORT TO RUN ON ELECTRICITY IS A CRUCIAL ELEMENT IN REALISING DENMARK'S LONG-TERM CLIMATE GOALS. *The 2050-targets in the Danish Climate Policy Plan will probably require an implementation period where new private cars already are fossil-free from around 2035. Electric cars are expected to become economically competitive with a satisfying range within the next 10 years. The transition to renewable energy is realistic and it cannot be expected to be a determining barrier to continued growth in traffic. However, the degree to which this transition is politically promoted has to fit the technological development in order to secure a sufficient and fast implementation in order to reach the 2050-targets.*

- The 2050-targets of a low-emission society independent from fossil energy cannot be achieved only by improving fuel efficiency and by switching to more energy efficient modes of transportation, such as public transport, bicycling, and walking. It requires an extensive transition to renewable energy (RE).
- The gradual introduction of new technologies to the new car market and the long lifetime of cars, makes it necessary to phase in cars running on renewable energy much earlier than 2050 in order to become completely independent from fossil fuels.

- Battery-powered electric cars that are charged with RE-based energy are expected to be the key technology in this transition. It will also produce less noise and improve air quality in cities. Hydrogen and other synthetic fuels for producing renewable energy are not considered mature technologies today, but in the long run, they might become economically sustainable alternatives.
- The most significant barrier to the distribution of electric cars is the price on batteries. The prices has been declining considerably in recent years and they are expected to decline further in the future, which can make the electric cars economically competitive within the next 10 years. This will also require an expansion of the charging infrastructure as electric cars become more widespread.
- With the current taxation structure, the revenue from taxes on car ownership and driving will decline with the emergence of electric cars, as they are much more energy efficient than petrol and diesel cars.
- The transition of other in-land transportation to renewable energy is also expected to be technologically possible without any increased socio-economic costs. International aviation and shipping will still have a large and increasing importance to the outlet of global emissions, and in these two areas the development of sustainable alternatives to fossil fuels will continue to be a challenge.

Traffic safety

THE SPREAD OF DRIVER ASSISTANCE SYSTEMS AND OTHER SAFETY EQUIPMENT WILL PROBABLY CONTINUE THE LONG TERM TREND TOWARD SAFER TRAFFIC. *Driverless cars, where the human factor is completely eliminated, have the potential to strengthen this trend in the longer run.*

- Autonomous features will most likely improve traffic safety in the medium term. However, there might be a risk to systems based on conditional automation, which requires the driver's readiness to act. It can be difficult to determine whether the driver relies on the features to a greater extent than they allow.
- Combined vehicles can also contribute to more safe travel through relevant safety information from other cars, or from car to driver.
- A number of driver assistance systems that already exist on the market, can contribute to fewer traffic accidents. Their introductions to new cars,however, are being held back by the value-based tax on vehicle registration, which requires taxation on safety equipment. This can be avoided by a compensated deduction in the value-based taxation for driver assistance systems that improve the active traffic safety.