Institute of Transport Economics
Norwegian Centre for Transport Research

Summary

Changes and Challenges in Future Transport

Drivers and Trends

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Several megatrends, affecting both passenger and freight transport, seem to be driving a set of radical innovations in the transport sector. Most important are technological, social and environmental trends related to digitalisation and the sharing economy, urbanisation, demographic shifts and climate change.

Transport in a digital age forms the core of this report and the project of which it is a part. The research project DIGMOB[1] examines and provides solutions to effectively link digitalisation and transport innovations for passenger and freight mobility in order to obtain a more efficient and sustainable urban transport system. Both freight transport and individual mobility in urban areas are increasingly reaching its limits since the process of urbanisation has caused continuous rising demand for urban mobility systems.

In urban areas with a well-developed transport system, further investments in physical infrastructure will often result in marginal improvements and declining marginal returns. However, digitalisation of the transport system may lead to significant improvements both in economic, environmental and social terms. The application of information and communication technologies (ICT) and Intelligent Transport Systems (ITS) can make transport safer, more efficient and more sustainable for all modes of passenger and freight transport. Moreover, the integration of emerging technologies can create new services and are key to support jobs and growth in the transport sector.

Disruption and transition of future transport

Transport demand is expected to grow significantly in the next decades for both passenger and freight transport. However, the rate of change together with increasing complexity of society, makes future projections of transport rather uncertain. The transport sector is in a fundamental transition process due to, amongst others, new technology, climate change, demography and new customer demands. It is also reasonable to assume that the ongoing covid19 pandemic will leave lasting traces both in terms of demand and supply for transport due to changes in work and consumer preferences. However, the accurate long-term impacts of the pandemic is difficult to estimate but we can probably expect a more flexible transport system in the future.

Transport is historically strongly related to population growth, economic activity measured by GDP and to international trade activity. With more people follows more mobility and an increased demand for passenger transport. Population growth also increases the production and consumption of goods and the demand for freight transport. The demand

[1]The project Digitalisation and mobility (DIGMOB): Smart and sustainable transport in Urban Agglomeration is financed by the Norwegian Research Council for the period 2018-2021.

for passenger and freight transport also increases by growth in disposable income and with growth in international trade.

The global demand for passenger and freight transport is expected to triple in the period 2015 to 2050. The strongest growth in passenger transport demand will be in Asia, and in urban regions. Shared mobility and public transport is expected to be responsible for larger parts of the increasing demand in passenger transport, but the private car will still dominate in non-urban transport. Most freight is travelled by sea, particularly over long distances, and this pattern is expected to be fairly similar also in the future.

Travel demand projections for passenger and freight transport in Norway 2016-2050 also indicate a growth in demand. The number of trips is expected to increase roughly in line with the population, the passenger car and air modes showing the highest growth rate. The freight transport sector in Norway has been characterised by growth and structural changes the past decades and projections indicate that the demand for freight transport will continue to increase. The main part of total freight transport travels by sea, followed by road whereas rail makes up the smallest part.

Disruption and pathways

Disruption in the transport sector takes place on different levels and various scales, on product categories, on sector level or as impacts across multiple sectors. The main factors which particularly drive disruptive changes are related to production costs, quality of new technologies and processes, changes in consumer or business customer preferences, laws and regulations and access to important resources.

Disruptive changes are often a result of a combination of the different drivers. New vehicle and fuel technologies (electrification) and new business models for mobility (shared mobility) together with digitalisation and automatization (ICT, ITS and AI), may result in a modal shift for both passenger and freight transport, and thereby lay the foundation for disruptive changes and a transition to a more efficient and sustainable transport system.

With digitalisation and technological innovations becoming ever more important for achieving the goals of smart and green transport and, increasing landscape pressure (climate change) combined with more mature niche innovations (technological and social), this may spur transition processes in urban transport and mobility, both at levels of behavioural changes and policy-making. The rapid electrification of the car fleet in Norway also illustrates the importance of financial incentives for accelerating disruption in transport.

Digitalisation and technology trends

Digitalisation has been at the forefront of mobility of people and goods for quite some time and with an increasingly stronger urban focus. Digitalisation is the motor of the ongoing 'servitisation' of the automotive industry and various design patterns of digital services and platforms are being developed. EU-directives stipulates that novel digital services and infrastructure should be introduced to improve safety, sustainability and mobility. The private sector is also highly active in developing digitalised services and infrastructure pertaining to the transport sector.

Data

The growth of data and its value are the key driver of the digital economy, and the ongoing proliferation of AI depends on it. From an innovation perspective, any piece of useful data can be viewed as a highly malleable complimentary asset forming an essential component

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of a digitalised service. From an economic perspective data has several defining features in comparison to other resources. Firstly, data is non-rivalrous and can be used by any number of applications or algorithms simultaneously. Secondly, data is also non-fungible which means that as opposed to money, certain data cannot be substituted for another one due to the uniqueness of each data point. Thirdly, data is an experience good; its utility is not obvious until analysing it. Finally, data tends to increase the amount of data by implication.

In the logistics industry, data sharing is on the one hand ubiquitous and a foundation on which globalized trade rests. Keystone 3PL (Third Party Logistics) actors integrate their partners in vast information networks spanning the globe, sending and receiving updates on transhipments and informing planning and authorities. On the other hand, for reasons of competition among firms, information sharing beyond the customary business networks is a notoriously difficult proposition in an information-driven business such as logistics. Additionally, consistent supply chain transparency remains difficult even within such networks.

A large amount of research networks, non-government and government bodies around the globe strive to further digital freight standards. New approaches to logistics and data sharing are also constantly being tested in living labs across the globe. Entrenched business models and high perceived risks of data sharing are among the main barriers to adopting more open decentralized ways of coupling freight and logistics providers across supply chains.

Analytics

Data must be analysed to obtain its full utility and analytics can be described as a combination of one or more of descriptive, predictive and prescriptive analytics activities. A *descriptive* analysis of traffic information would aspire to accurately determine and describe the current state of the traffic system. A *predictive* analysis would attempt to accurately forecast a future state of the traffic system. Finally, *prescriptive* analytics seeks to accurately gauge the optimal action to take in each traffic situation.

One should be aware of possible "algorithmic bias", several interpretational fallacies of data driven algorithmic decision making exist, including commercial, political and racial implication. While the mere implementation of an AI-driven decision process may indicate fairness and objectivity, the result can be the opposite unless care is taken to avoid such issues. Regardless of the type of analysis performed, data access and analytics capabilities are highly interdependent and they frequently join forces as two main building blocks of digital platforms.

Digital platforms and ecosystems

Three related concepts play important roles in data driven innovation – networks, platforms and ecosystems. Ranging from digitalised automotive modular vehicle platforms to data driven information service platforms, these platforms and their surrounding ecosystems are key to the development of new services and offerings to businesses, authorities and citizens alike. The rise of digital platform companies has led to the emergence of new types of competition in many sectors, including transportation.

A network's value is a function of its size. A direct "network effect" implies that the more firms are actively adopting new standards the more valuable the network using them becomes for other firms. However, "indirect network effects" also occurs when a platform depends on two or more user groups. This type of mutual dependence promotes the emergence of digital platforms. Such platforms can be conceptualized as interfaces between other artefacts and they are often embodied in products, services, and/or technologies.

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The description of data, analytics, networks, platforms and ecosystems is highly relevant to understand the current digitalisation of the transport sector and the various platforms that exist. Examples of platforms and initiatives mentioned in this report is the *The City Innovation Platform* (CIP), *The National Data Warehouse for traffic information* (NDW), *Traffic Management as a service* (TMaaS), *The Extended Vehicle concept and "neutral server"* and *Geofencing*.

Automation

All modes of transportation are affected by automation, prominent examples are the Swedish Einride which is producing autonomous electrical trucks and in the marine sector this is exemplified by the new Norwegian vessel Bastø Fosen VI. However, there are still both technological and regulatory hurdles to overcome before widespread adoption can take place. The SAE (Society for automotive engineering) scheme has five levels, ranging from Level 0 (fully manual) to Level 5 (fully automated). On Levels 0 – 3 a human driver is in the vehicle and either drives or is prepared to take over the driving task when the system requests it. In Levels 4 – 5, the vehicle can also handle exceptional situations, negating the need of human drivers. Most AVs (autonomous vehicles) still require a safety driver in the vehicle to warrant safety, due to a combination of ADS (Automated driving systems) limitations and regulatory constraints.

One can distinguish between four broad types of ADS (corresponding to Level 3 and 4) currently in development for use on public roads and that are expected to become mainstream within 5-10 years – *Automated shuttles and taxis* addressing first- and last-mile trips which are expected to revolutionize passenger mobility, *Automated goods delivery vehicles* which address the first- and last-mile urban delivery, between hubs or the final delivery destination, *Automated truck platooning on highways* which is anticipated to improve efficiency of freight transport in terms of reduced fuel consumption and road utilisation and - *Automated driving on highways* both for passenger and freight vehicles on specific highways.

Key benefits, challenges and development

Key benefits related to CAV (connected automated vehicles) are *improved safety* by eliminating accidents caused by distraction, driving under influence and speeding; *improved transport efficiency* by smoothing the traffic flow; *greater access to mobility* by enabling flexible, on-demand, and driverless transport; *higher productivity* by making commuting into productive time and make it possible for businesses to operate with fewer drivers; and *reduced need for new infrastructure* by increasing highway capacity.

Main challenges and development trends are related to technical limitations, linking the digital and physical infrastructure, general acceptance and trust and the need for proper regulatory framework to ensure good interaction between humans and technology. Automated and connected vehicles are slowly merging into connected automated vehicles (CAVs). Such vehicles, in combination with other parallel trends such as artificial intelligence, electrification and shared economy, hold the potential for a safer, more efficient, accessible, equal and inclusive mobility. However, due to current limitations of technological capability as well as trust, security, safety and regulations, many challenges remain for fully reaching the benefits of CAV.

Social trends

Transport is strongly affected by global megatrends such as urbanisation, ageing societies and digitalisation. Changes in urban and demographic structures lead to changes in transport demand. Growth in urban population usually increases movements of passengers

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and freight, and urbanisation often implies longer travel distances. Digitalisation plays an important role in meeting new transport demand and it also affects the working life and consumer preferences. The intersecting trends of urbanisation, an ageing population and digitalisation affect both passenger and freight transport.

Urbanisation

Urbanisation can lead to increased demand for public transport and to higher walking and bicycling shares in the inner city but also to increased car-based transport in the larger city-regions. The result depends on whether urbanisation is characterised by a compact city or by a city-sprawl development. Whether the demand for transport will increase or decrease is unclear.

People are walking or biking or using public transport much more in the cities than in the city regions. The car is the primary means of transport in the hinterland, and the inhabitants there travel more than the average in Norway. When cities grow due to urbanisation, the strongest growth also take place in the urban fringe zones and not in the inner city. This kind of urbanisation, therefore, may lead to more driving and associated problems related to emissions, congestions and urban land-use. Electrification of vehicles may reduce emissions problems but not solve the land-use problems. A smart city-approach, using digital technology to support city operations related to transport and land-use, may help cities to make urban transportation more efficient and safe.

Demographical change

More people usually means more transport, both passenger and freight transport. An ageing society is also increasingly important for the transport demand and for the mode of transport which is required. Elderly people often use public transport more frequently than younger people. Where the population live and work will also influence their demand for transport as well as their travel mode choice.

The "wave of elderly", will probably increase the need for transport and transport services. In Norway, the age group 75+ years will grow in the coming years and these elderly persons will probably have a different travel pattern than earlier cohorts. Several of them both have a driver license and a car, and they will probably be in a better health condition when getting older. Reduced travel activity due to health issues will probably occur later in life for many of these new seniors. All this indicates that the demand for mobility will increase, and that there will be more elderly car drivers in the traffic in the years to come. Smart urban transport, therefore, must respond to different urban transport demands generated from both urbanisation and population trends. It must coordinate both urban freight and passenger flows by use of digital technologies.

Digitalisation – changes in work, industries and consumer preferences

Digitalisation affects jobs to a greater of lesser extent in all sectors, and particularly the organisation of work in many service markets. *E-commerce* matches demand and supply of goods, and all kinds of services and information are delivered and exchanged by platforms through *e-work* and *e-communication*. One can distinguish between three generations of telework – *the home office* where the workplaces in or close to the employees' homes are remote, cheap and ecological, but also stationary; *the mobile office* where employees not only work at their home office but could perform their work from many places, such as home, cafes, libraries and *the virtual office* which is accessible anywhere at any time.

Digitalisation of transport may both reduce or enhance the demand for transport by means of telecommunication. Complex relations between ICT and transport and between new

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technology and human behaviour, therefore, makes it difficult to estimate both substitution and enhancement effects both on short and long terms.

Telework and passenger transport

Telework enables employees to work at a distance and this has the potential to reduce unnecessary work-related travel, particularly the daily commuting. However, there is no reduction in daily travel time for employees who carry out their work both at home and at the office (part-day telework). Telework may also increase the demand for travel because teleworkers use the saved time to make additional trips, for instance to go shopping. Telecommuting may also affect housing location and thereby transport demand because the distance to work may become less important.

The Covid19 pandemic has led to an unplanned and massive growth in working from home, particularly in high-tech sectors and for high-skilled employees. This comprehensive experiment may lead to changes in industrial structures, organisation of work and employee attitudes, and it may be a tipping point for home working. However, how this may affect the demand for transport in the next round is not easy to predict.

E-commerce and freight transport

The rapid growth of the Internet has led to a significant increase in e-commerce the past years and it is one of the fastest growing marketing channels for different kinds of products and services for consumers. E-commerce has augmented the importance of freight transportation but exactly how it will affect freight transport and logistics is not quite clear. It can both increase and decrease the amount of travel and it can alter the travel patterns of individuals in different ways; online retailing can be a complement to, or it can be a substitute for, traditional retailing. However, fast and flexible deliveries, home deliveries and growth in return deliveries (reverse logistics), are assumed to increase freight volume in residential areas. This may produce negative effects like congestion, noise and environmental concern from increased traffic. Urban areas with high population density will be particularly exposed to negative effects of increasing freight volume from e-commerce.

Climate and environmental trends

Climate and environmental challenges will enforce regulations for decarbonisation of transport and promote use of zero-emission vehicles for both passenger and freight transport. New vehicle and fuel technologies (electrification) and new business models for mobility (shared mobility) together with digitalisation and automatization (ICT and ITS), are supposed to result in a modal shift for both passenger and freight transport, and thereby lay the foundation for disruptive changes and a transition to a more efficient and sustainable transport system.

The transport system, and particularly the road transport system, is vital for people's daily mobility and for freight transportation. However, climate change has increased the vulnerability of the transport systems. It makes a transition to sustainable transport more urgent because transport, not only contributes to climate change, but also because it suffers severely from the consequences of climate change. Therefore, climate change is a driver for sustainable transport in a double sense.

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Transport and exposures to climate change

The transportation system faces both direct and indirect vulnerabilities or "pathways of disruption". The focus is often on direct physical impacts of climate change such as extreme weather events (flooding, landslide, heat waves etc.) on the transport system (washout of bridges, blocked roads etc.), or on direct non-physical impacts on human health and travel behaviour. However, indirect vulnerabilities due to increased complexities within and interconnections between the transport system and other critical infrastructure, is likewise important. The transport system is closely interlinked to the electricity system and the ICT-system and both can be exposed to extreme weather events. Power failure may lead to disruption in transport and communication system, and a breakdown in the ICT-system will disrupt traffic management system, real-time traffic and so forth. Therefore, the need for making the transport system more robust and resilient by mitigation and adaptation measures has increased considerably because of climate change.

Digitalisation and decarbonisation of transport

The transport sector relies heavily on fossil fuels, which is detrimental to both the global climate and the local environment. In order to reduce GHG emissions in the transport sector, the Norwegian government has launched several measures related to fuel and technology innovations but also to facilitate the use of digitalisation, such as intelligent traffic systems, autonomous driving, and shared mobility.

Extended use of digital technology may lead to less cars and less driving if it is combined with proper legislation and change of attitudes related to sustainable transport. Digital technologies may encourage the uptake of shared mobility and connected and autonomous vehicles and improve public transport. This may have a substitution effect and reduce transport demand, but only time will show if this will happen.

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