



How will digitalization change freight transport?

Future scenarios for the digitized freight transport landscape in Sweden

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About the project

This report presents the research methodology, the developed scenarios and an analysis of the transport system impacts in the respective scenarios.

The study was made possible thanks to contributions from more than 50 experts from actors in the freight transport landscape who participated in a workshop series.

A group of researchers and experts from Integrated Transport Research Lab – KTH, Scania, Closer and Kairos Future analyzed the data from the workshops and have compiled the results.

The study was performed during the winter of 2018/2019 in Stockholm, Sweden and was funded by Drive Sweden.



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Acknowledgement

56 experts from 33 organizations took part in the development of the scenarios





WHAT ARE THE IMPACTS OF DIGITALIZATION ON THE FREIGHT TRANSPORT LANDSCAPE?

Digitalization, including e.g. connectivity, automation and artificial Intelligence could play a major role in new, effective and sustainable transport system. At the same time there are significant risks for rebound effects such increased congestion and higher energy consumption. Digitalization will change freight transport, the question is: how?

In this report, we target this question by identifying the uncertainties and trend that the new technologies based on digitalization are associated with and how the freight transport landscape may look like depending on how trends and uncertainties unfold.



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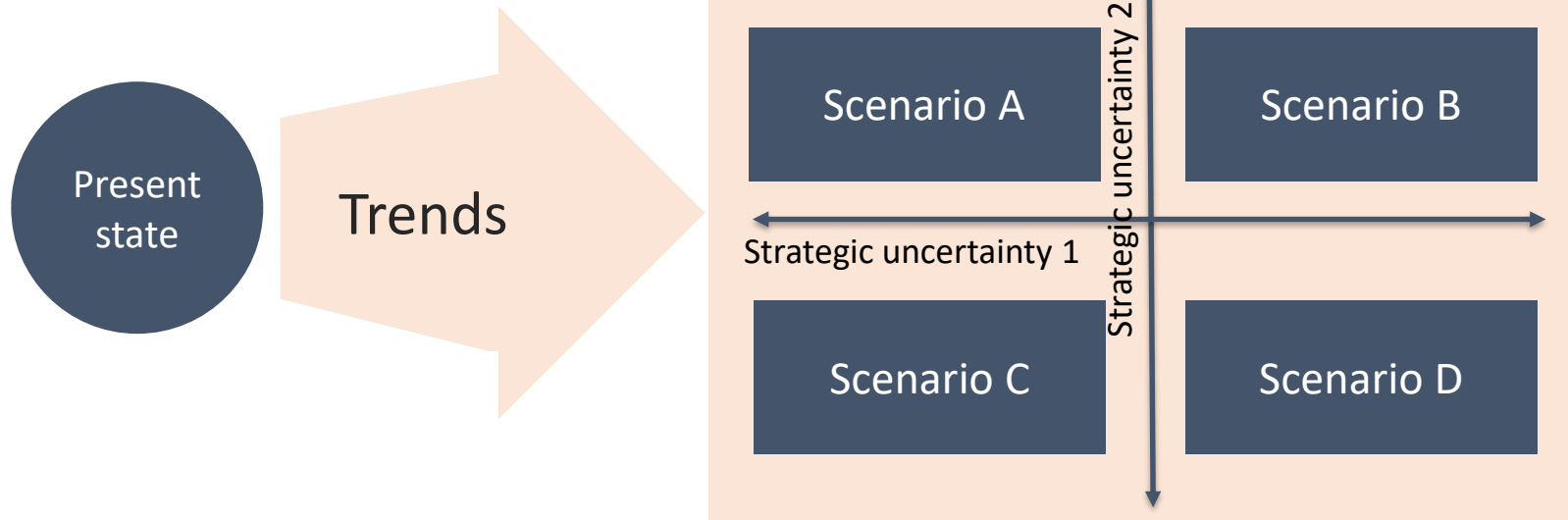
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An explorative scenario approach

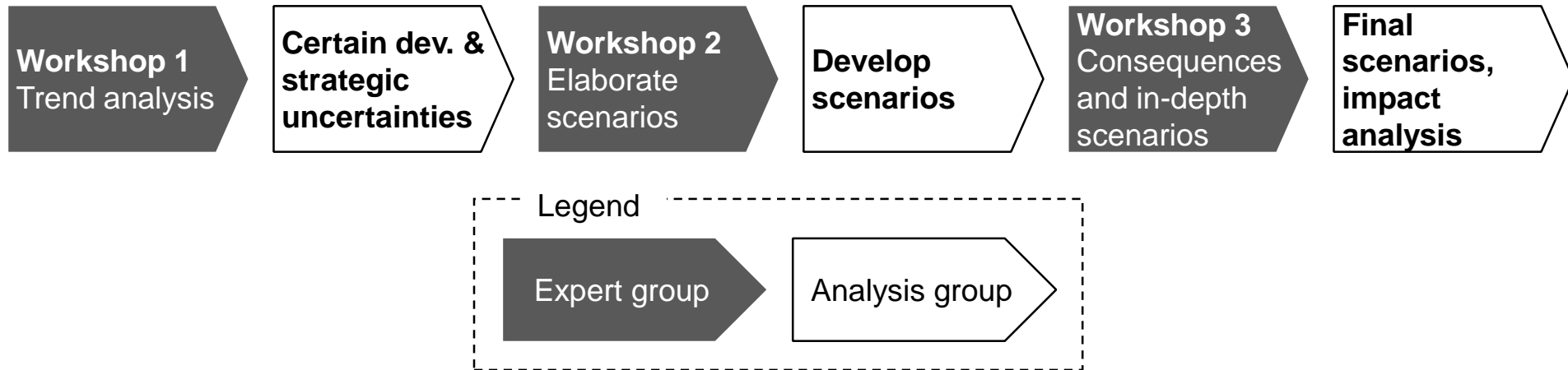
To handle that future is inherently uncertain we use an **explorative scenario** approach. Explorative scenarios aim at answering the question: **what could happen?** The scenarios presented in the report are plausible futures, but not the most likely or most wanted futures. The method we use is called **Intuitive Logics**.

In the Intuitive Logics method, trends are identified and sorted in "certain" and "uncertain". The certain trends constitute **the certain development**, i.e. a future that is likely to come true. For the uncertain trends, it is uncertain how they will unfold. Two of them are selected as the **strategic uncertainties** that are used as the axes in the scenario cross. This gives four different scenarios, each with the certain development present as a background.



The scenario development process

The cornerstones in the process to develop the scenarios presented in this report are three workshops with domain experts. The expert group consisted of more than 50 persons from 24 different organizations representing industry, academia, and public sector. Between the workshops an analysis group consisting of the authors of this report and two future strategists analysed and synthesised the material.



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The certain development

The "certain" development categorized in external trends (blue) and trends within the freight landscape (green).

Urban planning

- Urbanization AND regionalization
- Space is a challenge
- Focus on effective use of infrastructure
- Geofencing

Data & technology

- Owning data is important
- Internet of Things
- Cybersecurity important
- AI
- More and more automation functions in vehicles
- Driverless in dedicated places
- New vehicles are connected

Freight Transport

Urban planning

- Data based Optimization of critical features, e.g. charging infrastructure, deliveries in cities.
- Data based control of traffic on urban rows.
- Regulation of access to urban spaces (time slots)

Policy & politics

- Stricter requirement on local environment
- Sustainability requirements on transport ("miljözoner")
- Return/waste flows included in distribution services

Business models & organization

- Logistics is a question in the board room.
- New business models
- Changed roles
- Driverless vehicles the need for recruitment of drivers.
- New competences needed for drivers.

Consumer & opinion

- Demand for transports tailored after need.

Data & Technology

- Goods, palets, storages, vehicles are connected
- Digitalization of logistics data.
- Driverless vehicles in terminals

Policy & politics

- Demographic development
- Polarization city vs rural
- Change in taxation needed when electrification grows.
- Private sector continue to be a significant transport buyer

Consumer & Opinion

- E-commerce increases
- VR and AR approaches reality in quality.
- Awareness of climate impact (but does it change behavior?)
- Increase in sharing economy



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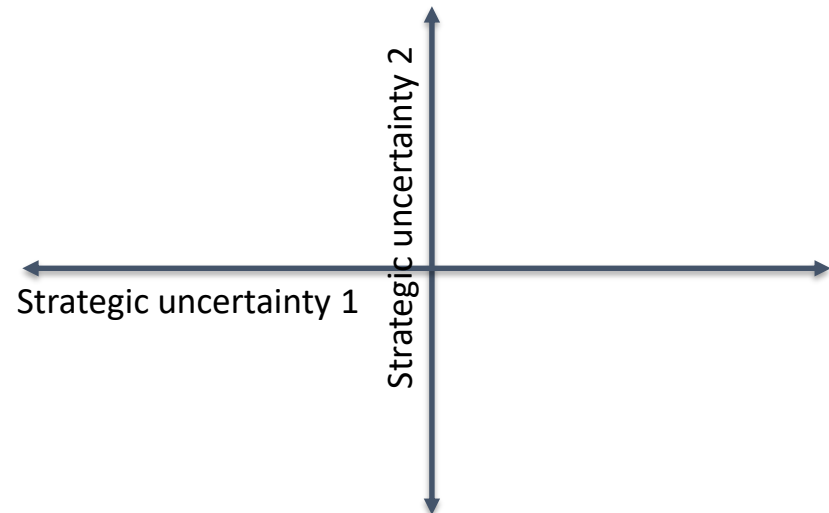


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Strategic uncertainties

Several uncertain trends were identified by the experts, and it was found by the analysis group that they could be clustered around three themes: **impact of climate-related actions**, **data-sharing and business ecosystems**, and the **speed of technological development**. The last of these three was selected to reflect a time perspective, and the two first were selected as the two strategic uncertainties.

In the workshops the two strategic uncertainties were reflected in trends at different levels of abstraction. These trends on different abstraction levels were aligned by the analysis group, and the level of abstraction to be used to create the scenarios was selected. This level was selected to be a balance between society in general and impact on the freight transport sector in particular. On the following pages, the two themes for the strategic uncertainties are shown, and the levels selected to form the scenarios are framed.



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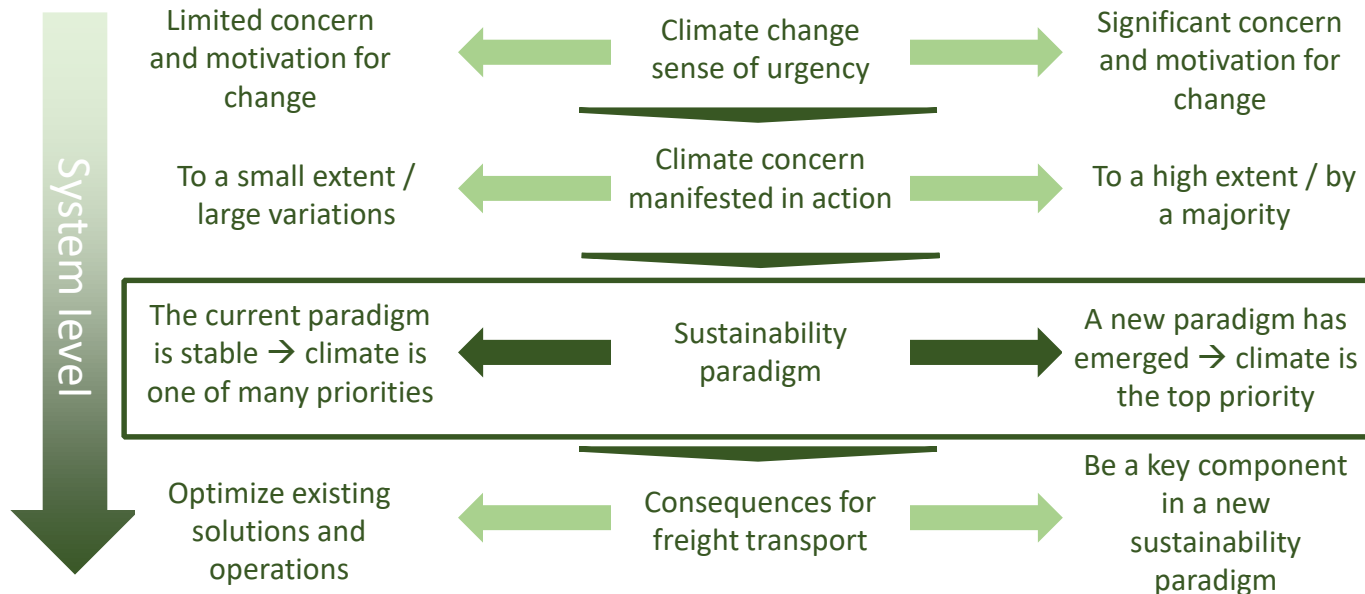
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Strategic uncertainty: sustainability paradigm

One of the strategic uncertainties addresses the **role and importance of climate issues**, and the sustainability paradigm. One outcome of this strategic uncertainty is that the current sustainability paradigm continues. Then sustainability includes many aspects, and climate, economic aspects and other societal issues (education, healthcare, security, etc.) are all more or less equally important and compete for attention and resources. The other outcome is that climate issues have become the top sustainability priority and climate awareness guides individual, business and political decisions.



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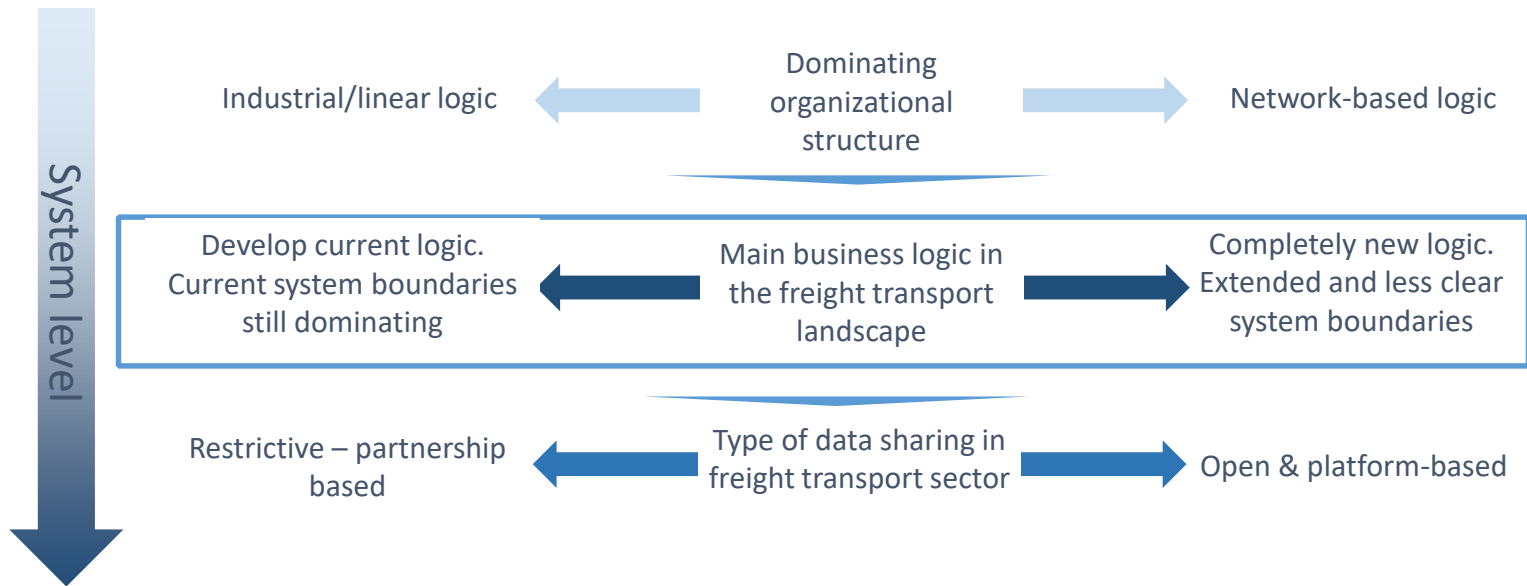
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Strategy uncertainty 2: Business logic

The other strategic uncertainty addresses the **business logic** in the sector. One outcome is that the current business logic continue to be prevailing. Within this business logic the willingness to share data outside the own organization and closest partner network is limited. In the other outcome a new openness to share data has changed the business ecosystem, and enabled a new network based business logic.



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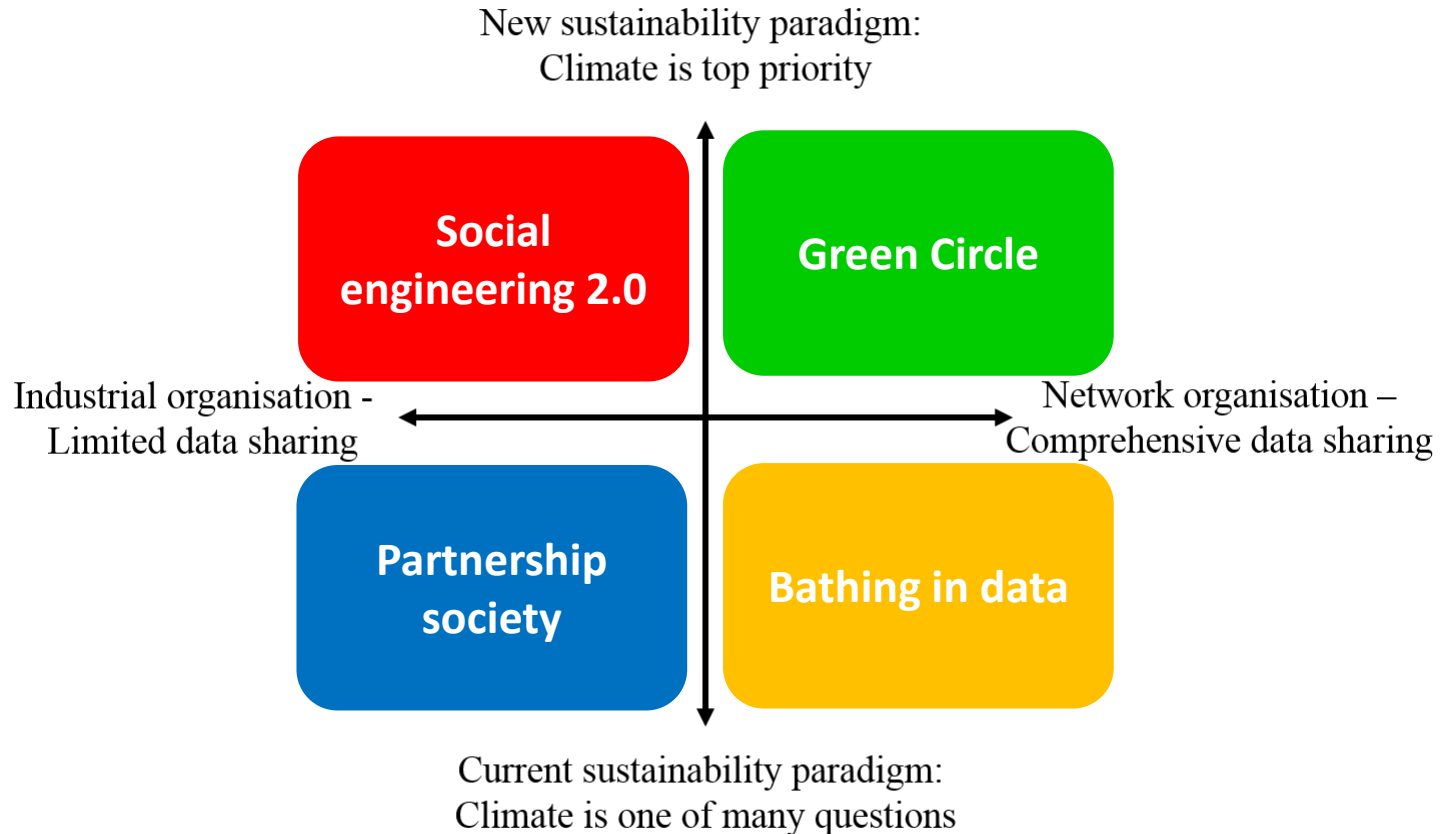
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The four scenarios

Crossing the two strategic uncertainties provides the scenario matrix with four scenarios. On the following pages each of the scenarios is described with illustrations, highlights of the development, and narrative stories from the perspective of 2040.



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Partnership Society

Partnership Society

- Same companies, new businesses based on data and partnerships
- Sustainability is in the backseat. Focus on trade, welfare, and immigration
- Risk awareness and regulations limit data sharing.
- Partnerships enable data sharing and improved solutions.
- Decreased GHG per km, but increased transport demand
- Fragmented political landscape with shortsighted political decisions gives changing prerequisites.



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Partnership Society

Back in the 2010's start-ups in various fields tried to challenge the big companies by providing new services. However, intensive flow of news in media highlighted issues with data security, and that data was abused to track people made people reluctant to data sharing. As a consequence the new services based on data did not take off. The large, already established enterprises that could continue to build on their existing strong customer relations turned out to be the winners. These large companies realized the potential in utilizing customer data. They managed to change their business, and engaged in strategic partnerships and alliances to increase their access to data and create new services. Today, in 2040, all producing companies (e.g. vehicles, furniture, ...) also have significant businesses providing services based on insights from using AI on the data collected by their products. Beside these large companies, there is a number of large platform based companies (including Air bnb and "LogisticsCloud") providing links between suppliers and consumers.

Since several years there are significant and visible signs of a planet in ecological and social stress, but during the economic crisis 2022 the "Paris Agreement" was forgotten and EU decided to prioritize actions to reach a stable economy. The years before 2020 there were signs of

decreasing global trade, but that has shifted and today the global and regional trade is larger than ever. It is obvious that the situation with the climate is untenable, and the number of climate migrants is expected to be all time high in 2035. This has led to new immigration challenges in many countries. To be politically viable, it is important that suggestions are beneficial for the economy, society, and well-fare. Environment alone is not a sufficient argument. The complex political landscape has led to that short sighted decisions made by political parties with the main focus to win next election instead of political agreements with a long term focus. All this has made climate actions very slow, but one example is the shift to electric vehicles powered by solar energy, that turned out to be a very lucrative business.

Everyday life has not changed significantly since the late 2010's, but the new data based services has made life much smoother. People and businesses are highly aware of the risks of sharing data, but most consumers and companies are willing to take the risk to share their data if the service they get in return is sufficiently good. Services include e.g. clothes tailored after the measurements provided by the smart mirror in the bedroom or proactive food deliveries based on the current content in the smart fridge. There is a strong focus on how data

is treated and shared to 3rd parties, and the GDPR legislation has been updated and is now even stricter than its first version that came in 2018.

There is a number of parallel platforms, owned by the main actors in the industry, providing effective logistics and deliveries. It is the largest actors during 2010's that has developed their own systems by adding data and AI. Flows are more effective than ever before, and both fill rate and route planning has reached new levels. To survive in the business, partnerships are fundamental. Both for larger companies, who can exchange data within the collaboration, and for smaller companies that need to be allied with the main actors to get access to the platforms and the services provided on them.

Increased population and increased transport demand has contributed to an economic growth in the transport sector. Data based solutions have made transport efficiency better than ever before, and service levels have increased significantly. GHG emissions per ton-km have decreased, but due to the increase in transported goods volumes GHG and emissions are still on the same level as back in 2019.



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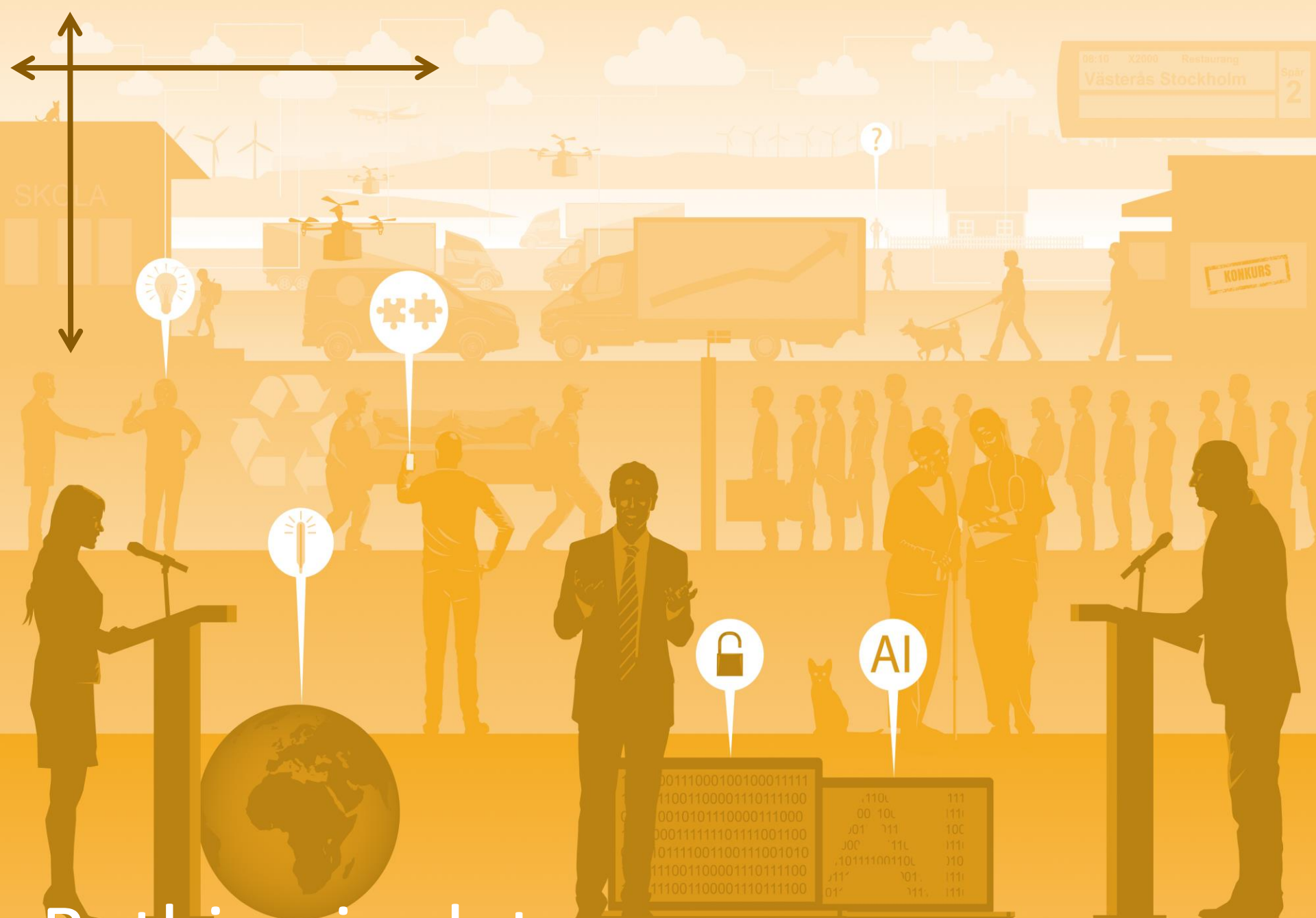


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Bathing in data

Bathing in data



- Data-driven, resource efficient and convenient solution through network organization and comprehensive data sharing paradigm that is enabled by government directive and initiatives
- Environmental sustainability is second to resource efficiency, convenience and social sustainability
- AI-powered solutions are a key to enable new concepts
- IT and social media giants with customer insight provide cloud based logistic building blocks that are used to deliver opportunistic niche services



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Bathing in data

Economic inefficiencies of public organizations triggered an extensive public and political debate in Sweden during the 2020s. Inspired by the good examples of how Dutch and Estonian municipalities reduced their operation costs and created new and improved digital organizations and services, the government declared the concept of “*network as a basis*” for all public organizations and actions in 2026. This declaration empowered the Agency for Digital Government to carry out a reorganization of public authorities, and increased publication of data between the authorities and for commercial actors creating proactive services in education/schools, healthcare, crime prevention. The utility of data sharing has also manifested itself in several transport related services, for example, geofencing has allowed the spread of deliveries and traffic over all hours of the day and AI-powered predictive approaches for infrastructure maintenance have significantly reduced the number of unplanned service outages. Next to economic growth and efficiency, sustainability has also benefited from the network organization and the comprehensive data sharing. Initiatives like “Sharing for Earth”, that was started in 2025, has triggered companies and organizations to share their data to reach environmental and social sustainability goals.

Inspired by the new efficient and convenient solutions and services citizens as well as organizations and municipalities are more open to share their data. To enable novel and genuinely effective and user-friendly solutions by utilizing various kinds of data, several companies in Sweden and globally have joined the “The digital deal” agreement that specifies how data collected from / about people, buildings, vehicles, utilities and organizations should be shared and used. The few companies that did not submit to the data sharing paradigm and did not dare to open their data and a consequence have lost their competitive edge.

The amount of goods transported is at an all-time high. E-commerce has dramatically grown. People expect deliveries to be delivered just-in-time that are fitted to their personal schedules and conveniences. The last-mile delivery challenge has been resolved by a number of innovations such as autonomous electric distributions vehicles, delivery robots, integrated pick-up-delivery boxes powered by digital locks, and modular multi-purpose vehicles that can pick up recycling after package deliveries. In addition to enabling efficient consolidation of local distribution, data sharing and digitalization became the key to a number of AI-powered predictive solutions that combine user and consumer insight with information about transport flows and vehicle demand. For

example, through predictive shipping and autonomous electric vehicles the concept of rolling warehouse becomes reality.

There are groups of citizens that are fed up with fast paced and largely convenience- and efficiency-driven society. Despite data sharing and sustainability initiatives, we did not manage to keep the climate temperature increases below the 2 Celsius goal. This has led to a global political dissatisfaction in the geopolitical landscape that has drastically changed due to elimination of fossil-fuel based economy.

In addition to the established transport actors that capitalized on the opportunities that are provided by the network organization and comprehensive data sharing paradigm, digitalization also created new market entrants and partnerships. IT and social network giants not only became important via the customer insights that they deliver, but have created pay-as-you-go building blocks of cloud-based logistics that service providers can build on. New global transport actors appear that without having their own vehicle fleet, drivers, warehouses or terminals can create niche services with little investments. The opportunistic creation of such niche services are enabled by digital micro contracts that enable the simple and secure procurement of small and special transport assignments.



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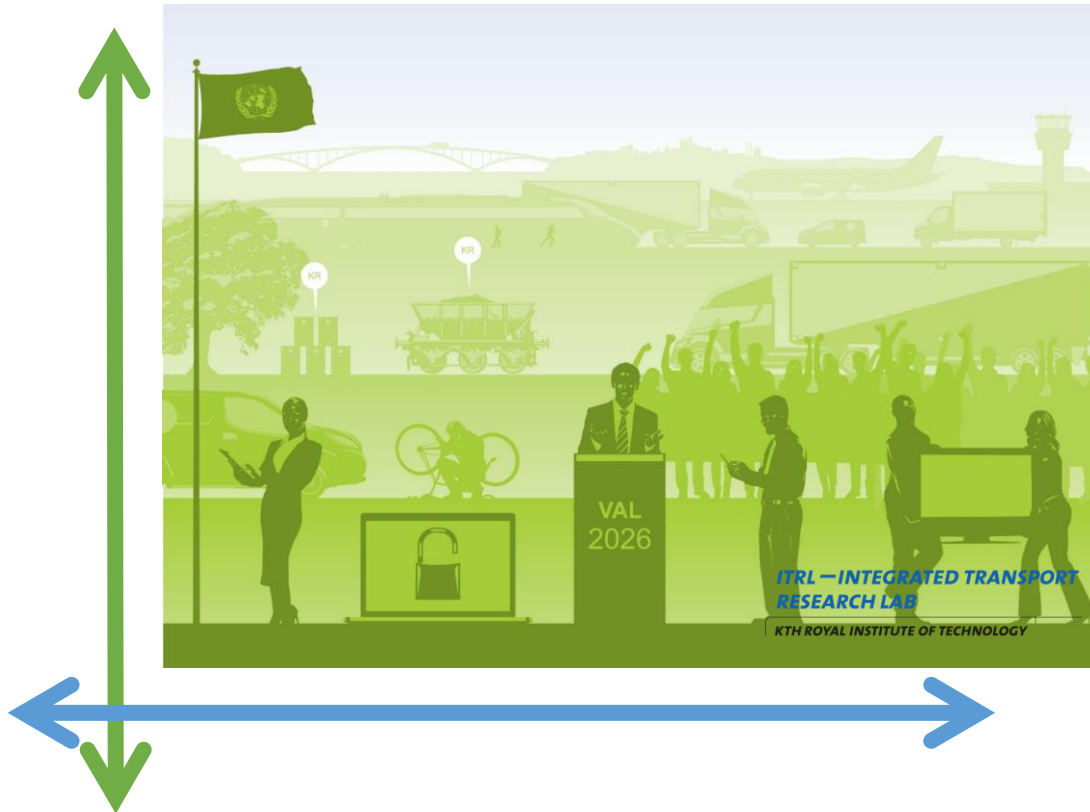


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Green circle

Green circle



- Signs of climate changes has empowered government to take decisions to reach UN sustainability goals
- Economy is relying on circular principles
- A large increase in peer-to-peer transportation, in areas where people live.
- Shift in focus from welfare and equal rights to environment has led turbulence in the political landscape
- Governmentally supported platform for data sharing, and legal requirements on transparency on environmental impact.
- Many small, specialized actors has changed transportation landscape



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Green Circle

Stopping the climate changes is not only one of many goals, it is the highest goal. Back in the early 2020s powerful computer-based simulations and visualizations was able to clearly deliver the message about consequences of the climate changes. The sense of urgency empowered government, companies and people in general to take tough decisions to fulfill UNs global goals to stop climate change. Just as EU went from a place where smoking indoors was taken for granted to something that is almost unthinkable during the 10s, cities and streets without vehicles has been something people has become accustomed and appreciative of. It is easy to buy sustainable through taxes, subsidies and a governmentally supported labelling of sustainable products. The economic structure is now based on circular principles, and a radical reduction of material-based consumption has change the way we produce, consume and value our possessions. Selling something that you no longer use, mending something that is no longer working or recycle things

you don't need any more is easy while throwing things away is expensive.

The circular economy has led to that the main form of transportation today is a peer-to-peer where local re-use and re-selling are producing big flows of goods where people live. Previous long distance goods transports that was almost invisible to consumers has shifted to short distance logistics occurring in everyone's backyard. These more visible transports has made many citizens upset, and has forced the haulage and logistics companies to come up with smarter and better ways of doing things. Data sharing has been the key success factor to enable effective transports and use of the shared public space in the cities. This was recognized by the government, who already in the early 2020s not only provided a platform for data sharing, but also implemented laws that forced the actors to share their data on the platform to be transparent on their environmental impact. The openness in data has provided opportunities to create new services and also provided tools for

anyone to verify that the services are sustainable.

Compared to early 2020s there has been a big change in focus in politics, with less attention to employment, equal rights, and welfare on behalf of the environment. This change has not gone by without protest and it has been a turbulent time were some citizens feel that they have sacrificed more than others and big protests has been a part of the political landscape.

A big flora of actors is present, and the scene is dramatically different from how it looked in the beginning of the 2020s. New actors as well as actors from other business are entering the logistic sector where established actors are struggling to make money in the new data intense era. Flexible and innovative small actors has changed how transportation is performed in both urban and rural areas.



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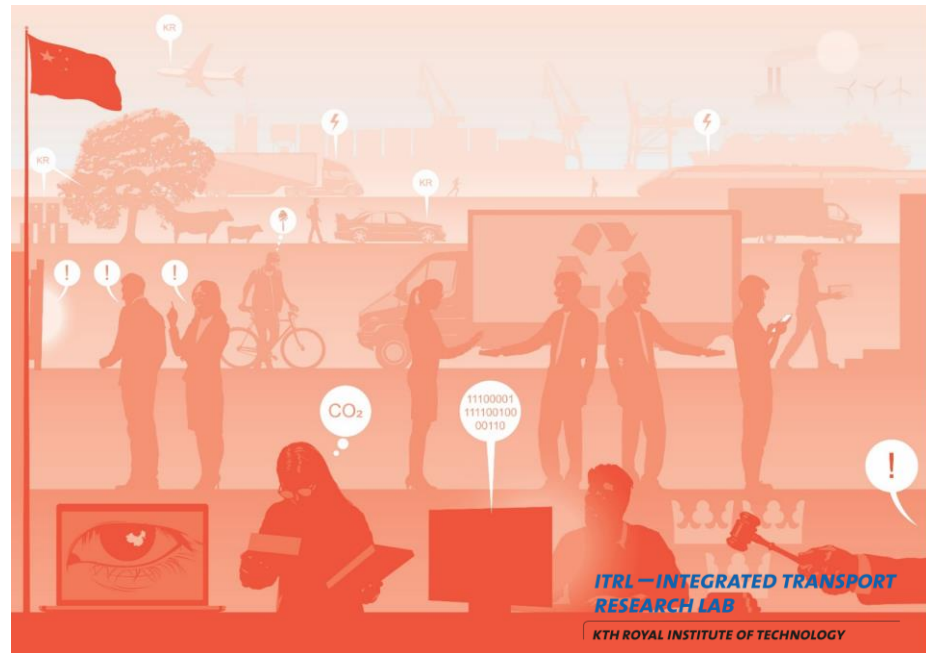


Social engineering 2.0

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Social Engineering 2.0

- A policy driven society fighting to avoid devastating climate change. Climate impact is part of companies accounts.
- Bio-materials and circular solutions instead of lifestyle changes
- Massive amounts of data available, but restrictive sharing
- An electrified and flexible vehicle fleet
- Data is shared within alliances of large actors



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Social Engineering 2.0

The negative impacts of climate change during the 2020s created support for transformative policies. Since then taxes on petrol and diesel has been multiplied. This made fossil fuel vehicles very expensive. Now, in 2040, there are also taxes on extraction of non-degradable raw materials. Furthermore, a national digital nudging-system has been introduced to incentivize a more sustainable consumption. EU-level regulations forcing all manufacturing companies to track and recycle all materials used has been implemented.

Consumers perceived the development with mixed feelings. There was a strong awareness about the impacts of climate change but the willingness to decrease consumption was limited. This led to that the producing companies addressed the climate issue by shifting bio-material based production, and national and global demand for Swedish bio-based materials have skyrocketed. Also, the reuse of products and material recycling have grown drastically since 2020s. Subscription and deposit models have made it easier to comply consumption with the recycling regulations that are present.

Developments within AI and IoT have materialized by an abundance of sensors and

data, and provided new decision support systems. Most people are aware of the business value in personal data. However, previous scandals in which personal data was shared with third parties for commercial and political purposes has created a skepticism to data sharing. For public bodies it has been necessary to introduce data sharing regulations forcing companies to report emission data.

In 2025 the parliament settled on a long-term transport agreement to promote climate aware transport. Legislation on minimum fill rates was one of the interventions. It was first received with criticism but over time it has improved collaboration and efficiency by the use of connected goods. Another important policy was the decision to invest in electric roads for important freight corridors and the European highways. The surging demand for biomaterial has increased the amount of road freight transport of timber and wood products.

The increase of recycling and reuse of products has generated a new type of local transport flows. In the cities, a steady stream of used products are transported to new users, second-hand retail or recycling facilities. However, material recycling typically require

large-scale plants for economic reasons and therefore there are increased outflows from cities. The growing urban freight traffic, the skepticism towards data sharing and fill rate regulations make delivery times for e-commerce packages around the same as in 2019. To counter the increased urban traffic, logistics is centered in “community hubs” serving as both package pick-up- and drop-off points for waste and products for recycling.

The bonus-malus policy incentivizing electric vehicles together with the governmental investments in electric infrastructure has catalyzed the shift to an electrified vehicle fleet. The new urban freight flows has led to a more diverse and flexible freight vehicle fleet. Automated vehicles are frequently used in the industrial flows of bio-material to keep transport costs low.

The strong data integrity focus has led to silo-structures, where large actors from different sectors has created alliances. Data is shared only within these alliances. Transport actors are attractive partners due to their abilities to gather data about goods and freight movements and conditions along the roads and within cities.



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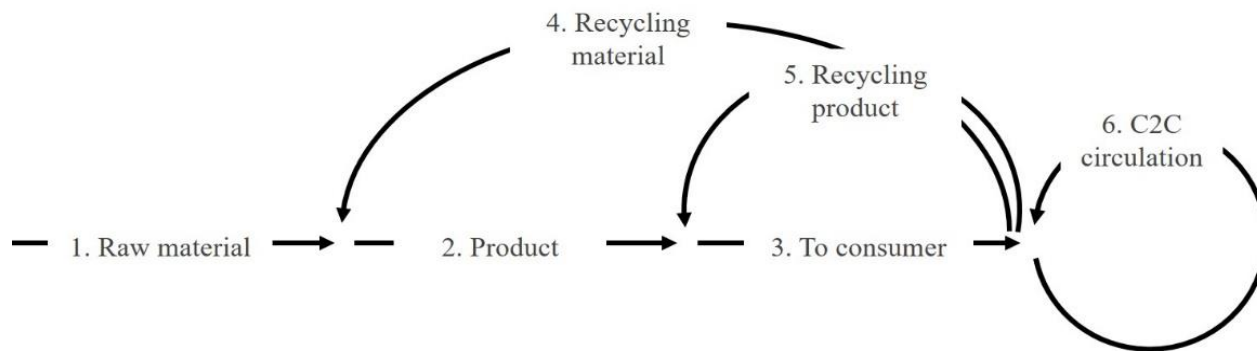


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A schematic transport chain for analysis of transport in the scenarios

For the analysis of the scenarios a schematic transport chain is used. The schematic transport chain consists of the following six legs:

1. *Raw material* transport from extraction site(s) to product manufacturing site(s).
2. *Product* transport from manufacturing sites to retail (e.g. physical stores or fulfilment centers for e-commerce).
3. Transport *to end consumer* from retail. This may be performed by the end-consumer, e.g. by driving a private car to and from a shopping mall, or by a e-commerce distributor through home delivery or delivery to a pick-up point.
4. *Material recycling* flow, where products are transported from the consumer (or recycling centres) to material recycling plants.
5. *Product recycling* transport where products are transported from the consumer for product refurbishment or to second-hand retailing sites.
6. *Consumer to consumer (C2C) circulation* of products directly between consumers who sell and buy used transport directly between each other or between consumers participating in sharing services.



The effects of different parts of the transport chain in the four scenarios

The change in transport in vehicle-kilometers is marked with + and – signs, spanning from major demand increase (+++) to demand decrease (--)

Part of the flow	Social Engineering 2.0	Green Cycle	Partnership Society	Bathing in Data
1 Raw material	<p>+</p> <p>Increase in forest and other bio-based material for manufacturing</p> <p>Increasing export flows of bio-materials</p> <p>Shift to rail and sea offset CO2 emission increase from volume growth</p>	<p>--</p> <p>Increased re-use and recycling leads to decreases in raw material transportation.</p>	<p>++</p> <p>Population growth and increased consumption increases demand</p> <p>Intermodal transport pushed by government</p> <p>Automation and driverless vehicles in industrial flows.</p>	<p>++</p> <p>Transport demand increases, but data enables improved efficiency and fill rates</p> <p>Intermodality is improved due to data sharing</p>
2 Product	<p>++</p> <p>Fewer products produced from new raw-materials</p> <p>More products made of recycled material are transported.</p>	<p>+</p> <p>Fewer products produced from new raw-materials</p> <p>Products made are made out of recycled material.</p> <p>Data sharing enables high filling rates and effective transport.</p>	<p>++</p> <p>Population growth and increased consumption increases demand</p> <p>Limited data sharing limits efficiency improvements</p>	<p>++</p> <p>Increased demand due to e-commerce and population growth.</p> <p>Data sharing enables effective transport.</p>

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Part of the flow	Social Engineering 2.0	Green Cycle	Partnership Society	Bathing in Data
3 To consumer	++ Increase in consumption enabled by sustainable production and recycled materials	+ Increased distribution of recycled products Improved efficiency and filling rates due to data sharing	+++ Population growth and increased consumption increases demand. Limited data sharing limits efficiency improvements	+++ Increased demand due to increased e-commerce and increased sharing economy Short delivery times and tailored deliveries increases transport demand
4 Recycled Material	+++ High taxes on raw material generate material recycling	++ Green policies foster increased recycling of material.	+ A limited increase, primarily driven by scarcity of raw materials.	+ A limited increase, primarily driven by scarcity of raw materials.
5 Recycled Products	+ Limited product recycling	+++ Increased sharing and product recycling driven by sustainability policies and enabled by data sharing.	+ A limited increase, primarily driven by larger companies offering recycling of their own products.	+++ Many new services based on circular principles provided by companies. Short delivery times and tailored deliveries increases transport demand
6 Consumer to consumer (C2C)	+ Policies make peer-to-peer sharing services attractive, but growth potential is held back by limited data sharing	+++ New and growing flow between customers when goods are resold and/or reused. New platforms and connections enables new possibilities for sharing, changing and selling.	+ Growth potential is held back by limited data sharing, and by lack of customer demand.	+++ Many new services for peer-to-peer sharing enabled by data sharing Short delivery times and tailored deliveries increases transport demand
Typical delivery times (to consumer)	Several days	Hours - Days	Hours - Days	Minutes - hours



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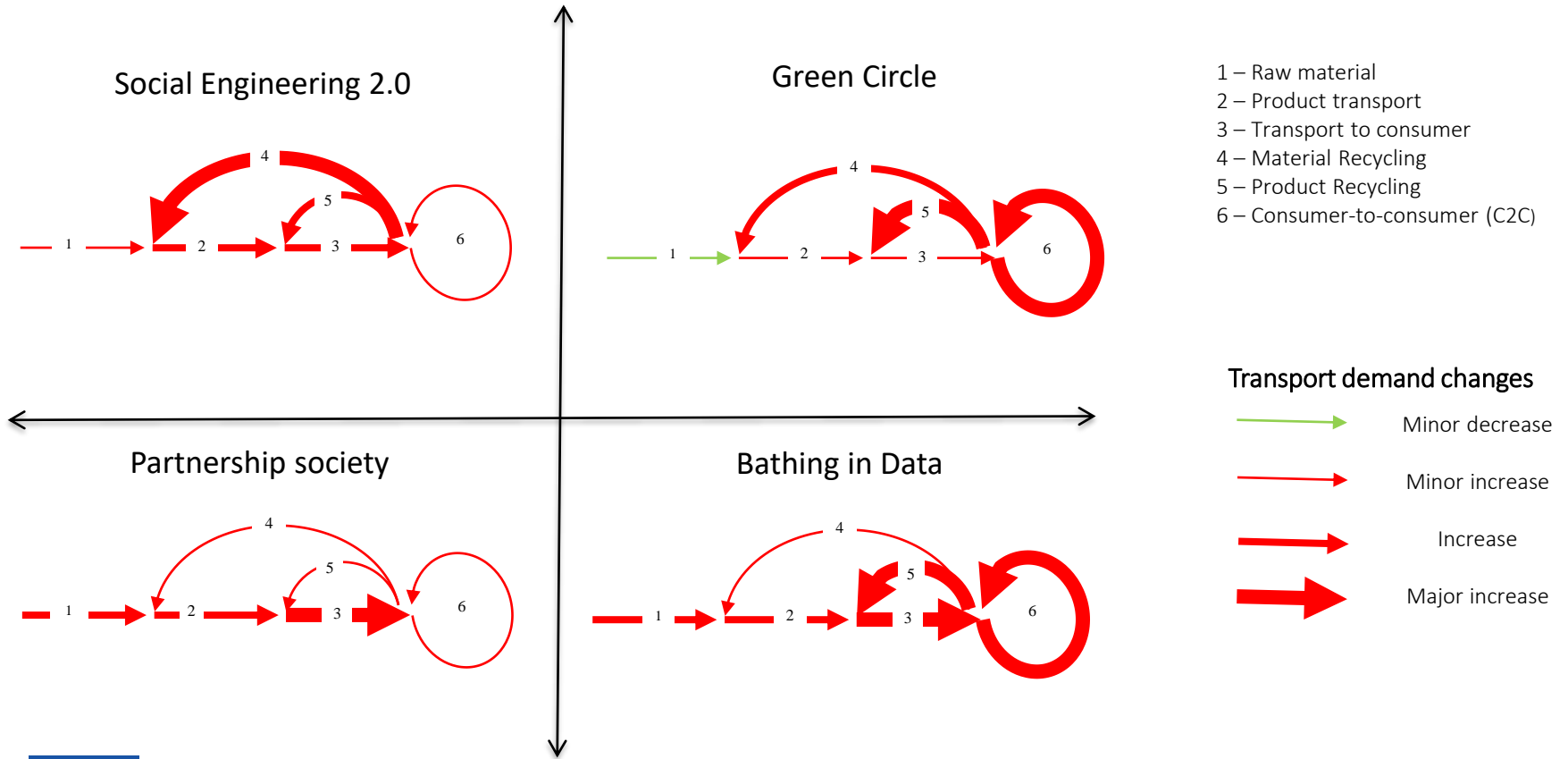
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Predicted changes in transport flows in the scenarios

The figure below shows the expected changes in transport demand, compared to 2019, for the different scenarios. The predictions are based on a synthetization of the inputs from the expert group.



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Conclusions

In this report, four explorative scenarios describing how digitalization may affect the good transport landscape has been presented. During the process two main uncertainties have been identified: Whether a new sustainability paradigm will be present or not, and whether traditional (hierarchical) business logic or network based business logic will be present. By crossing these two strategic uncertainties, the four scenarios are formed.

The four scenarios should not be seen as the most probable futures, but plausible future with “extreme” characteristics that provides a platform for discussion and development. The development of the transport sector is predicted to be very different in the different scenarios. Three main take-aways are:

- **New flows** - In three of the four scenarios there will be an increased focus on recycling flows. In two of the scenarios, significant increases of recycle flows and flows from peer to peer are predicted. This leads to new challenges in optimization of flows, and that freight transportation are increased in urban areas.
- **Increase of VKT** – In all scenarios an over-all increase in VKT is predicted, also in scenarios where climate has a high priority. Handling of this increase is important to reach climate goals, and focus needs to be on fossil free fuels, efficiency improvements, and policies to target the climate goals.
- **External events and uncertainties** – The scenario development process highlighted that how societal uncertainties that are not directly related to neither freight transport nor digitalization play out are highly important for the digitized freight transport landscape. This is highlighted by the strategic uncertainty related to if the current sustainability paradigm will transform towards a higher climate focus. This issue is expected to have a strong influence on what problems the digitalization of the freight transport sector should solve and what digital solutions are feasible.



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This work provides a first step towards understanding the impacts of digitalization on the goods transport landscape, with focus on road transport and the authors look forward to a continued dialogue.

A video of a presentation of the work is available at
<https://www.facebook.com/KTHTransportLabs/videos/367417920567840/>

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