

Summary

Transport sector innovation and societal changes

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Digitalisation and increased awareness of climate change and the environmental impact of the transport sector are singled out as the societal trends that have the highest probability of creating a new and different transport sector. Other trends, such as population growth and demographic changes, economic developments and globalisation are all trends, that will have an important effect on the transport volumes and the modal split. Still, these trends are more likely to have their effect without radically restructuring the sector. At the same time as these societal trends are evolving a wide range of new technology is developed. This include many innovations that attempt to enter the transport system, by providing new solutions to existing or new issues. Each of these innovations may only have a limited direct impact on the market, but when bundled together their potential impact increases radically.

Context and methods

This report has been written as part of the preliminary work for the Norwegian National Transport Plan 2022 – 2033. The report focuses on identifying trends that can cause a radical change in the relationship between the transport system and society. The analyses that leads up to this prioritising and discussing of different societal trends and technologies is based upon the Multi-Level Perspective (MLP) and transition pathways.

Previous research on adjacent topics have provided the starting point for selecting relevant trends and technologies for this study. In particular we have used the report *Teknologiendringer og nullvekstmålet* (Østli mfl., 2017), that looks at the Norwegian policy objective of having zero-growth in car traffic in urban areas is affected by new technology, with an emphasis on Automated Vehicles, Mobility-as-a-Service, and Sharing Economy related modes. The report *Teknologitrender som påvirker transportsektoren*, (Bakken mfl., 2017) which describe different new transport- and related technologies. *Fremsyn 2050* (KPMG mfl., 2018), that present and describe a selection of trends. In addition we have also used the Danish report *Mobilitet for fremtiden* (Kristensen mfl., 2018), which looks at the consequences of a selection of new technologies and trends on mobility behaviour and travel patterns in a Danish context.

A simplified version of MLP is presented in figure s1.

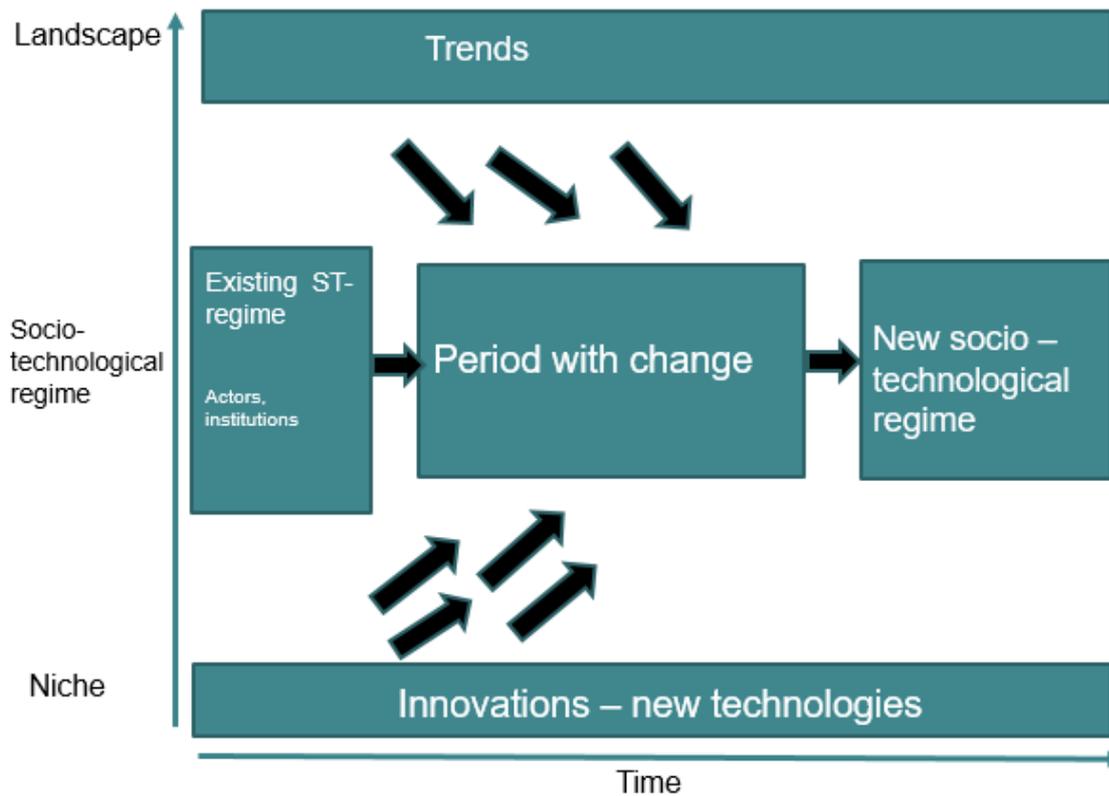


Figure S1: the Multi-Level Perspective (MLP) in a simplified form, adapted from (Geels, 2002).

In this report the MLP framework is used as a tool to study the interaction between trends that affect society through slow and deep changes and innovations that appear much more frequent, but with much less force. The interplay between these two phenomena gives rise to changes in the socio-technical regime. Depending on how the interaction between trends and innovations play out, the development can follow different transition pathways. In this report we utilize the following pathways adapted from (Geels og Schot, 2007).

- Reproduction process (regular change), when the sociotechnical regime remains dynamically stable and reproduce it-self. New innovations come, but within the existing sociotechnical regime. The continuing evolvement of safer cars, can be seen as an example of this.
- Transformation pathway. Where there is moderate landscape pressure for change, but the innovations have not yet fully developed so that the regime actors respond by modifying the direction of their activities. An example of this is the development towards ever less emissions from heavy vehicles.
- De-alignment and re-alignment path. Where the regime is faced by external pressure that lead to the regime collapsing before an alternative is ready, this create a situation where multiple niches evolve into competing niches. An example of this is the transition from a horse based city transport system to a system based upon the private car.
- Technological substitution, where there is a combination of external pressure on the regime and the existence of an alternative technology. The large scale implementation of steam technology on goods shipping following the opening of the Suez-canal serves as an example of this.

- Reconfiguration, where symbiotic innovations develop in niches and are adopted by the regime to solve specific problems. This further results in adjustments in the regime and over time results in a new regime. An example here is the transition from steam powered rail transport to high-speed electric power for intercity passenger transport.
- Sequential transition, where different pathways are followed at different points in time.

For this study we have formulated three key questions:

Which of the trends have the possibility to change the transport system radically?

How is the demand for transport in society affected by new technology and the existing trends?

To what extent can new technology and new ways of organizing contribute to radical changes in today's transport system and which impact does this have for the future transport demand?

Landscape level trends

The trends selected in this analysis include:

- *Globalization*, which we primarily see as increased intensity in the interaction between individuals at global level.
- *Growing and aging population*, which is describing how the population is changing over time.
- *Economic growth*, which is a result of an expectation of increased productivity and increasing division of labor.
- *Urbanization*, which is a reflection of the increasing share of the population living in urban areas.
- *Digitalization*, which as a trend is a sum of new technologies available through progress in digital technology and infrastructure.
- *Increased labor mobility*, increase in the number of tasks that can be provided independent of time and place.
- *Improved transport systems*, ever decreasing disutility from transport as a result of incremental increases in infrastructure quality and technology.

These trends both impact the transport systems and society. In this study we focus on the intersection between transport and society, in particular behavioral changes at societal level related to changes in the transport sector.

New technologies that influence society and the transport sector

The number of new technologies and ideas that can have an impact on society and the transport sector is long. In this report we have focused on four groups of innovations. *Electrification, Automatization, Sharing Economy and Cooperative Intelligent Transport Systems.*

- Electrification, is in this context exemplified by the transition from mechanical to electric powertrain for vehicles, independent of energy carrier.
- Automatization, which is exemplified by ever increasing levels of autonomous vehicles

- Sharing economical business models, which is used as a term describing peer-to-peer transactions facilitated by new technology.
- Cooperative Intelligent Transport Systems, which is technology and applications that utilize efficient data exchange between units, actors and infrastructure within the transport system.

In addition to these technologies, we have included a selection of specific innovation that can be specially relevant for the transport sector. These include *Mobility-as-a-Service*, *Hyperloop*, *E-commerce*, *Drones* and changes in airplane technology.

Trends and technology are working together

A complicating factor in studying and analyzing the different transition pathways is that the trends and technologies are correlated. Each trend, or technology, when analyzed on its own have a very limited impact on the sociotechnical regime. However, as these trends and technologies are evolving in parallel they form more complex causal relations and can together result in a radically different regime.

This report conclude that neither of the trends, technologies or new business models, discussed will affect the transport system significantly by its own and in the short term. The expectation is rather that these trends and technologies together will have a great impact, resulting in complex chains of events and societal changes in the medium to long term. In particular we find that the combination of increased environmental awareness and digitalization has the potential to change the regime.

Looking at technology we conclude that innovations treated under the umbrella automation, can together with e-commerce have the potential to change society radically. In this we perceive a development along these lines. First, the trends undermine the existing regime, where the main actors no-longer think that business as usual is a viable policy option. Second, there is a period when it is unclear which technology is the most promising and viable, many technologies will exist in parallel. Third, there is a period where one, or a few, of the alternative technologies become dominant, and a new regime based upon this technology is established. This is a development along the “de-alignment and re alignment path”. In this transformation proseecco the expectation is that the number of new alternative technologies increase as part of the transition process. This number will later be reduced as one or a few new technologies become dominant. This is contrasting the common expectation of an ever increasing diversity in transport modes.

Freight transport is also affected by trends at landscape level and niche innovations, however from the data available to this study, it seems that freight transport is less likely to experience the same regime-level transformations as passenger transport. Both the trends and innovations point towards a change in demand, probably in the direction of more differentiated services. This means shorter distribution of processed goods, packaged in smaller units. Similarly, but to a smaller extent the underlying heavy and long transport of un-processed raw materials will become less centralized as production become less centralized. Iron will still be mined at the same location, but it will be processed at more locations. Pointing towards increased demand for shipping, but utilizing smaller ships.

Which of the trends have the possibility to change the transport system radically?

This study point to digitalization and increased environmental awareness as the two landscape level trends that have the potential to change society and the transport system radically. Other trends are expected to contribute to changes in transport volumes, and may as such result in a greater volumetric impact, but within today's sociotechnical framework. Digitalization and increased environmental awareness on the other hand opens up the regime for new actors and new solutions, which again can result in a different sociotechnical regime.

How is the demand for transport in society affected by new technology and the existing trends?

We expect that the demand for transport will continue to increase. This is both as a consequence of new technology, which we expect will reduce the experienced disutility related to transport and as a consequence of landscape level trends that point towards increased demand. Expected environmental impact from each unit of transport is expected to be reduced while the negative externalities, in the form of congestion and reduced mobility is expected to increase, particular in the urban areas. At the same time the amount of transport is expected to increase, if this is not mitigated with restrictive policy.

To what extent can new technology and new ways of organizing contribute to radical changes in today's transport system and which impact does this have for the future transport demand?

Each of the technologies or business models described in this report is not expected to have a radical influence on the transport system on its own, with the possible exception of the technologies grouped under the label automation. The expectation is rather that the technologies and trends mentioned in the report will act together and that this in sum will result in radical changes and changes where the causal relations will be complex to follow. We identify the combination of the trends digitalization and increased environmental awareness, as trends which are likely to result in a transition that can result in a "de-alignment and re-alignment" transition pathway, with a new and different regime as an outcome.

In parallel with this analyses on aggregate level, the transport system can be subdivided into regimes focusing on each transport mode. Using this approach as a point of departure and retaining the MLP-framework this results in a picture where there is a series of regimes being affected by the landscape level trends, in particular digitalization and increased environmental awareness. Both of these trends result in an increased risk for 'chocks' such as political decisions and new technological possibilities. Using this approach each regime will face the possibility for a transition following either a transformation pathway, technological substitution pathway or a reconfiguration pathway, depending on the type chock, the available technology and how the regime actors respond to the changes. In the Norwegian context this development can be exemplified by the technological substitution from internal combustion engines with high levels of local emissions to much cleaner

engine technology and electric drivetrains. This transition has been made possible by a combination of landscape level trends, in particular increased awareness of the negative externalities of using old internal combustion engines on heavy vehicles in city traffic, combined with incremental technological innovations. The transition has followed a pathway combining the properties of regular change and reconfiguration in terms of technological innovation and transformation in terms of shocks, in the form of political decisions on compulsory environmental standards.

It is very difficult to predict the probability or time horizon for when and how different transition pathways may accrue. This is highly dependent on the interplay between the landscape level trends, the regime actors and the innovations.