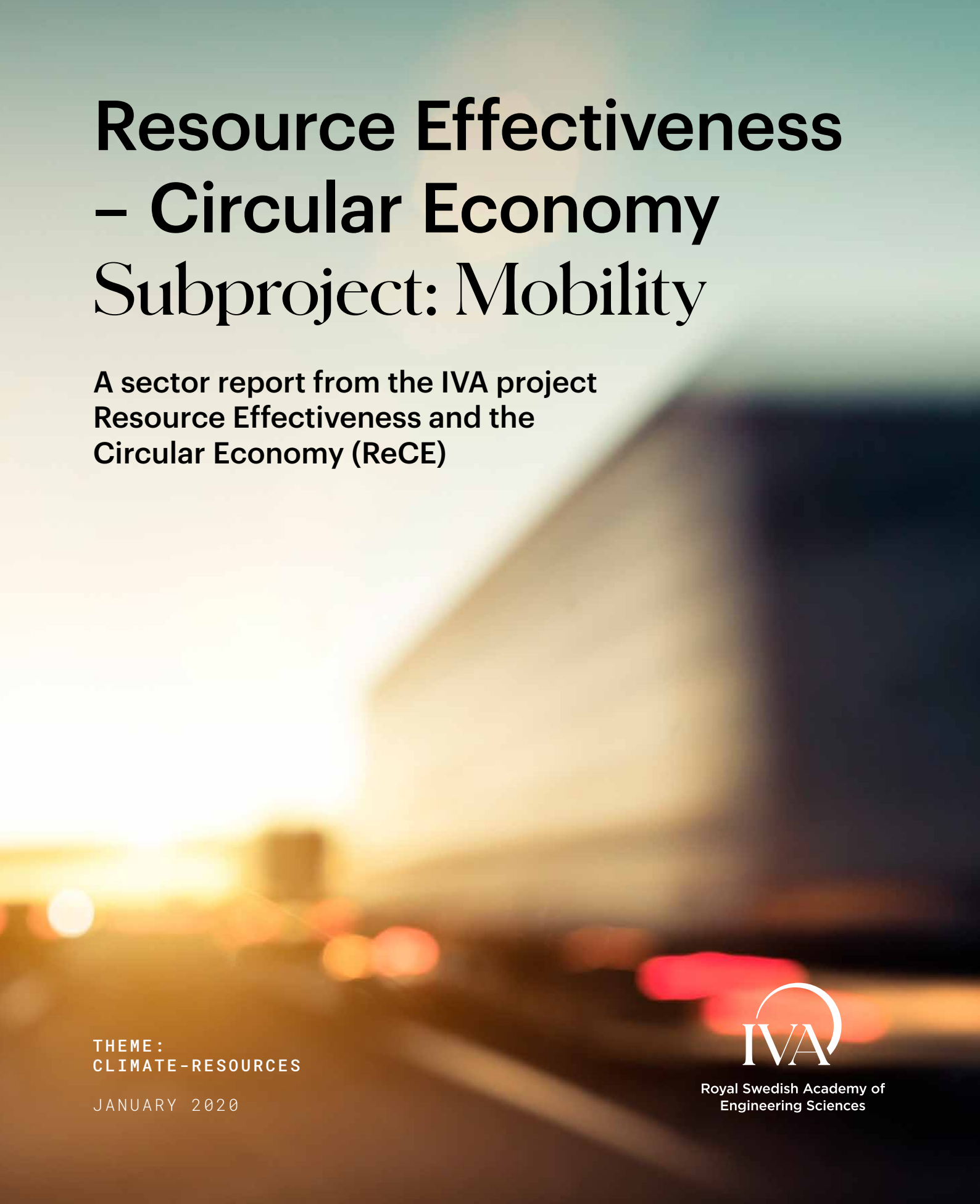


Resource Effectiveness – Circular Economy

Subproject: Mobility

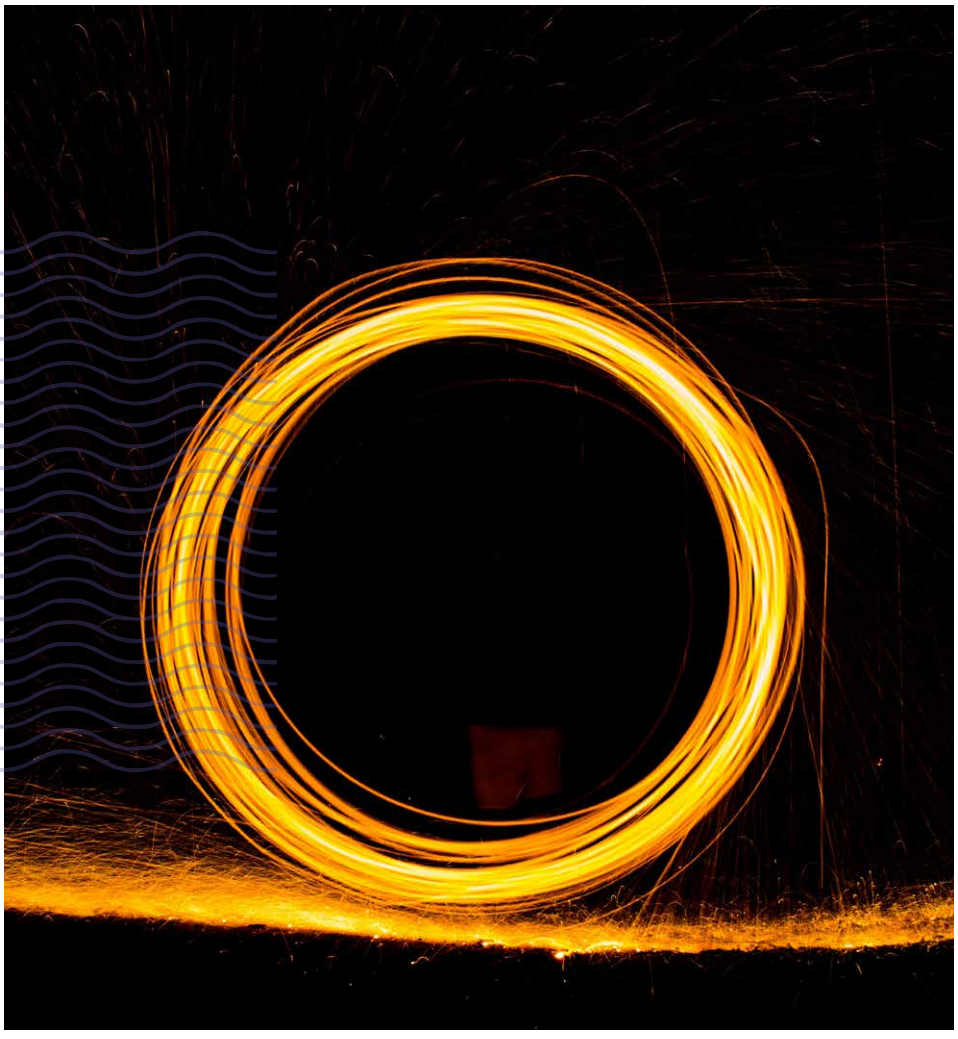
A sector report from the IVA project Resource Effectiveness and the Circular Economy (ReCE)

THEME:
CLIMATE-RESOURCES

JANUARY 2020

IVA
Royal Swedish Academy of Engineering Sciences

Contents



Foreword: Resource Effectiveness and the Circular Economy

»The purpose of the project is to strengthen Sweden's competitiveness in a future with finite resources in line with the UN's Sustainable Development Goals.«

The Royal Swedish Academy of Engineering Sciences' project *Resource Effectiveness and the Circular Economy* has assembled more than 50 companies, organisations and public authorities around the **vision** of Sweden being the leading nation as a resource-effective, circular society. The **purpose** is to strengthen Sweden's competitiveness in a future with finite resources in line with the UN's Sustainable Development Goals.

The project's **goals** are: to create a platform for resource effectiveness and circularity; to draw conclusions on Sweden's resource options in public policy, research and industry based on initiatives that are under way, and to create collaboration and forward motion.

Resource Effectiveness and the Circular Economy builds on the IVA project *Resource Efficient Business Models – Greater Competitiveness* from 2014–2016. That project presented the significant potential that exists to make society considerably more resource efficient and to generate new commercial opportunities and business models. It defined five material flows (biomass from wood, steel, concrete, food and textiles) to show where flows are "leaking" and thus where commercial opportunities exist through more effective resource management.

This project continues the work of the previous one, using the same sector breakdown and exploring the commercial opportunities that were identified. It is divided into five subprojects: mobility, facilities, food, textiles and plastics. This report will present analysis and observations from the Mobility subproject. The most important conclusions from all of the subprojects will be compiled and presented as the project's recommendations for a broader societal transformation in a joint synthesis report.

The five subprojects have gathered representatives from the entire value chain to participate in individual work groups. They come from the private and public sectors and from the research community. IVA's work is based on a scientific approach and draws from relevant research, but also involves critical analysis of other issues of relevance. Source references are included where appropriate. The project's results come out of an intense programme of workshops and work group meetings involving a large number of people.

The reason for this initiative from IVA is that resource effectiveness and circularity are both crucial for a future with greater global prosperity. One particularly important aspect is ensuring that we successfully improve efficiency in material management and advance material development. To support this, we also need to design new business models and identify commercial opportunities that will stay relevant many years into the future, meet the UN's Sustainable Development Goals and allow us to remain within the planetary boundaries.

We need sustainable systems that can deliver resources to meet the real needs of society. To achieve this we need a long-term system perspective and an overall understanding of, and system of managing, society's resource flows. We need to take a holistic approach in which all aspects in the production chain are included – from material extraction and raw materials, the design phase, manufacturing, business models and financing, through the user phase to the recycler and back to a new producer. This requires cooperation between all actors, as well as clear rules to create the right incentives and market conditions. We also need to accelerate, and better understand the benefits of, digitalisation, innovation and new business models that focus on resource effectiveness.

A lot is already happening – both internationally and around Sweden – with numerous initiatives and projects examining how resource effectiveness and circularity can be introduced in various sectors. But there is no unifying arena to show the need for a systemic change and where differ-

ent perspectives can come together. IVA believes that a platform for cooperation between the private sector, the research community, the political sphere and the public sector is essential in order to achieve a resource-effective and circular society. Actors within such a platform are also the project's overall **target group**.

Resource Effectiveness and the Circular Economy was launched at the beginning of 2018 and will continue until mid-2020.

The project's definition of resource effectiveness and the circular economy

Resource effectiveness[1] and circular economy[2] are two distinct concepts under the same umbrella. A measure that supports the circular economy often also supports resource effectiveness. In this project we regard resource use within the planetary boundaries as the overarching goal. In order to manage any conflicting objectives in future development it is important for there to be clarity and an understanding of systems.

The primary focus of this report is more effective management of the value of society's and nature's resources beyond, for example, mere volumes or mass. Unless otherwise stated, this also includes the concept of a circular economy. In cases where conflicting objectives between the concepts are identified, they are described.

Geissdoerfer et al, for example, define circular economy below mainly in terms of the circulation of materials:

> *A regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling.*[3]

The project's premise is that resource effectiveness takes priority over the circulation of materials. We believe that it is important to include the user phase in the definition – not just the production phase; to include business models and services – not just physical products:

> *A performance economy goes a step further by selling goods (or molecules) as services through rent, lease and share business models. ... In addition to design and reuse, the performance economy focuses on solutions instead of products, and makes its profits from sufficiency, such as waste prevention.*[4]

The project believes that this perspective is missing in some circular economy definitions, even if it is sometimes considered an implicit aspect. One example is the average car which is parked 95 percent of the time. We do not improve the efficient use of resources by merely recirculating the materials the car is made from – no matter how good we get at it. The effective use of resources ("resource effectiveness" = using resources as efficiently as possible while also avoiding negative environmental impact) must be improved.

1 *Europa 2020 – A strategy for smart, sustainable and inclusive growth COM (2010)*, and *A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy COM (2011)*. There is unfortunately no actual definition of resource effectiveness.

2 Kirchherr, J., Reike, D., Hekkert, M., 2017, "Conceptualizing the circular economy: An analysis of 114 de nitions", in *Resources, Conservation and Recycling* 127, pp. 221–232.

3 Geissdoerfer, M., Savaget, P., Bocken, N. and Hultink, E., 2017, "The circular economy – A new sustainability paradigm?" in *Journal of Cleaner Production* 143 (1), p. 759.

4 Stahel, W., "The circular economy", 23 Mars 2016, in Nature 531, pp. 435-438 (https://www.nature.com/news/the-circular-economy-1.19594; accessed 10 December 2019).

As Florian Lüdeke-Freund et al. wrote in their article entitled "A review and typology of circular economy business model patterns":

> *The circular economy may not be a final goal, but rather part of an ongoing process to achieve greater resource efficiency and effectiveness.*[5]

This is a theory the project is happy to endorse.

For the project:

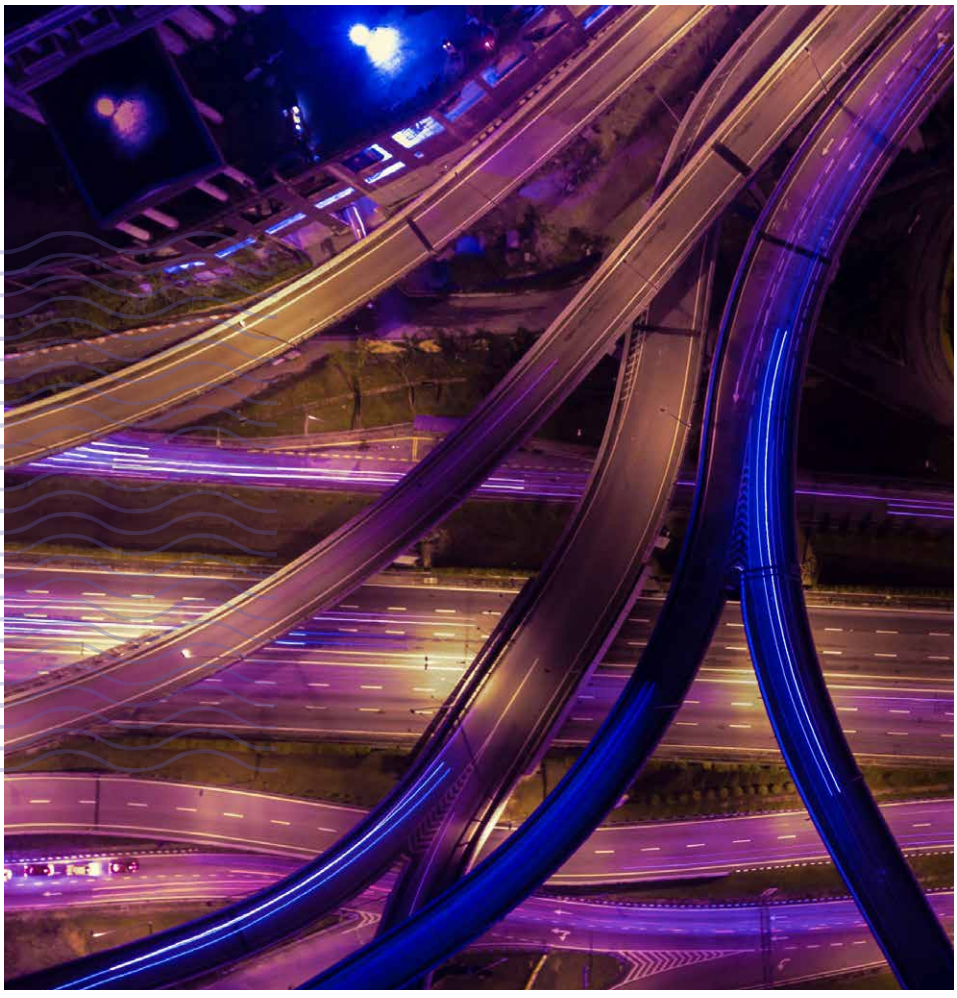
Åke Svensson, Chair
Caroline Ankarcrona, Project Manager
Jan Nordling, Project Manager

The mobility work group

Chair: **Jan-Eric Sundgren**, Association of Swedish Engineering Industries
Project Manager: **Jacqueline Oker-Blom**, AboutFuture
Vice Chair: **Elinor Kruse**, Association of Swedish Engineering Industries, Head of Environment

Kristian Bjursell, Handelsbanken, Senior Sustainability Manager
Ulrika Bokeberg, Region Västra Götaland, Head of Department of Public Transportation and Infrastructure
Henrik Gustafsson, Scania, Manager Global Public Affairs
Tord Hermansson, Lindholmen Science Park, CEO
Pär Hermerén, Association of Swedish Engineering Industries
Olle Isaksson, Ericsson, Director Global Partnering & Ecosystems
Anna Kramers, Royal Institute of Technology (KTH), MISTRA SAMS (Sustainable Accessibility and Mobility Services), Programme Director
Helena Leufstadius, Swedish Public Transport Association, CEO
Lina Moritz, CLOSER, Programme Director
Annelie Nylander, Swedish Transport Administration, Strategist, Strategic Development
Harry Robertsson, Stena Line, Technical Director
Helena Wiberg, Landvetter Airport, Head of Business Development
Lars Zetterberg, IVL Swedish Environmental Research Institute, Mistra "Carbon Exit" Programme Director

5 Lüdeke Freund, F., Gold, S. and Bocken, N., 2018, "A Review and Typology of Circular Economy Business Model Patterns", in *Journal of Industrial Ecology*, Volume 23, Issue1, February 2019, pp. 36-61.



The subproject's summarised conclusions

»Sweden needs to avoid unnecessary transportation, coordinate existing transportation and increase space utilisation and utilisation rates to achieve a resource-effective society.«

During the course of the project the Mobility work group arrived at the conclusions summarised here.

Design, development and planning for resource-effective transport solutions

1. In recent years there has been rapid development of new mobility services and actors. At the same time, no business models, roles and regulations have been developed that can allow us to fully benefit from technology development and new innovative service providers, and from digitalisation and data sharing that can facilitate resource-effective transport solutions. Three types of infrastructure – physical transport infrastructure, energy infrastructure and digital infrastructure – need to work together. Sweden should therefore develop a national strategy for digitalisation and data sharing to promote the development of resource-effective transport solutions.

    a. Ensure that reference architecture for "the digital infrastructure" is produced (including 4G/5G communication networks, data/transaction sharing platforms and cyber security) for data collection and data sharing in realtime.
    b. Define roles and responsibilities within and between the three infrastructure areas at the national and municipal levels.
    c. Bring ongoing EU-funded initiatives into the data sharing arena.
    d. Secure funding for the defined roles to realise synergies between the infrastructure areas.
    e. Establish data sharing platforms for neutral and reliable data sharing in each application area. Secure shared data with respect to privacy, competition and harmful content.
    f. Ensure that harmonised rules apply to transport companies throughout the EU and not individual national legislation.

2. It is not only infrastructure investments that need to be obtained, but also traffic flows that are as resource-effective as possible by implementing the three-step approach of "Avoid-Shift-Improve" prescribed by the United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport[6] where "avoid" is prioritised over "shift" which is prioritised over "improve" as follows:

    - **Avoid** => Avoid transportation by choosing, e.g. video conferencing. Avoid returns in e-commerce etc.
    - **Shift** => Shift to more efficient or innovative transport solutions, e.g. by switching from using personal-use cars to public transport or shared vehicles.
    - **Improve** => Improve current modes of transport, e.g. through optimisation by sharing vehicles and using existing infrastructure etc.

6 United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport, 2016, *Mobilizing Sustainable Transport for Development. Analysis and Policy Recommendations.*

The project group believes that it should be ensured that public (national, regional and municipal) transport buyers and providers introduce the three-step approach and that this is then followed up by the Transport Analysis government agency and the Swedish Transport Administration, and through public procurement.

3. To address the customer behaviour of "over-ordering" when shopping online and therefore avoid unnecessary returns, the following measures should be implemented:

    a. Introduce a regulation whereby shipping costs and an estimated environmental cost are reported for every online purchase (analogous to the WEEE Directive for transparency on the cost of waste).
    b. Nudging could be a useful method; for example, by a sustainable shipping option being pre-selected to guide behaviour when orders are placed.

4. Plan physical infrastructure and buildings for resource-effective transport solutions:

    a. At the national level, regulate transport solutions to promote coordination of common (not supplier-specific) parcel lockers and collection points.
    b. At the municipal level, plan and change the design of cities for short transport distances, by focusing, for example, on the location of parcel lockers and hubs, and by prioritising pedestrian and bike traffic and public transport.
    c. In connection with urban development, plan and create frameworks for how to use autonomous vehicles, public transport, ride-share vehicles and other vehicles more resource-effectively, both within and across municipal borders. Use "urban environment agreements" to ensure steps are taken in connection with new urban construction.

5. At the regional level, develop and incentivise coordinated transport of goods and people in sparsely populated and rural areas by overhauling competition laws and by using new technology for increased sharing.

Industrial symbiosis to increase space utilisation and cooperation between transport buyers and providers

6. To increase space utilisation:

    a. Introduce independent – both private and public sector – and digitalised marketplaces for cargo shipped by sea and air
    b. Make space utilisation visible on load carriers, i.e. pallets, rolling cages, etc.
    c. Ensure that freight exchanges, shipping agents and fourth-party logistics include a *resource efficiency* parameter to encourage customers to differentiate instead of routinely choosing expedited shipping.

7. Standardise and make load carriers lower and stackable to achieve increase space utilisation. The EU Directive on Packaging should pay more attention to resource effectiveness and carbon emissions in package freight.

8. Continue working on improving railways, roads and bridges to handle high-capacity vehicles.

9. Assign Traffic Analysis the task of measuring the domestic portion of air freight and passenger traffic to and from other countries in the same way as for waterborne and rail freight/passenger traffic.

10. More flexible delivery terms could increase utilisation rates; for example, through night-time deliveries (using the potential of electrification and autonomous vehicles).

11. Cooperation is needed among transport buyers and between transport buyers and providers regarding resource-effective mobility. Transport

efficiency needs to include parameters other than cost, time and delivery reliability. Digitalisation, platforms and cooperation could be useful here.

12. Promote intermodal transportation by:

    a. Further developing digital tools that can visualise the resource effectiveness of a mode of transport on a given route. To encourage the use of these tools, authorities and municipalities should introduce procurement criteria whereby transport providers must demonstrate the resource effectiveness of their transport solution on a given route.
    b. Increase awareness (through nudging) among private individuals and smaller actors of the cost of transport.
    c. Invest in combi terminals, including infrastructure connections to terminals, to handle reloading from road, rail and waterborne transport to make the reloading processes faster and more cost-effective.
    d. Continue to focus on improving railway maintenance.

Emergence of new business models

13. The regional public transport authorities should work with Samtrafiken and other private operators to ensure:

    a. that open data can be made available in a competition-neutral way;
    b. that publicly financed public transport facilitates the introduction of new mobility services in an easy and transparent way (e.g. the first and last mile); and
    c. that sustainable and long-term business and financing models are produced.

14. Continue investing to improve public transport combined with other forms of mobility based on sharing and pedestrian/bike traffic, by:

    a. Supporting growth and producing control mechanisms that promote public transport and other forms of combined mobility.
    b. Cooperating and building on the work that has been done in a variety of projects such as KOMPIS (Vinnova), Energy Challenge from Sweden (Swedish Energy Agency), Swedish Mobility Program (Samtrafiken) and Mistra SAMS (Mistra).
    c. Continuing to invest in research and evaluating the effects of combined mobility implementations and pilot projects.

15. Facilitate for ride-share vehicles in legislation through:

    a. a legal definition of ride-share,
    b. lower VAT,
    c. a change in the tax deduction for businesses so that ride-share vehicles are fully deductible, similar to other transport services, and
    d. a change in the parking laws so that parking spaces are made available for ride-share cars.

16. Make it worthwhile for private individuals to share cars and easy to include car-sharing in tax returns.

The significance of the financial sector's role

17. There is demand from the financial sector to invest in green bonds, and particularly in infrastructure such as electric roads. Currently infrastructure investment is managed by the Government. A welcome move to increase awareness of green infrastructure would be if the Government invited more actors to participate and help to identify future solutions for sustainable transport.

18. The Government should invest in activities and projects aimed at increasing resource effectiveness and circularity. The EU's taxonomy could provide useful metrics here. It is also important for projects aimed at making an enterprise/organisation more resource-effective to be able to benefit from various types of investments.

19. To achieve a greater understanding of commercial considerations in connection with a transition to a service-based economy, actors providing financing and companies need to be educated in resource effectiveness and the circular economy, as well as the impact that selling services has on the balance sheet, income statement and cash flow. The Swedish Bankers' Association has a key role to play here.

20. Various ways to measure resource-effective mobility should be explored, e.g. facilitated by the Swedish Environmental Protection Agency in cooperation with industry organisations.

21. Insurance companies should produce new insurance products adapted for sharing services.

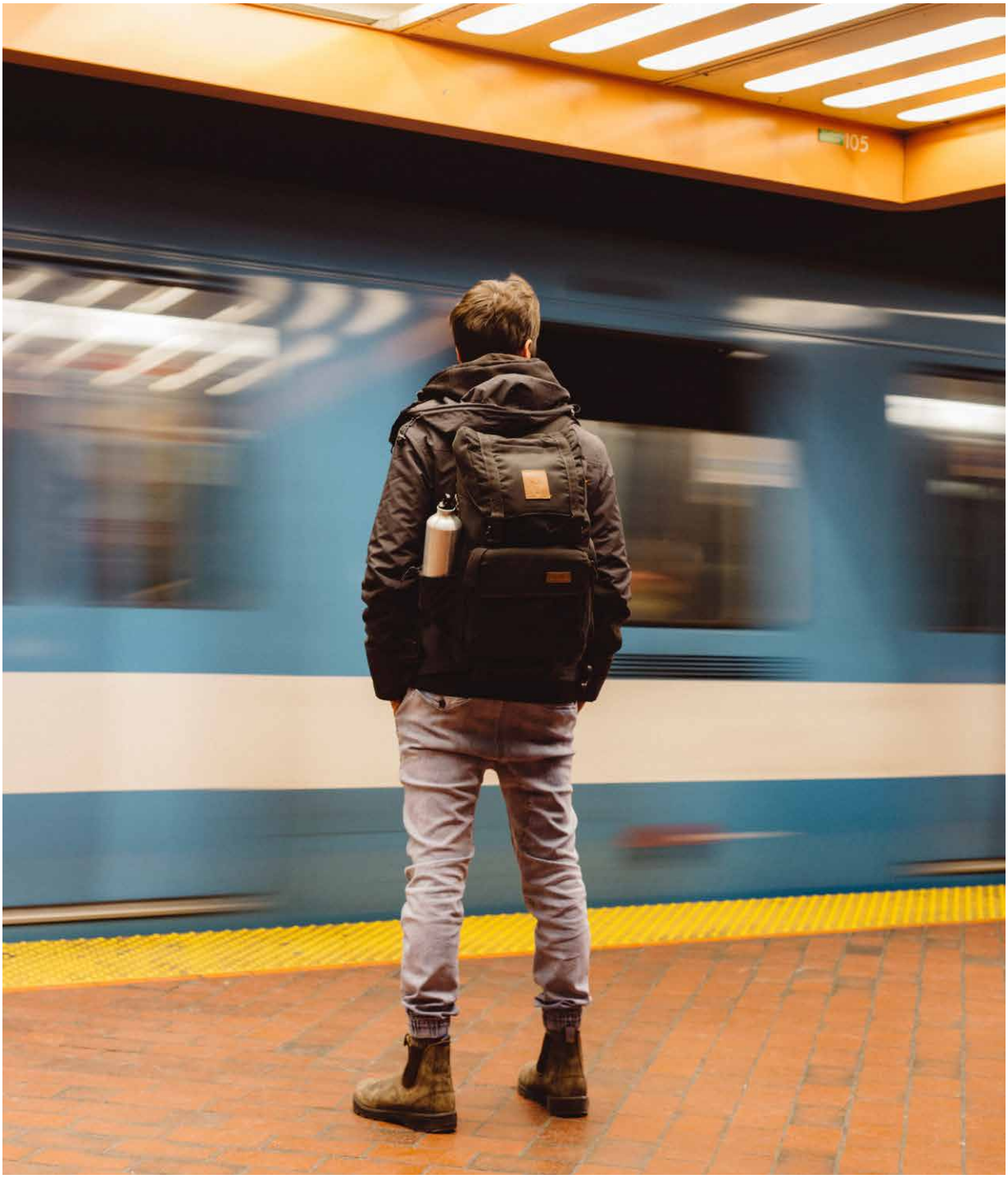
The need for innovative environments

22. Greater coordination is needed to improve the effectiveness of existing and future innovation programmes for transport research. Vinnova has a key role to play here. Swedish R&D programmes and calls for grant applications should be designed to reflect priorities and schedules in international programmes, in the immediate future primarily Horizon Europe, to encourage Swedish participation in these programmes.

23. Allocate resources for test and demonstration facilities and accelerator environments focusing on mobility in the upcoming research and innovation bill. For a sector that is as broad and multifaceted as transportation, it is particularly important for new ideas and concepts to be tested under real-life conditions by testing research results in new urban districts that are looking to implement resource-effective solutions.

24. To promote innovative resource-effective mobility, the following action is needed:

    a. Task the National Public Agency for Procurement with making resource effectiveness one of the procurement criteria or part of an incentive agreement.
    b. Increase knowledge of resource-effective mobility among municipalities and Government procurement officers.
    c. Ensure that reliable and standardised metrics are available to scale up innovation and innovation procurement in resource-effective mobility are produced by, for example, the Swedish Institute for Standards (SIS), but financed with public funds.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Mobility challenges, definitions and boundaries

»Historically, the volume of transportation has increased in line with the growth of economies and populations.«

This report focuses on transport use and how transport solutions can be designed to make them as resource-effective as possible. This involves everything from avoiding unnecessary transportation to coordination to reduce traffic flows by improving space utilisation and increasing utilisation rates to optimise the use of vehicles, vessels and aircraft, as well as the infrastructure associated with them. Describing resource-effective transport systems is complex because there are many resources that could be optimised depending on from whose perspective one or more resources are to be optimised. It is important to define which resource is be used more effectively. Within mobility there are hard resources such as vehicles/vessels/aircraft and infrastructure, but also softer resources such as the environment in the form of air quality and noise levels, and passenger travel time or the time a recipient has to wait for a delivery. Many of these resources are impacted positively when transport use is optimised. This report focuses on resource use in vehicle transport and infrastructure.

The transport sector's main challenge is without doubt that carbon emissions must be reduced. Possible ways of achieving this reduction are discussed in IVA's *Climate Crossroads – Transport Systems* report. By making essential transportation as efficient as possible, we of course also reduce total transportation energy consumption and thereby also carbon emissions in relation to transport volume. Optimising resource use in transportation also affects other drawbacks of transportation in a positive way, for example, by reducing particle emissions, accidents and congestion.

Resource effectiveness is extremely important for society and the economy – from both an environmental and cost perspective. If Sweden can help design mobility solutions for the future that are as resource-effective as possible, transport costs will go down, there will be a positive impact on the environment and Swedish businesses will be more competitive. Mobility is highly significant and has a considerable impact on all sectors because products and people need to be moved around in a globalised world..

Challenges

Historically, the volume of transportation has increased in line with the growth of economies and populations. We will continue to see a similar trend in the future – an increase in the need for freight and passenger transportation. How can we meet increased transportation needs in the future without using more resources than necessary?

A number of global development trends are impacting the transport and mobility sector. They include increased urbanisation, digitalisation and the fast growth of artificial intelligence (AI) and big data. Collectively these are leading to an increase in servicification and a sharing economy. An increased focus on sustainable transportation has also resulted in political actors calling for a reduction in the use of cars in metropolitan regions. Technology development towards self-driving cars has the potential to reduce transport operating costs and lead to new mobility solutions and value chains.

The Global Sustainability Goals and the Paris Agreement also require the transport sector to move towards becoming fossil-free. All of this means that there is now a strong focus in the transport sector on electrification and other fossil-free energy sources, as well as self-driving cars and effective transportation of freight and people.

Society can achieve reduced traffic, lower emissions etc. with the help of greater *space utilisation* and *utilisation rates*.

Space utilisation can be measured in a number of ways; for example, as a percentage of the available load volume or maximum permitted weight, or freight density expressed as a ratio between the freight weight and volume. *Utilisation rate* can be measured based on how much of the available time (for example hours in a day) a vehicle (lorry, train, vessel, aircraft) is being used. There is significant underutilised capacity in freight transport space in all modes of transport. Many freight containers are relatively empty on return trips; for example, after ore has been transported from northern Sweden or timber from the forest. In passenger transport, an average European personal-use car has a utilisation rate of only around 5 percent, in other words it is parked 95 percent of the time. Space utilisation and utilisation rates are this low because they have been optimised based on other variables such as time, availability (people's freedom to drive their own car whenever they want) or cost.

Innovation and advanced technology development are important factors in meeting the challenges that the sector is facing. They can help us find solutions for new customer demands, and new ways to run a profitable enterprise with low investment costs and a fast launch. It is also important to remember that many of the obstacles preventing more resource-effective mobility are related to factors such as the need for institutional changes to laws, regulations and behaviour, as well as new business models. How can technology, business models and regulations on gathering, sharing and analysing data in self-learning systems make it easier for transport buyers (individuals, companies and public sector actors) to make more conscious and considered decisions with respect to resource effectiveness and the resource impact from individual transport solutions? Is it possible to create new opportunities around resource use if private individuals, businesses, municipalities and other public sector actors start to increase the degree of sharing in passenger and freight transport? How can the Government create better conditions in which people will be more willing to share? How can we share, optimise and plan traffic flows to achieve higher resource effectiveness? How can we achieve a system perspective over various mobility solutions and not individual modes of transport?

As mentioned above, to meet future demand for more sustainable transportation by reducing resource use, both new technology and new business models need to be developed that promote increased utilisation, e.g. through transport sharing. A significant shift in behaviour is also needed – both in the habits of individuals and among transport providers and buyers.

Vision, purpose and goals of the Mobility subproject

The vision: "Sweden will be the leading nation in resource-effective transportation and mobility". The purpose of the subproject is to "produce a body of information to stimulate resource-effective transportation and mobility by detecting obstacles and exploring opportunities for a resource-effective transport system, and to identify resource-effective measures for various aspects of the transport system to strengthen Sweden's competitiveness".

The Mobility subproject addresses the transportation of goods and people in all four modes: road, rail, waterborne and air transport in Sweden. Although the report has primarily used road traffic as an example as this is the most comprehensive domestic mode, many observations are general in nature and relate to all modes of transport.

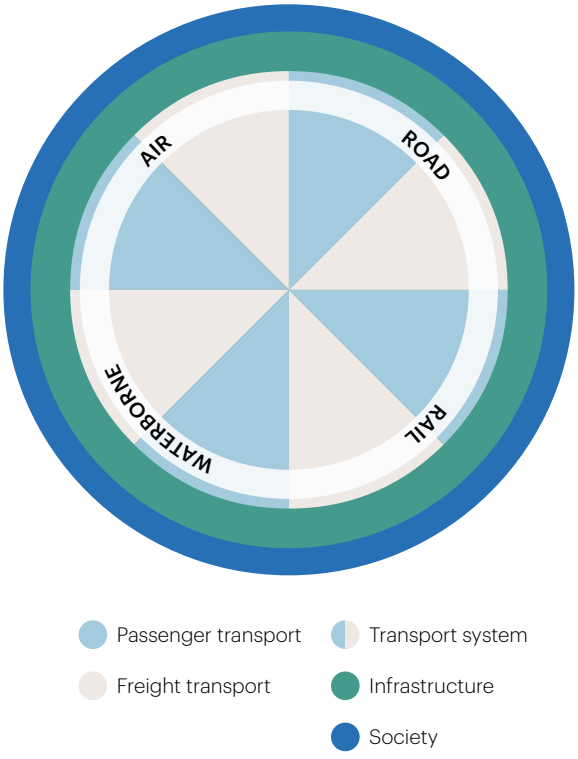
DEFINITION: TRANSPORTATION AND MOBILITY

Transportation is the physical moving of goods and people from one place to another. Transportation now normally means movement involving a vehicle or other type of motorised mobility.

The term **mobility** has a meaning that is broader than transportation. It encompasses the movement of people and goods by vehicle and other means of conveyance, but also mobility e.g. on foot. Mobility is not limited to existing infrastructure, behaviour or market offerings.

Source: Nationalencyklopedin.

Figure 1: Schematic overview of mobility.



The subproject has defined resource-effective mobility as a system of, among other things, supportive business models, control mechanisms, digitalisation and technology to facilitate combined mobility for passenger and freight transportation and to create seamless movement and changed behaviours.

Schematic overview of mobility

The schematic overview below has been used as the starting point for discussion on mobility. At the centre of the diagram are the various modes of transport. The four modes can also be defined according to what is being transported, i.e. freight or people. Passengers or freight transport buyers are users of – and have requirements of – the transport system. Transport providers may be individual, commercial or publicly paid (such as emergency services or military) actors.

The next circle, in light grey, is the infrastructure in the form of physical roads and tracks, charging stations, ports etc., as well as digital infrastructure with access to data, including expanded 5G, etc.

The outer circle is society and what it values, for example accessibility, time, e.g. in the form of avoiding congestion or queues, price and environment and avoiding carbon and particle emissions.

Measures that make mobility more resource-effective also, in many cases, save energy and reduce carbon emissions, particles and noise. Many initiatives that make the transport system more resource-effective also bring cost savings, which raises productivity throughout society. There is, however, a risk that as transportation becomes more efficient and easy to use, more people/actors will take advantage of new solutions to transport themselves or their products, resulting in an overall increase in transportation (the so-called rebound effect).

COMBINED MOBILITY AND MaaS

Combined mobility and mobility as a service (MaaS) are concepts for access to various transport services that do not require ownership of a personal vehicle. Examples are public transport, car sharing, bike sharing, electric scooters and taxis in a separate digital platform or through an individual subscription. Public transport is the backbone of MaaS. MaaS is available 24/7 and offers integrated planning, booking and payment, as well as route information for efficient mobility.

Energy efficiency and carbon emissions in the transport sector

Do we need to increase resource efficiency? Isn't it enough to switch to electric vehicles? Although the percentage of electric vehicles of new vehicle sales is growing rapidly, electrification alone cannot provide sufficient emissions reductions to reach the 2030 goal. One of the reasons for this is that renewing a vehicle fleet is a slow process. A car sold today will be on the road for about the next 15 years. Road traffic is the largest source of emissions in the transport sector and cars in turn constitute the largest source of road traffic emissions. The same also applies to air and waterborne transport; an aircraft/vessel is expected to be in use for at least 20 years. Another reason why it will be difficult to reach the goal through a technology shift alone is that it is hard to produce the amount of fossil-free energy globally that is needed to meet all of society's needs (even if conditions in Sweden for producing fossil-free energy are significantly more favourable). A third reason is that the charging infrastructure, in the form of slow-charging units, fast-charging stations and electric roads, needs to be expanded at a faster pace than is currently the case. Energy storage and more local energy solutions are needed to meet peak demand; in fact a paradigm shift is needed with respect to actors and solutions. Biofuels will be needed for a long time into the future, taking into account, for example, the slow replacement pace, but also the fact that electrification is expensive and does not work well in all geographic locations and for all transport solutions. To create a transport system that is sustainable for the long term, it is therefore important for us to travel smarter and limit the number of vehicle kilometres travelled. The most resource-effective mode is public transport.

Even if electrified and autonomous vehicles are introduced, it does not automatically mean that the number of vehicles will fall. More autonomous cars could mean more vehicle movement overall as they drive people to work, return empty to a parking space, return to pick up etc. Fully autonomous commercial vehicles and buses could lead to increased resource effectiveness through their flexible use 24 hours a day without the need to adhere to today's driving and rest-time rules for drivers. In order for self-driving passenger vehicles to contribute to a more resource-effective transport system the vehicles need to be shared by multiple users and thereby reach a significantly higher utilisation rate than is the case today. This will require a considerable shift away from the traditional business model where people own their own cars. Resource effectiveness will also largely be determined by access to capacity on roads and railways. Self-driving vehicles could result in less space being used for parking and fewer traffic lanes. The entire transport system, including all modes must therefore become more resource effective.

Boundaries

The transport sector's carbon emissions are affected to a great extent by the type of fuel, i.e. energy carrier, that is used and how vehicles and aircraft/vessels and their drivelines are designed. These are profound and important issues – especially when bearing in mind the climate challenges we are facing – but they are addressed in another IVA project: Climate Crossroads, Transport Systems subproject.

Other areas beyond the scope of this project are:

- Vehicles or individual products (the focus is instead on overall systems).
- Resources for vehicle manufacturing, e.g. earth metals.
- Calculation models – both for climate impact and for infrastructure investment.
- Social sustainability, which can influence choice of mode of transport.
- Specific observations on how circular business models impact the transport system.

As the project is aiming at strengthening Sweden's competitiveness, the observations here are limited to Sweden. A number of examples from other countries have, however, been included to inspire and learn from.

Structure of the report

To exemplify and more clearly understand the challenges that resource-effective mobility is facing, the Mobility work group has chosen to study food transportation in more depth in a separate report.[7]

This report is structured so that it will first summarise the project's observations. Chapter 1 describes mobility challenges and the report's boundaries. Chapter 2 provides a very general outline of Sweden's transport systems, including some of the national and global goals that impact the transport sector. The Resource Effectiveness and the Circular Economy project as a whole has five common themes for all subprojects: design, industrial symbiosis, new business models, the role of the financial sector and innovative environments, with workshops arranged around each theme. This report follows the established structure for Chapters 3–7 as follows:

- Design, development and planning for resource-effective transport solutions.
- Industrial symbiosis to increase space utilisation and collaboration between transport buyers and providers.
- Emergence of new business models.
- The significance of the financial sector's role.
- The need for innovative environments.

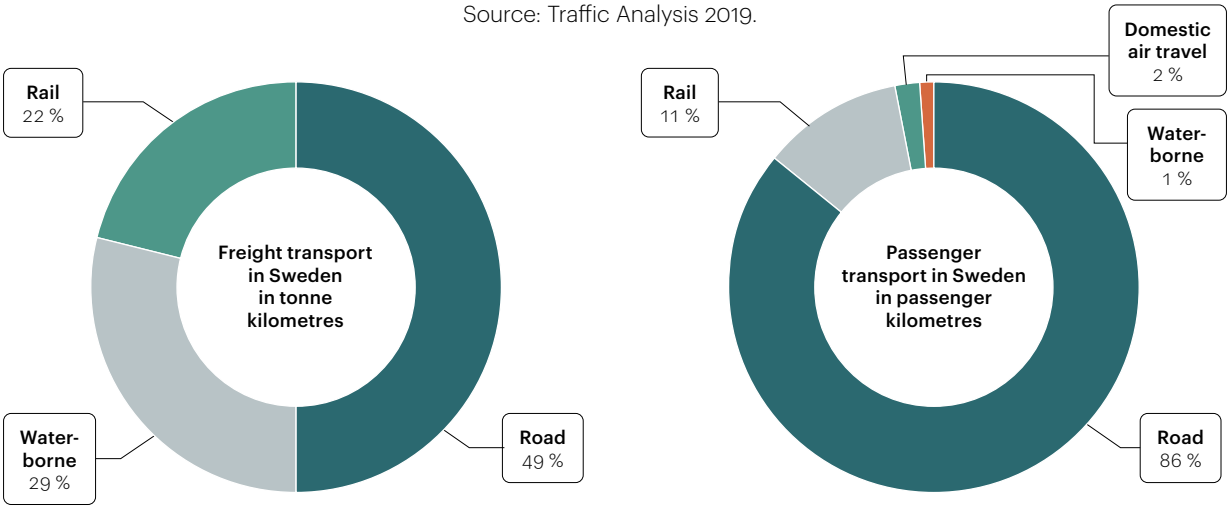
Each chapter describes the Mobility subproject's main observations on the theme with a focus on the areas the project has discussed and considered of the most importance for resource-effective mobility. It is, however, important to point out that the project has neither the ambition nor the ability to provide a fully comprehensive review of research in the area of mobility.

7 The Royal Swedish Academy of Engineering Sciences (IVA), 2019, *Så klarar Sveriges transporter klimatmålen* (https://www.iva.se/globalassets/info-trycksaker/vagval-for-klimatet/transportsystem-slutrapport-2019-06-12-id-132097.pdf; accessed 21 November 2019).

Sweden’s transport system – facts, national goals and global goals

»Greenhouse gas emissions from domestic transport must be reduced by at least 70 percent between 2010 and 2030.«

Figure 2: Freight and passenger transport.
Source: Traffic Analysis 2019.



Both passenger and freight transport in Sweden have increased since 2000 for all modes of transport. This is a logical development bearing in mind Sweden's strong growth in recent years and is expected to continue to increase in terms of both passenger kilometres and tonne kilometres.[8] In domestic passenger transport, road transport by car and bus is dominant, at 86 percent of all passenger transport measured in passenger kilometres in 2018. 11 percent of passenger transport is by train.

Domestic freight by road accounts for 50 percent of all transport. This is followed by waterborne freight at 29 percent and railway at 22 percent, measured in tonne kilometres.[9] Air transport – both passenger and cargo – only accounts for a few percent because only transport between Swedish airports is included in the calculation and therefore a large portion is missing in the form of the domestic portion of international flights to and from Swedish airports.[10]

Freight is mainly transported within the country by heavy goods vehicles due to their flexibility. Waterborne traffic is dominated by international traffic. Waterborne and rail are used for long routes, heavy goods and bulk goods. For example, Ore, wood and steel product are exported and coal and raw oil are imported.[11]

It is important to bear in mind that much of the freight transported by lorry into and out of the country has often arrived at or will depart from ports in Europe to continue to or from other continents by ship. Waterborne transport accounted for 48 percent of Sweden's trade with countries *outside* the EU in 2015 based on *value*.[12] This is followed by planes carrying cargo that needs to arrive at its destination quickly and securely, such as medicines, electronics and inputs for just-in-time production, perishables and express goods.

8 Traffic Analysis, 2019, *Transportarbete i Sverige 2000–2018*.

9 Traffic Analysis, 2019, *Transportarbete i Sverige 2000–2018*.

10 For air transport, only routes between Swedish airports are included, while the domestic portion of international routes is not. For waterborne transport, the portion of domestic routes along Sweden's coastline is included.

11 Traffic Analysis, 2019, *Transportarbete i Sverige 2000–2018. Statistics published on 11 October 2019*.

12 Eurostat, 2016, *World Maritime Day Half of EU trade in goods is carried by sea Rotterdam, Antwerp and Hamburg busiest cargo ports*. 184/2016.

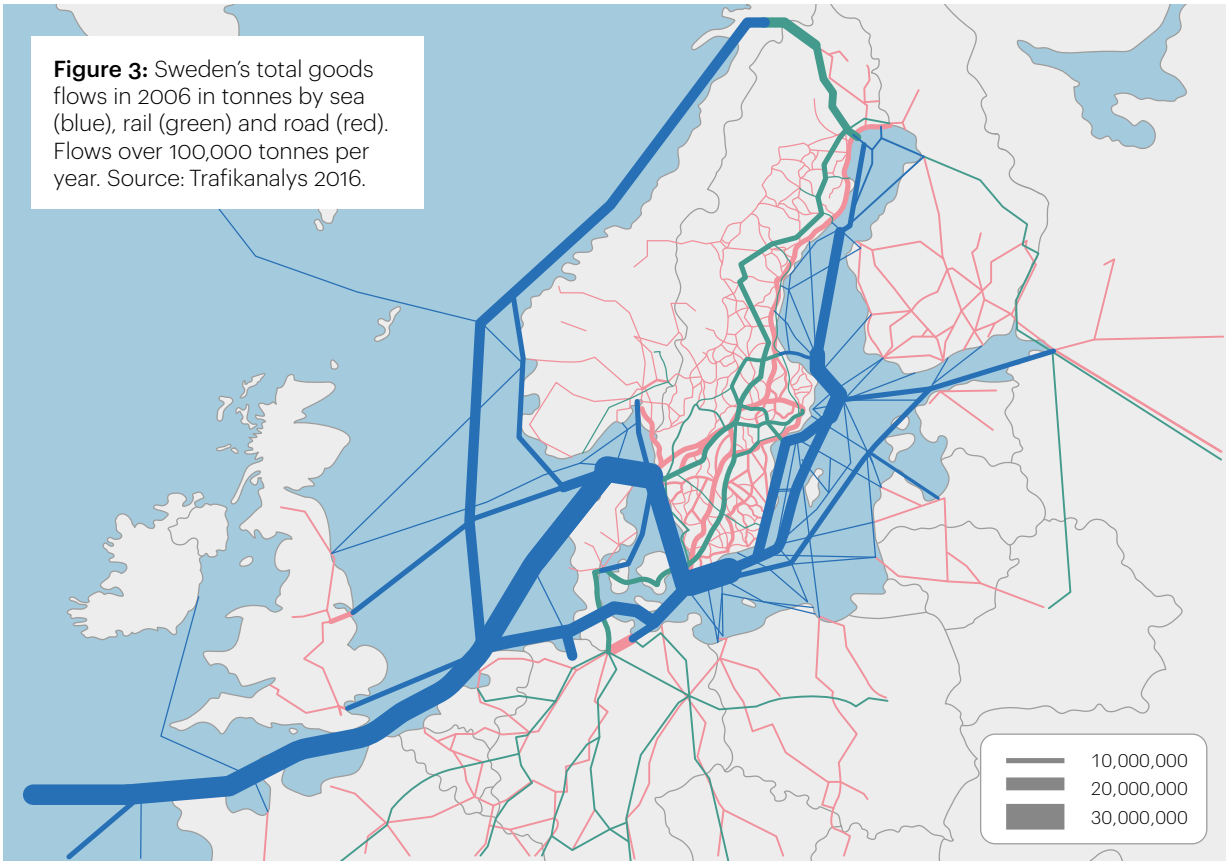


Figure 3: Sweden's total goods flows in 2006 in tonnes by sea (blue), rail (green) and road (red). Flows over 100,000 tonnes per year. Source: Trafikanalys 2016.

National goals

There are numerous challenging political goals at the national level with respect to transportation. In Sweden "greenhouse gas emissions from domestic transport are to be reduced by at least 70 percent between 2010 and 2030"[13] In addition, "public transport's market share is to be doubled by 2030"[14] according to a joint initiative (Partnersamverkan

13 The goal does not include air and international maritime transport

14 K2, Sweden's national centre for public transport research and education and the Swedish Public Transport Association. The goal of doubling the market share of public transport is based on a baseline from 2006 when public transport had a market share of 18 percent. Doubling this by 2030 means that public transport needs to reach a market share of 36 percent. In 2018 the market share was 31 percent. The market only includes trips with motorised modes of transport. Public transport includes trips with publicly procured public transport, commercial bus and rail traffic, and taxi travel. Taxi travel is thus included in public transport and not in car traffic.

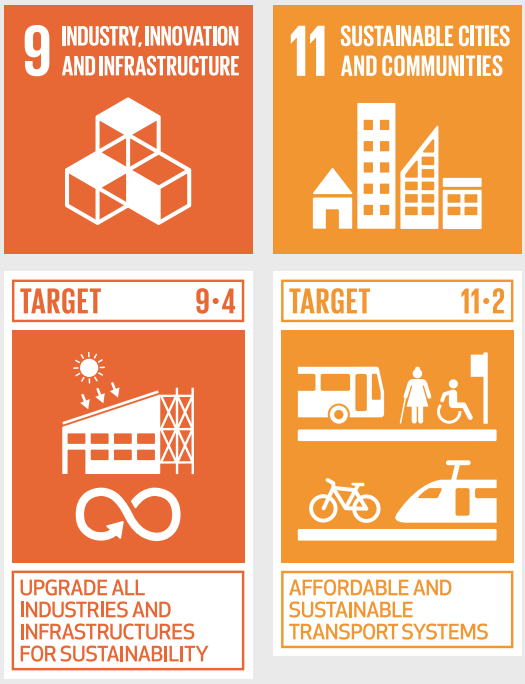
för fördubblad kollektivtrafik).[15] At the same time, the aim of transport policy is to "ensure a transport system that is sustainable in the long term and efficient from a public finances perspective for the citizens and industry throughout the country", This incorporates both functional goals and health/safety/environment goals. Furthermore, the objective of enterprise and industry policy is to "strengthen Swedish competitiveness and create the necessary conditions for more jobs in more and growing companies".

The Government's joint programme *Nästa generations resor* (Next Generation Travel) includes a route plan for combined mobility as a service in which it establishes goals that include achieving the following effects by 2027:[16]

- 50 percent of Sweden's population have the option to choose sustainable travel with shared resources as an alternative to owning a car.
- 25 percent of Sweden's population use shared mobility services on a regular basis.

There are also several local goals. All regional public transport authorities have, for example, decided that cities must reduce their car traffic to cut carbon and particle emissions, and to increase accessibility.

UN'S SUSTAINABLE DEVELOPMENT GOALS



The Global Goals and the EU goals

At the global and European levels, numerous goals have been established relating to resource-effective mobility. The EU also has significant goals and legislation for gradually reducing the climate impact of transportation. Altogether these constitute important factors in the ability to reach the climate goal in the Paris Agreement of limit warming to 1.5 degrees. These are objectives that all actors in the transport industry need to take into account now.

The overall purpose of the *Resource Effectiveness and the Circular Economy* project is, in line with the UN's Sustainable Development Goals, to make Sweden more competitive in

15 The Swedish Public Transport Association, Sveriges Bussföretag, Taxiförbundet, Association of Swedish Train Operating Companies, Swedish Transport Administration, Swedish Association of Local Authorities and Regions (SKL) and Jernhusen.

16 Holmberg, P., Kramers, A., Laurell, A., Pernestål Brenden, A. and Smith, G., 2018, *En aktivitet i samverkansprogrammet – nästa generations resor och transporter. Combined Mobility in Sweden*, Swedish Energy Agency, Samtrafiken, Swedish Public Transport Association, Swedish Transport Administration and Vinnova.

a future with finite resources. Resource-effective mobility is mentioned in several of the 2030 Global Goals. The most relevant goals for this subproject are Goal 9: Industry, Innovation and Infrastructure and Goal 11: Sustainable Cities and Communities.

The EU also has significant goals and legislation for gradually reducing the climate impact of transport because the transport sector accounts for 33 percent of the EU's energy consumption and 65 percent of oil consumption. To reach the EU's vision[17] of clean, connected and competitive mobility, the European Commission is making substantial investments in infrastructure, expanding charging facilities through, for example, the Trans-European Transport Network, TEN-T, and Connecting Europe Facility, CEF, and through measures to stimulate increased use of sustainable public transport. Earlier rules and economic incentives will also encourage intermodal transportation, i.e. transport systems using several modes of transport as efficiently as possible. The European Commission also has a goal of Europe being a world leader in electromobility and has an action plan to expedite the transition to a circular economy.

Ongoing mobility initiatives in Sweden

Numerous projects are under way focusing on transport. Even a general analysis performed by this subproject at the beginning of 2018 identified around 20 initiatives in Sweden. Money is being invested by both the public and private sectors – close to SEK 800 million alone in the initiatives identified. Added to this are projects being implemented via the EU.

Several of the initiatives are *comprehensive*, i.e. they involve the research community as well as the public and private sectors, and *national*, for example the Government's partnership programme *Framtida generationers resor och transporter* (Travel and transport in future generations). The strategic innovation programme called Drive Sweden is coordinating numerous initiatives within road-based mobility for connected, self-driving and shared vehicles focused on MaaS.

There are also additional research-based projects such as "Mistra SAMS", which is focusing on accessibility and mobility services and behaviour, and innovation environments such as Lindholmen Science Park, which is focusing on mobility for people and goods.

A lot is happening at the national level within mobility as well. In 2018 the Government decided to introduce a national freight transport strategy[18] and presented a national strategy and action plan for the use of intelligent transport system, ITS.

The diagram below shows various Swedish mobility projects that are in progress focusing on users, research, infrastructure and providers, based on the national road map *Combined Mobility as a Service in Sweden, KOMPIS*.

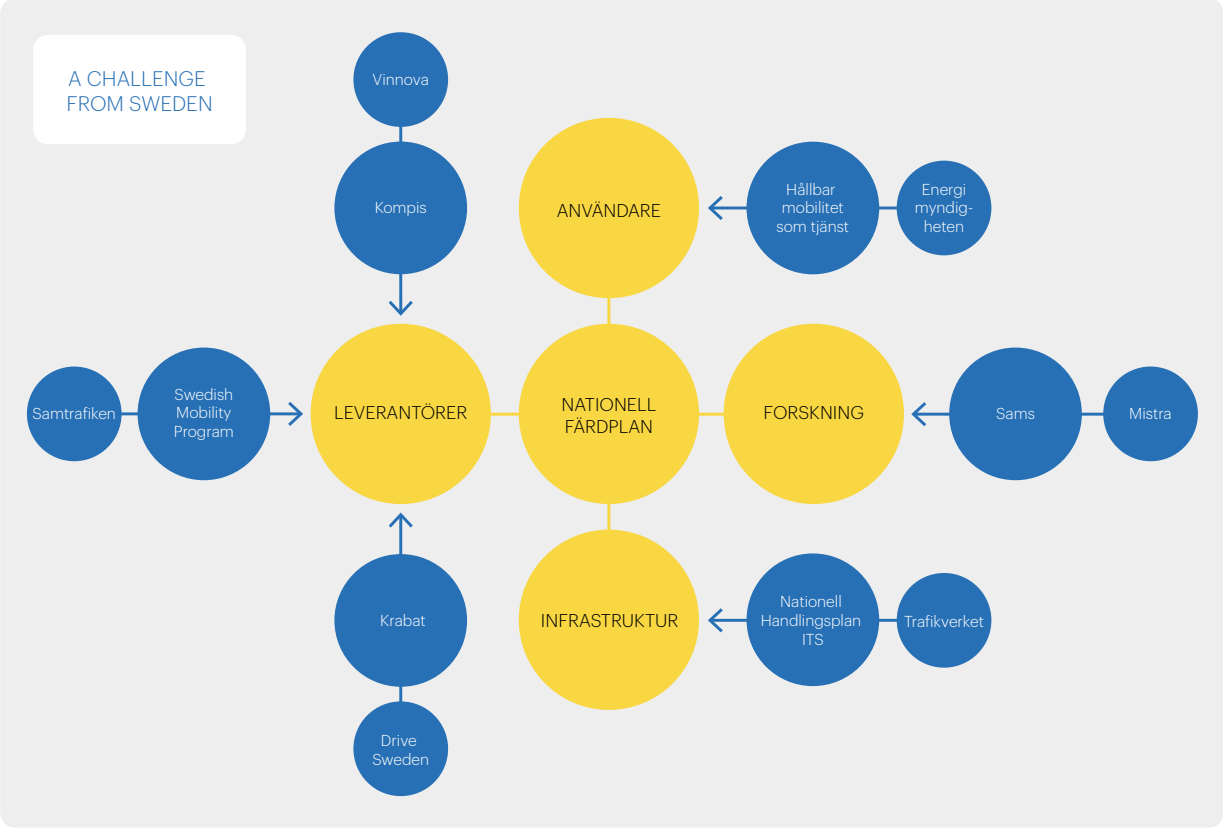
The Government has also assigned the Swedish Transport Administration a number of tasks, including:

- Coordination and cooperation for increased intermodality, including the appointment of a national coordinator for increased domestic waterborne transport and short sea shipping, and identifying measures to increase freight transport by rail and vessels.
- Another area is *transport efficiency*, in which the Swedish Transport Administration is analysing the use of longer and heavier vehicles and open data for increased space utilisation.
- In 2019 the Swedish Transport Administration was commissioned for a Government inquiry on MaaS.

17 European Commisson, 2018, *10. Clean, Connected and Competitive Mobility*.

18 Government Offices of Sweden, 2018, *Effektiva, kapacitetsstarka och hållbara godstransporter – en nationell godstransportstrategi*, N2018.21.

Figur 4: Overview of mobility services projects by Jesper Johansson, A Challenge from Sweden. Swedish Energy Agency.



As indicated above, in combination with the funds being invested by vehicle developers themselves, large total amounts are being invested in transport solutions. The majority of the initiatives are focusing on road haulage. The reasons for this include Sweden's historically large and significant automotive industry, the country's reliance on transportation due to its geographic size and that it is relatively sparsely populated, and that the transport sector must also reduce its climate impact.

It could also be noted in this context that there are significant technological changes happening in the automotive industry, particularly in the development of autonomous vehicles, electrification and digitalisation. A Government inquiry called "The path to automated driving" proposes that the owner, not the driver, should be responsible for an automated vehicle. This provides opportunities for commercial actors with vehicle fleets.[19]

19 SOU 2018:16, *Vägen till självkörande fordon – introduktion: slutbetänkande.*

Design, development and planning for resource-effective transport solutions

»Physical transport infrastructure, energy infrastructure and digital infrastructure need to work together. Sweden should therefore develop a national strategy for digitalisation and data sharing to promote the development of resource-effective transport solutions.«

Success in achieving resource-effective transport solutions depends on conscious design, development and planning of the entire transport system, as well as its infrastructure. In addition to the physical infrastructure in the form of roads, ports, airports, reloading terminals and – in the case of road haulage – charging infrastructure, the digital infrastructure also needs to be in place.

Development and planning of digital infrastructure and data

In recent years there has been rapid development of new mobility services, which has opened the way for a new kind of market for new actors. Digitalisation and data sharing combined with greener energy sources are facilitating resource-effective transport solutions. Meanwhile, it is evident that business models, roles and regulations have not been developed with sufficient clarity to take full advantage of the fast technology development and new innovative services providers. Three types of infrastructure that are traditionally distinct from one another and each have a service ecosystem (physical transport infrastructure, energy infrastructure and digital infrastructure) must work together for long term efficiency and safe transport systems with the least possible environmental impact. The three areas all have an infrastructure component and a service/application component, but at this time they have very different business models and regulatory frameworks. They all have a planning phase, an implementation phase and an operational phase to ensure capacity and quality for the best possible end-user experience for the services that each type of infrastructure makes possible.

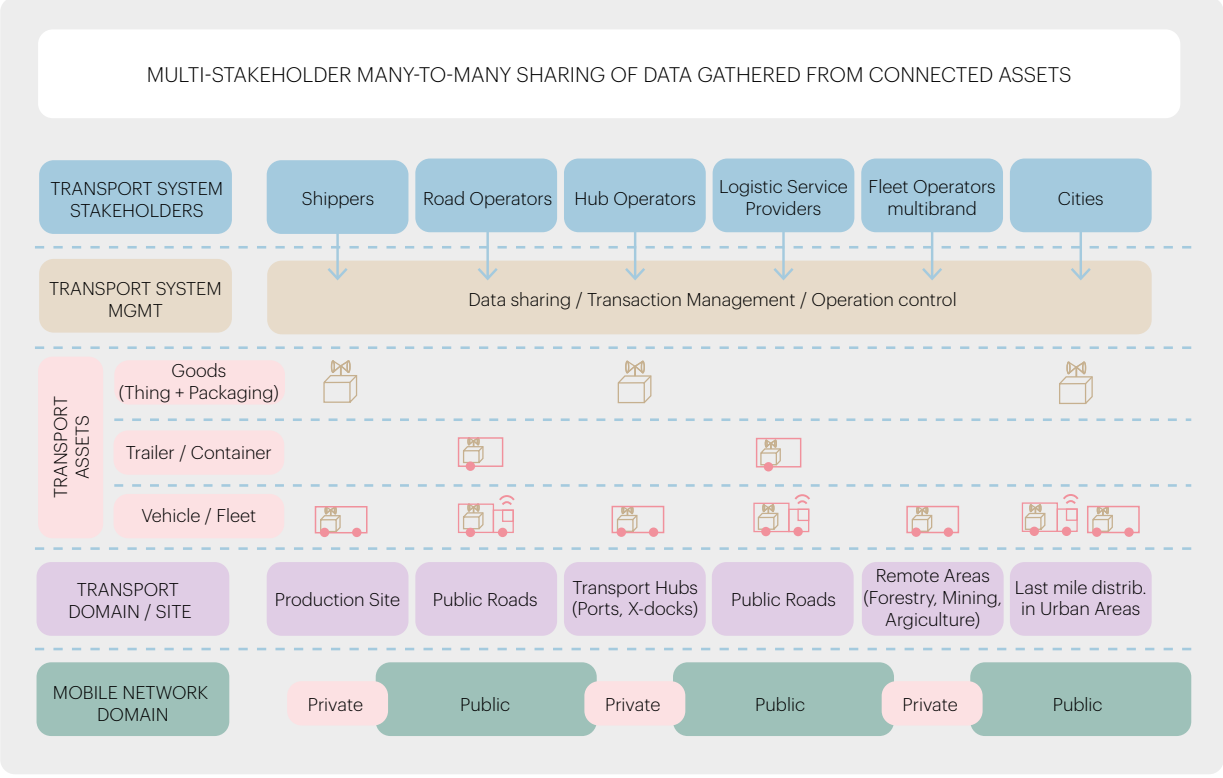
To support future growth, Sweden should develop a clear strategy to ensure focused legislation that supports digitalisation and data sharing to develop resource-effective transport solutions – and thus also improve Sweden's competitiveness.

Digitalisation facilitates increased resource-effectiveness. Advanced coordination services around transport and transport networks base their services on data from the product or passenger level up to which type of transport solution is used.

Digitalisation in the form of data, sensor connection etc. can help to solve several of the problems that exist in transport today, including inadequate resource effectiveness. One example is Stockholm where public buses have priority at smart traffic lights if they are more than one minute late. This reduces both environmental impact and waiting times.[20] Traffic is controlled with the help of GPS and 4,000 detectors in the ground.

20 Axelsson, S., Flyborg, N., Fors, P. and Haglund, T., 27 March 2019, "Sverige bör släppa datan fri för klimatets skull", in *Dagens Industri* (https://www.di.se/debatt/sverige-bor-slappa-datan-fri-for-klimatets-skull/; accessed 23 September 2019).

Figure 5: Example of how data can be shared and monitored in realtime when transport systems are connected. Source: Ericsson.



Digitalisation of transport systems impacts multiple services areas, such as payment solutions, safety, fleet management, vehicle operation and management and optimisation of the infrastructure, such as roads, railways, ports and hubs. The digital infrastructure relies on technologies working together to enable services to be developed within and between different application areas. The various parts in a process and different sectors now have the possibility through digitalisation to be linked and monitored in realtime throughout the process (see diagram below).

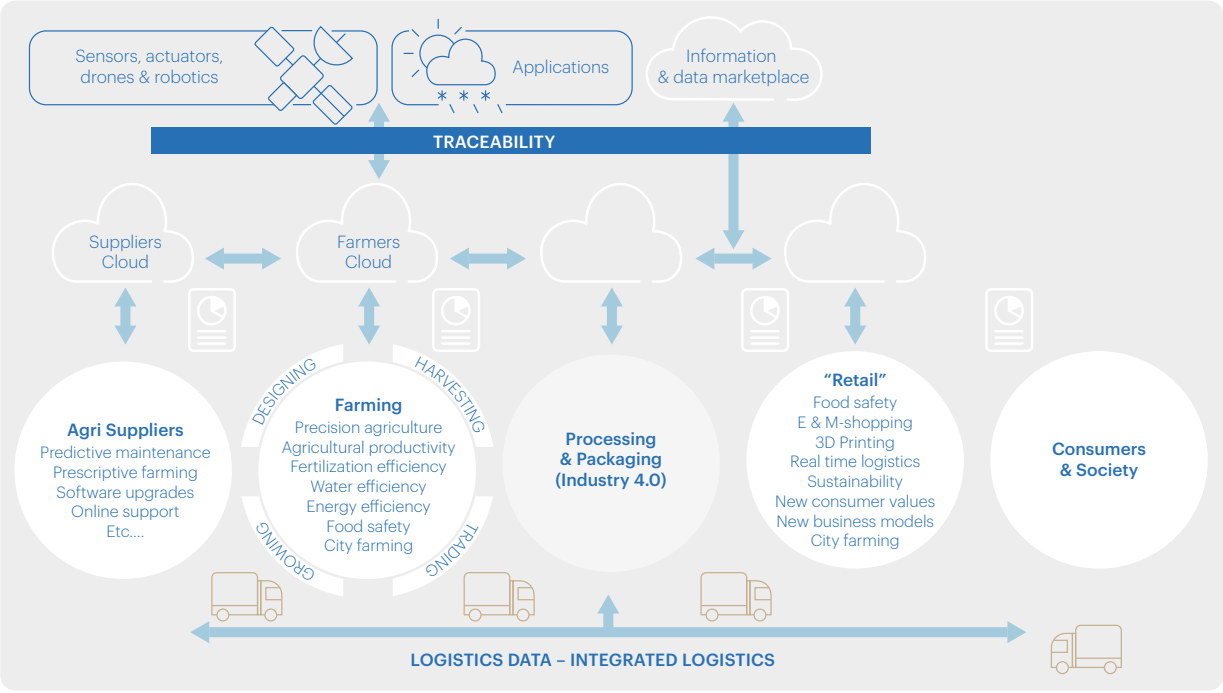
Another example is presented in the next diagram, where information, data and transportation are integrated in all the stages of food production.

Similarly, information and data on passenger transport can be processed digitally to achieve greater coordination and resource effectiveness.

Traffic flow data forms the basis for development of MaaS and LaaS (logistics as a service). National regulation of traffic flow data that both commercial and public sector actors can use is needed. One possible model could be licences or concessions similar to those for electricity grids, data frequencies and fibre-optic cables.

The Government has commissioned the Swedish Transport Administration to work with relevant actors, such as transport companies, vehicle manufacturers and transport

Figure 6: Example of how data and transportation are integrated in food production. Source: Ericsson.



buyers, to prepare proposals for systems for information exchange and open data for horizontal coordination and increased transport effectiveness, and to reduced climate impact. An example of this is reducing empty transport flows and increasing space utilisation. In a report the Swedish Transport Administration describes how it is technically possible to develop and manage systems for open data but that the principle of public access to official records as well as security issues need to be addressed. Systems should be developed and managed by a neutral party that is trusted in the market, and using public funding.[21]

There are many aspects that need to be taken into consideration when designing systems, such as security – both privacy and national cyber security. Questions such as how to ensure that the data collected is used appropriately and who verifies compliance need to be answered. Another aspect is that large shipping agents rely on coordination of and access to this information. Data drives profitability, and if data is shared there is a risk of lost revenue. The aspect of competition between companies when data is made available also needs to be addressed. Data sharing does not, of course, automatically lead to increased resource effectiveness.

21 Swedish Transport Administration, 2019, Swahn, Magnus. *Government commissions: Horisontella samarbeten och öppna data*. Report 2019:110.

The project is proposing the following initiatives for data sharing to increase transport resource effectiveness.

- Ensure that reference architecture for "the digital infrastructure" is developed (including 4G/5G communication networks, data/transaction sharing platforms and cyber security) for data collection and data sharing in realtime for the fastest possible action in the relevant operational process. 5G plays a crucial role and it is important for Sweden to expedite the 5G network rollout and allocation of frequencies.

- Define roles and responsibilities within and between the three infrastructure areas to ensure the most efficient infrastructure is available for resource-effective transport solutions (for example, capacity in digital and energy infrastructure needs to be ensured for efficient and green transport routes). Roles and responsibility need to be defined at both the national and local government levels.

- Apply EU-funded initiatives to data sharing, for example in the area of logistics (EU expert group om Digital Transport and Logistics Forum, DTLF) and or road incidents (Nordic Way).

- Secure funding for defined roles to realise synergies between areas of infrastructure that have so far been managed separately.

- Establish data-sharing platforms (technology environments and APIs) for neutral and reliable data sharing in each application area. Secure shared data with respect to privacy, competition and dangerous goods.

- Ensure that rules applying to transport companies are harmonised throughout the EU (not specific national requirements).

One extra challenge is that the transport system is not coordinated at the national level today. One example of this is public transport where different actors, such as the Government, county councils, regional public transport authorities and individual municipalities are responsible for different parts of the infrastructure, operation, school transportation, mobility service, etc. Added to this are commercial buses and train traffic. The Swedish Transport Administration has, however, been tasked with launching a national access point for all traffic data – public and private sector – for all modes of transport. This assignment is being carried out by Samtrafiken.

One example of collaboration within the transport sector that is taking advantage of the opportunities of digitalisation within data and knowledge exchange is the Swedish-initiated EU project Port Collaborative Decision Making, Port CDM, which is enabling coordinated entry and freight management in ports and helping to increase security and efficiency while also reducing emissions.[22] In the past there was a sporadic exchange of information between individual entities, such as ships and the port, or lorry drivers waiting in queues. To create cooperation between different modes, ports were established as the hub in the transport ecosystem, to which vessels, aircraft and railways for both freight and passenger transport are connected. Research results have been turned into practice in nine European ports. Port CDM now has international standards for how data is shared, common information platforms, a compliance model and an interface with low entry barriers for third party innovators. The results have led to improved resource use, predictability and a higher level of precision for departures and arrivals, reduced wait times, etc. Cooperation and open data sharing are creating the conditions for resource-effective, global logistics chains.

Development and planning of physical infrastructure

Infrastructure investments are often substantial and cost-

22 RISE, 2019, *Finansiering av cirkulära affärsmodeller – risker och möjligheter.*

ly. Not all decision-makers consider which infrastructure investments are the most profitable. The benefits are instead sometimes overestimated and costs underestimated.[23] They are often unaware of their failure to take these aspects into account.

It is therefore important for the Swedish Transport Administration in its traffic planning for infrastructure investment to follow the four-step approach established by the Government. The four-step approach is to be "applied to ensure good resource economy and that measures contribute to the sustainable development of society".[24] The four steps in the planning process, where the step 1 is always prioritised over step 2 etc., are:

1. **Rethink** – measures that impact demand for transport and mode of transport, for example, taxes, parking fees, travel-free meetings, information, etc.

2. **Optimise** – measures that use the infrastructure more efficiently, such as increased trip frequency, logistics solutions, travel planners, etc.

3. **Rebuild** – limited rebuilding in the form of reinforcement, platform extensions, channel dredging, ITS solutions, etc.

4. **Build new** – new investment if the demand cannot be met in the previous steps, for example new railway lines, electric roads, diversion routes, airport links, etc.

The project believes that the benefit of the four-step approach is that it enables well thought-through and thoroughly evaluated decisions to be taken.

The Swedish Transport Administration is also carrying out "measure option studies" to plan transport solutions, the reason being that early dialogue leads to shared responsibility and consensus on possible solutions. The action option studies are based on dialogue with municipalities and regions and involve several actors. All modes of transport and all types of actions, as well as combinations of these, are being taken into account. The project believes that as the municipalities now also have an opportunity to conduct simplified action option studies (a type of simplified and thereby less expensive preliminary study), this will facilitate good decisions applying the four-step approach.

Traditionally, increased demand for freight and passenger transport has been met by building new infrastructure. This is neither sustainable nor resource effective. It is not only infrastructure investment that is needed but also resource-effective traffic flows. The project suggests that the goals can be reached by implementing the three-step approach of **Avoid-Shift-Improve** prescribed by the United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport.[25] This model was originally developed in the early 1990s in Germany as a way to structure policy measures to reduce environmental impact from transportation.

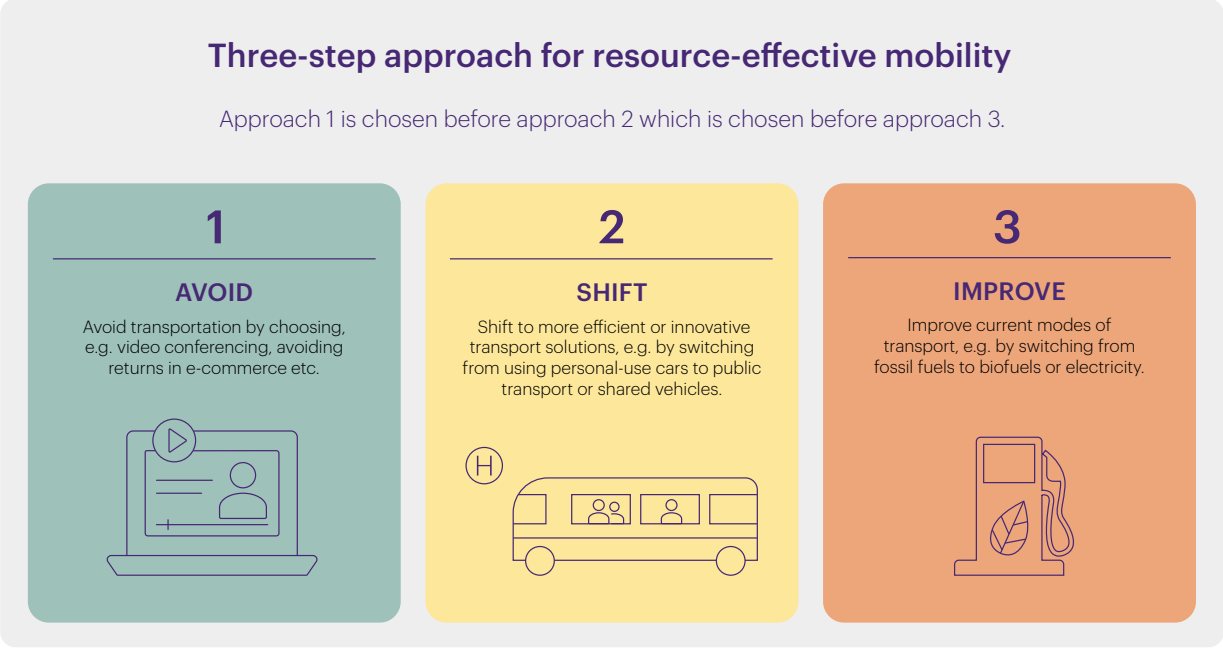
The project recommends ensuring that public (national, regional and municipal) transport buyers and providers introduce the three-step approach for resource-effective transport flows, and that these are then followed up by Traffic Analysis and the Swedish Transport Administration, and through public procurement.

In addition to the policy measures, investment in infrastructure is also needed. The railway is, for example, struggling with poor capacity and reliability, at the same time as the pressure on this sector has never been this high. This, in

23 Davidsson, S., and Hansson, Å., 2019, *Att bygga rätt infrastruktur*, Fores.

24 Swedish Transport Administration. 2018. *Fyrstegsprincipen* (https://www.trafikverket.se/for-dig-i-branschen/Planera-och-utreda/Planerings--och-analysmetoder/fyrstegsprincipen/; accessed 23 August 2019).

25 United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport, 2016, *Mobilizing Sustainable Transport for Development. Analysis and Policy Recommendations*.



combination with the fact that the physical infrastructure is old and in need of maintenance, creates an inherent conflict in renovating and upgrading a system when it is being driven close to its capacity ceiling. In other words, the railway system needs continued repair and development.

Development and planning of e-commerce infrastructure and distribution of the "last mile"

Another area where transport development and planning are needed to achieve increased resource effectiveness is in the growing e-commerce sector which saw growth of 15 percent in 2018 in Sweden.[26] This, in combination with increasing numbers of people moving to cities, means that transport systems and flows for both people and goods into cities needs to be managed. Many so-called "last mile" trips – e.g. from shop to home – are still by vehicle. The last mile is considered the most expensive, least efficient and most polluting part of both the e-commerce chain an in regular retail.

Consulting firm Sweco in a report states that municipal authorities need to plan for new functions such as e-commerce terminals instead of retail outlets. Terminals shorten the distance for the last mile and enable coordinated and faster deliveries.[27] Municipal authorities could take greater

26 PostNord in cooperation with HUI Research and Svensk Digital Handel, 2018, *E-barometern 2018 annual report*.

27 Frisk, S., Karlsson, H., Petersson, H. and Rogat, D., 2019, *E-handelns konsekvenser på Huddinge kommuns samhällsplanering*, SWECO.

responsibility for logistics and ensure that existing infrastructure is being used in a resource-effective way.

In its report, Sweco recommends:

- Residential planning that promotes more efficient internal distribution; for example, temporary spaces for loading and unloading, parcel lockers in building entrances and smart doors.
- Setting up parcel lockers at schools, care homes for the elderly and public spaces such as bus stops and public buildings.
- Providing space for more public pick-up locations to make it easier for consumers to collect parcels without having to make an extra car trip.

Before establishing municipal and open terminals, obstacles such as congestion, extra administration, time and costs in connection with delivery via a terminal instead of the end-destination need to be taken into account.[28]

It is important to take advantage of the potential of growing e-commerce to improve resource effectiveness and to avoid extra vehicle trips by coordinating transport and efficient last mile solutions through planning and changing the design of cities so that pedestrians, bike traffic and public transport are prioritised, and through conscious decisions in the planning process to shorten transport distances. This would, for example, involve locating supermarkets, parcel lockers, hubs and parcel pick-up locations close to homes, public buildings, schools and bus stops.

As e-commerce grows, consumers are demanding more, faster and more flexible deliveries – preferably at no cost. One example is clothing, where the number of returns is increasing. An average of 22 percent (varies between 18 and 60 percent) of all clothes purchased online in Sweden are returned.[29] New consumer behaviour has been created where customers tend to systematically over-order products. Returned products need to be checked, processed and repackaged before they can be sold again, which often involves more transportation. Sometimes they are even thrown away. For example, Swedish clothing companies often send returned clothes to Estonia and Poland, where payroll costs are lower, to manually process them before they are sent back to Swedish warehouses and then on to new customers.[30] The project therefore suggests launching the term "return shame" to inform consumers about the transportation and environmental costs that returns involve.

To address the consumer behaviour of over-ordering when shopping online and therefore avoid unnecessary returns, the project proposes the following:

a. Introduce a rule whereby shipping and estimated environmental costs are reported for every online purchase (analogous to the WEEE Directive for transparency on the cost of waste).

b. Nudging could be a beneficial method in connection with online shopping; for example, by a sustainable shipping option being pre-selected to guide behaviour when an order is placed.

It is important to point out that the proposed measures described, such as introducing reporting on transport and

28 Olsson, J. och Woxenius, J., 2014, *Localisation of freight consolidation centres serving small road hauliers in a wider urban area: barriers for more efficient freight deliveries in Gothenburg*, i Journal of Transport Geography 34 (2014), pp. 25–33.

29 Cullinane, S., Browne, M., Karlsson, E., 2017, *An examination of the reverse logistics of clothing (r)e-tailers in Sweden*, University of Gothenburg..

30 Breakit, 9 November 2019, *Vi spårade nätjättarnas returer – så långt åker kläderna som du lämnar tillbaka*, (https://www.breakit.se/artikel/22407/vi-sparade-natjattarnas-returer-sa-langt-aker-kladerna-som-du-lamnar-tillbaka; accessed 6 November 2019).

estimated environmental costs, require the allocation of a reasonable amount of time and administration to for data collection. Expertise in digitalisation and automated data collection need to be applied here. Follow-up with actual data is also needed in order to make comparisons with the estimated costs.

New technology facilitates last-mile distribution

New methods for resource-effective distribution in the last mile may in time be identified with the help of new technology. Tests are being carried out with one-time codes for homes so that food can be delivered directly into refrigerators. Other options are delivery into locker hubs, e.g. at fast-charging stations, trains stations or bus stops. A third alternative that already exists is product delivery directly into the boot of a car – where individuals decide to have their own car – when it is parked at work (such as Volvo In-car Delivery).[31] In the future, drones could be an alternative method of last-mile distribution for small items, such as defibrillators to islands, blood tests and medicines between hospitals, although there is little chance of this option being used to transport large volumes.

Development and planning for urban passenger transport

In more and more cities around the world local politicians and mayors are starting to limit vehicle traffic in inner-city areas for environment and space reasons. Cars take up space and are inefficient in terms of resource utilisation. As already mentioned, an average European personal-use car has a utilisation rate of only around 5 percent.[32] When cars are driverless, although there will probably be less demand for parking spaces, more street space may be needed as the cars, instead of being parked, will constantly circulate or be parked outside the city centre. One example is the city of Gothenburg which has produced a strategy for future urban development involving autonomous vehicles to plan for resource-effective mobility.

At the national level, control mechanisms, such as taxes on fuel and vehicles, will need to be changed as electrification and sharing increase.

Urban planning can also be a drawn-out process. It involves visualising goals and creating planning and permit processes to promote the achievement of the goals. It is also important to encourage more cooperation between neighbouring municipalities and urban districts.

Future urban development should include planning and frameworks for how ride-share vehicles, autonomous vehicles, public transport etc. can be used more resource-effectively – both within and across municipal boundaries. "Urban environment agreements" could be used to include resource-efficiency measures in connection with new urban construction.

Development and planning for rural passenger and freight traffic

Not everyone in our long and narrow country lives in a city or town, and in rural areas vehicles are often the only convenient option. Mobility challenges differ between metropolitan and rural areas, and opportunities to improve resource effectiveness are also highly dependent on pop-

31 Volvo offers In-car Delivery in cooperation with mat.se with the help of a digital one-time key.

32 Analysis by McKinsey & Company shows that an average European car spends 92 percent of the time parked, 1.6 percent searching for a parking space, 1 percent in traffic queues and 5 percent driving around. In addition, the average car transports 1.5 people per trip even though it is a five-seater.

ulation density and distance. E-commerce offers an opportunity to have access to the products of retailers that are located far away. Ensuring transport effectiveness in e-commerce distribution outside cities is, of course, an important and clear priority considering the operating costs. The simultaneous transportation of goods and people is already taking place. Freight and passenger traffic share the same mode of transport when products are shipped in an extra trailer connected to passenger buses on regular bus routes and there is more and more air freight on passenger planes. Railways, however, have only limited combined passenger and freight transport. Examples of co-transportation across industries include Arla and PostNord co-transporting goods and packages in sparsely populated areas to increase trip frequency and MatHem delivering pre-packed bags of groceries to consumers while also taking PostNord's returned parcels from consumers. Competition legislation in this area needs to be overhauled and the legal situation clarified in terms of what is permitted, for more cooperation between competitors to increase coordinated transport, for example outside the inland of northern Sweden and in city centres. In sparsely populated areas and at times when transport frequency is low, freight and passenger transport services can be coordinated through new technology to a greater extent than today.

Example: Freeway coordinates goods and passenger transport within and between organisations in an app. In a rural municipality, medical transport and mobility services are combined with delivery of parcels and post on behalf of the municipality.

The roadmap from KOMPIS, which is part of the "Next generation travel and transport" programme,[33] suggests, among other things, that we need to develop and test a responsibility model for public sector, non-profit and commercial actors to implement MaaS services in non-urban areas, such as a "rural MaaS".

33 KOMPIS, Samverkansprogrammet för Nästa generations resor och transporter, 2018, *Färdplan – Andra lägesrapporten Nästa generations resor och transporter*, revision 2, November 2018.

Industrial symbiosis to increase space utilisation and cooperation between transport buyers and providers

»Resource efficiency could be increased through transparency about transport space utilisation. This requires cooperation between transport providers and transport buyers.«

There is a close connection between transport services and all commerce involving goods and physical services provided in one place (such as craft or other services), which means cooperation with many different sectors. In the future when resources are re-used to the greatest extent possible in a circular economy, there will probably be more demand for freight and passenger transport solutions within the country. In industry, resources not used by one company (and previously regarded as waste) will be used by others (so-called industrial symbiosis). Various platforms will be built. Finland (FISS) and the UK (NISP) have, for example, created national platforms for sharing resources to encourage cooperation across sectors for increased resource effectiveness. Transportation is an essential aspect of sharing resources as effectively as possible in different platforms.

To achieve greater industrial symbiosis transport solutions also need to be more resource-effective. Two ways to measure resource effectiveness in transportation are by measuring *space utilisation* and *utilisation rate*. Below are examples of discussions around space utilisation for freight shipped per lorry. More cooperation is also needed between transport buyers and providers to achieve resource-effective transport.

Many of the observations made may also apply to the other modes of transport, such as rail, air and waterborne. Passenger transport and utilisation rates are discussed in more detail under "Business models".

Space utilisation and utilisation rate

There is significant underutilised capacity in the transport sector, with a low level of space utilisation across all modes of freight transport. An analysis of road haulage by product group shows that for all product groups, on average 20 percent of all lorries drive with no load. They empty to mines, farms, forests etc. before moving the raw materials in the other direction. A trip carrying a load is, however, not necessarily synonymous with high space utilisation. A lorry load of empty carriers (rolling cages, plastic crates, packaging, pallets) is included in the calculation of kilometres driven with a load. By using logistics optimisation, space utilisation can be increased and empty return trips can be reduced in freight transport. An estimate of the utilisation rate for freight transport per lorry, i.e. how much time the lorry is actually driving, is between 50 and 70 percent, depending on if it is distributing small or bulk shipments.[34]

Space utilisation for freight trains, reported as average utilisation of the length of the train, is around 68 percent, and as average utilisation of the train's weight, around 69 percent.[35]

A number of obstacles and challenges that need to be tackled to achieve high space utilisation and utilisation rates are presented below:[36]

- Variations in demand for transport services due to economic fluctuations.
- Customers demanding fast deliveries and "just-in-time" service, resulting in fewer shipments in each delivery.
- Shrinking window of time for loading and unloading, which limits the amount of goods that can be loaded before and during a transport assignment.
- Congestion and queues in densely populated areas, resulting in deliveries taking longer.
- Laws and ordinances regulating vehicle size, weight and freight weight.

34 Samuelsson, A., and Tilanus, C. B., 1997, "A framework efficiency model for goods transportation, with an application to regional less-than-truckload distribution", in *Transport Logistics*, 1/2, pp. 139–151.

35 Swedish Transport Administration, 2019, *Dina val gör skillnad* (https://www.trafikverket.se/resa-och-trafik/Dina-val-gor-skillnad/; accessed 5 November 2019).

36 Andersson, K., and Diamante, S., 2011, *Fyllnadsgrad inom vägtransporter – dokumentation av det enskilda åkeriets miljöprestation – En fallstudie av Sanfridssons Åkeri AB*, University of Gothenburg School of Business, Economics and Law.

- When carrier equipment and types of freight do not match, this limits the type of goods that can be transported in a lorry.
- Having pre-packaged goods on pallets or non-stackable goods limits the ability to utilise the full height of the cargo space.
- Safety instructions on how goods can be stacked during transport and how their weight is to be distributed over the load surface.
- Regulation of work hours for drivers reducing the utilisation rate of vehicles.

Multiple measures are needed to remove the obstacles described above. Several of them are discussed below.

Logistics optimisation

Logistics optimisation, i.e. improved coordination between orders placed and transport planning, can be increased through digitalisation. For example, digital platform technology shows supply and demand for space in the transport system, which could lead to increased space utilisation and utilisation rates, and fewer empty returns.

Transparent and open marketplaces

In both waterborne and air transport, transparent and open public and private marketplaces are needed where more actors can sell their empty cargo space to increase space utilisation and reduce overbooking. In waterborne transport it is still common for shipping companies to have their own shipbroker to buy and sell shipping space. In other words, the marketplace is not transparent for all actors.

It is also important to increase space utilisation on carriers such as pallets, rolling cages etc.

One problem with shipping being relatively inexpensive is that customers do not differentiate their demand sufficiently, but instead routinely choose expedited shipping. One priority going forward is for freight exchanges, shipping agents and fourth-party logistics to include indicators such as resource effectiveness.

Controlling freight transport

Researchers at Chalmers University of Technology have conducted tests with so-called *foliated transportation networks*. Simulations have shown that it is possible to improve resource effectiveness and reduce environmental impact of freight transport by combining two of the transport systems that are used separately today:

- **Direct delivery networks** where freight is driven directly from the point of origin to the final destination.

- **Hub networks** where all goods are first transported to a collection point – a hub – and then forwarded to their final destination.

According to the researchers' models, a transition to this type of foliated (overlaid) transport system would in principle not require any changes to the physical system (the infrastructure) but would only involve how the freight is managed. Above all, foliated transport networks provide an opportunity for shipping of general cargo by, for example, both large and smaller shipping agents.[37]

37 Kalantari, J., 2012, *Foliated transportation Networks – Evaluating feasibility and potential*, Chalmers University of Technology.

Design resource-efficient packaging and pallets

Space utilisation is also affected by the design of packaging, pallets and rolling cages. Carrier equipment that is adapted to only one type of shipment makes it more difficult to reload and is an obstacle to competition. Within the framework of the EU project Food Port, Findus has analysed how it can reduce shipping costs and its environmental impact in exports and imports. The project has focused mainly on three different measures: a transition to more intermodal transportation, replacing high pallets with lower/stackable varieties, and using longer lorries to a greater extent. The result showed that the biggest savings – both in terms of reduced transport costs and lower environmental impact – can be achieved by investing in intermodal transportation or in lower, stackable pallets. In financial terms, the analysis indicated a potential cost reduction of 8.5 percent.[38]

Due to the importance of return systems for carriers, Svenska retursystem has developed a system for reusable crates and pallets for retail.[39]

Half a million pallets would be saved annually if the air in consumer packaging, for example, breakfast cereals, was reduced by 10 percent.[40]

High capacity vehicles for increased resource efficiency

Sweden and Finland are the countries in the EU that have been using high-capacity vehicles the longest, i.e. heavier and longer lorries, which means more freight shipped per lorry. But in order to use the heaviest ones of up to 74 tonnes, roads and bridges need to be reinforced, especially in rural areas. Finland has now introduced the option to use 32 metre lorries. The longest permitted length in Sweden is 25.25 metres. There is now a proposed regulation to allow 32 metre lorries in Sweden but as yet no formal decision has been made. The Swedish Transport Administration has conducted an overall analysis and has concluded that around 4,500 kilometres of public roads are suitable for traffic with longer lorries and the Administration recommends further analysis.[41] The project recommends continued efforts to improve railways, roads and bridges to handle high-capacity vehicles.

Measure air transport

Air and waterborne transport are often included in systems for freight from other continents to Europe (air freight is important for *both* imports and exports) where the first and last stretch of the journey is by lorry. According to the statistics, air freight accounts for a minor portion of total freight volume in the world (>1percent), but 35 percent of the trade value. Almost half of all air freight is currently transported by passenger planes to improve efficiency, reduce operating costs and increase airline revenues. Growth, in other words, is not happening by adding cargo planes but in so-called belly cargo on passenger planes. For this reason we have not placed air freight in a separate category but instead consider it a natural aspect of air transport development, integrated with passenger trends. For example, under our feet when sitting on a Boeing 777 over the Atlantic Ocean there may be cargo equivalent to a load val-

38 Food Port, 2016, *Findus Case – How to reduce cost and environmental impact for Swedish food export and import* (http://archive.northsearegion.eu/files/repository/20141211142528_WP3_1_Cor2_The_Findus_Case_how_toreduce_cost_and_environmental_impact_from_swedish_food_export_and_import.pdf; accessed 20 September 2019).

39 Svenska retursystem (http://www.retursystem.se/sv/; accessed 16 October 2019).

40 APak. *Skickar ni Luft?* (https://www.apak.se/skickar-ni-luft/; accessed 15 October 2019).

41 Swedish Transport Administration, 2019, *Dina val gör skillnad* (https://www.trafikverket.se/resa-och-trafik/Dina-val-gor-skillnad/; accessed 5 November 2019).

ue in 40 containers. Air freight is used for high-value and sensitive goods which, from a safety and time perspective, need to be transported securely and quickly. Air freight is also important for goods with a short product life, such as pharmaceuticals, electronics, spare parts, perishables and express goods. E-commerce, which is largely consumer driven, also favours air freight.

According to the statistics, air freight is so marginal measured in weight that it is not included in the Swedish statistics (except for Cargo IS and Seabury[42]). There are also no statistics on the domestic portion of international freight transport per flight. This means that the data upon which future traffic planning is based for air transport and the infrastructure associated with it may be incomplete. The same is true for passenger traffic. One example is when planning for a railway line to Landvetter Airport it became clear that there were no traffic analysis models for international travel. It was therefore difficult to include the 80 percent of passengers who fly internationally in the train calculation data so that the new line could be correctly dimensioned. The project proposes tasking Traffic Analysis with measuring the domestic portion of air freight and passenger traffic to and from other countries in the same way as for waterborne and rail freight/passenger traffic.

Logistics chains need to be made more efficient by using smart solutions, as globally there is still an average of 40 percent empty space in the cargo holds on planes. Belly cargo is resource-efficient as it shares space for passengers, baggage and freight. With respect to space utilisation in aircraft cargo holds, there is often a disparity between exports and imports, although Sweden has a relatively good balance of the two.

Awareness and cooperation among transport buyers and transport providers

Different product groups use different modes of transport for obvious economic and geographical reasons. In Sweden coal and refined petroleum products are mainly shipped by waterborne transport. Ore is mainly shipped by rail but also to a large extent by road. Food is the product group that is mainly transported by lorry, at 95 percent.[43] The fact that lorries are used to such a large extent is due to their flexibility and that food transport is time-critical. It is, however, important to remember that the same food at some prior point has usually been shipped to a European port to be forwarded to Sweden by lorry or air from another country and is therefore not visible in the Swedish statistics. Incentives need to be created for actors to consider alternative transport solutions to achieve effective change.

The transport system is facing several considerable challenges. One of the most important ones relates to how to find sustainable ways to meet increasing demand from customers for more, faster, cheaper and more precise transport solutions, and at the same time be resource effective.

The role transport buyers will play in the transition to resource-effective freight transport is key. Increased awareness about the importance of resource-effective transport solutions among transport buyers is essential for the right change to happen. To meet the challenges, cooperation is needed among transport buyers and between transport buyers and providers around resource-effective mobility. One example of a transport buyer working horizontally is SSAB which, in cooperation with ICA, is coordinating transport on the northern steel route, on trains between Borlänge and Luleå.[44] Transport efficiency needs to

42 Statistics from IATA and Tulldata. Cargo IS are statistics from IATA, based on the airlines that register the breakdown between cargo agent/airline at IATA's clearing house, which is around 80 percent of air freight. Norwegian is, however, not included in the statistics because it is not an IATA company. Seabury provides statistics based on Tulldata.

43 Traffic Analysis, 2016, *Godstransportflöden – statistikunderlag med varugruppsindelning*, PM 2016:3.

44 Closer, 2018, *Horisontella samarbeten project* (https://closer.lindholmen.se/nyheter/stort-intresse-i-naringslivet-nya-transportlosningar-genom-horisontella-samarbeten; accessed 11 November 2019).

NIGHT DELIVERIES

In a partnership to increase productivity, McDonald's and its logistics partner HAVI are testing night deliveries with Scania's hybrid lorry making quiet night deliveries in Stockholm. Heavy vehicles are not normally permitted to drive at night due to the noise, but electric vehicles and rubber mats alleviate that problem.

Source: McDonald's 2019.

include parameters other than cost, time and delivery reliability. Digitalisation, platforms and cooperation are therefore needed as well.

More flexible delivery terms and times

Delivery times are often a deciding factor in the choice of mode of transport. Transport buyer requirements with respect to delivery terms could be developed by providing more information about, for example, flexible delivery times and optimising purchasing plans to take into account increased resource effectiveness. Increased utilisation rates can be achieved through night deliveries by using quiet electrified vehicles, including quieter unloading through adapted rolling cages and rubber mats. Fully autonomous heavy goods vehicles and buses improve resource effectiveness through flexible use 24 hours a day without the need to adhere to today's driving and rest-time rules for drivers.

Scania's new self-driving, battery-powered concept vehicles – which combine autonomous operation and electrification – could, by using the same chassis but switching modules from passenger to freight, take commuters to and from work in the morning and evening, deliver goods during the day and collect waste overnight.[45]

Digital tools

In addition to large international actors such as DB Schenker, Bring etc., the shipping and haulage industry is also made up of many small firms. The smallest ones do not always have digital tools to optimise routes and space utilisation, even if several of them are connected to large shipping company systems. Here, digitalisation can increase transparency and lead to more co-transportation with increased space utilisation and a higher utilisation rate. The Network for Transport Measures (NTM) has developed a method it calls NTMCalc which is being widely used internationally to calculate the combined environmental impact of freight and passenger transport for transport buyers and sellers.[46] There are digital tools/calculators for intermodal transportation to make it easier to choose which mode of transport to use. One of these is Eco-tool for railways. Some airlines, such as Lufthansa Cargo, are presenting their emissions per route. This means that transport providers can to a greater extent provide a visualisation to their customers of how effective their transport services are.

Increased awareness of transport costs

Private individuals and organisations alike could be made more aware of the transport costs associated with individual products. One way of doing this would be to show a standard estimated cost for the product if transported by a vehicle that meets the latest environmental standards and is in compliance with laws and regulations. This could facilitate

45 Scania, 2019-06-10, *Med konceptet NXT tar Scania stadstransporter till en ny nivå* (https://www.scania.com/group/en/med-konceptet-nxt-tar-scania-stadstransporter-till-en-ny-niva/?sf214071967=1; accessed 6 October 2019).

46 NTM, 2019, NTMCalc (https://www.transportmeasures.org/sv/; accessed 11 November 2019).

EXAMPLES OF COORDINATED FREIGHT TRANSPORT

"Älskade stad" (Beloved City) is the name of an initiative in which Bring, Ragn-Sells, the City of Stockholm and Vasakronan are collaborating on co-loading of waste and freight. This involves freight being transported to a co-loading centre in central Stockholm where it is reloaded onto smaller electric vehicles. When the goods are delivered to shops and offices, the vehicles also collect waste and products to be returned. Recycling materials can then be transported out of the city outside of rush hour times.

Source: Scania 2019.

the freight transport procurement process. Increasing the efficiency of logistics flows and electrification could also reduce transport costs over time. One example of making it easier for transport buyers to purchase sustainable transport solutions is an initiative from the Swedish Association for Road Transport Companies called *Fair Transport 2.0*. This initiative was launched to highlight sound transport solutions from responsible haulage firms that operate with a focus on road safety and climate smart solutions, and have good working conditions.[47]

Provider coordination and co-loading

Increased resource effectiveness can be achieved through delivery coordination, co-loading different types of freight in the same vehicle and intermodal transportation. (To achieve results, cooperation and solutions for the physical flow, the information flow and the payment flow are needed.)

- The physical flow involves the location and operation of reloading terminals, for which planning at the local, regional and national level is required.
- Information flows in the form of data-sharing and advanced forms of cooperation are needed for all modes of transport, as well as among companies, organisations and individuals. Digitalisation could be used in transportation to define data and principles for data sharing, and to identify optimal solutions for freight and passengers with respect to the transport system and its vehicles, reloading points etc. Package sensors could be used to measure and control things like the temperature of chilled goods during transportation. Increased sharing of data from the transport system between transport buyers and sellers could lead to higher space utilisation and utilisation rates.
- Payment flows, including insurance and legal aspects, also impact collaboration potential.

In road haulage the project recommends driving with fossil-free heavy goods vehicles as far as possible (to avoid ineffective reloading) and reload to smaller, electric vehicles in parts of the city where heavy vehicles are not permitted.

Intermodal transportation

Traffic Analysis[48] has concluded that for routes exceeding 300 km there are clear benefits to be gained from reloading freight from lorries to trains. In Sweden only about 8 percent of freight transport routes are that long. According to Traffic Analysis there are currently multiple challenges that need to be tackled in order to bring about large-scale investment in intermodal transportation. Proposals put forward – and that the project would also like to recommend – are the following:

47 Swedish Association for Road Transport Companies, 2019, *Nu lyfter vi fair transport till nästa nivå*.

48 Traffic Analysis, 2016, *Godstransporter i Sverige – en nulägesanalys*, Report 2016:7.

A FREIGHT TRAIN CAN HOLD AS MUCH FREIGHT AS 30 ARTICULATED LORRIES

Distance travelled for one tonne of freight that emits one kilo of carbon dioxide by:

- lorry just over 20 km,
- cargo vessel just over 200 km, and
- freight train just over 9,000

Source: GreenCargo/EcoTransIT.

- Investments are needed in combi terminals – including infrastructure connections to terminals – to handle reloading from road, rail and waterborne transport to make reloading processes faster and more cost-effective.
- In order to build an intermodal transportation network, far more cooperation is needed between various actors than is taking place today.
- To get the shipping industry to choose rail transport, it will also be necessary to tackle train traffic disruptions. Continued investment in improving railway maintenance is also necessary.[49]

Intermodal transportation can be made more efficient when both haulage firms and train operators have access to access information in realtime. This is the topic of a project called DREAMIT at Chalmers University of Technology. Some effects that can be achieved are reduced vehicle turnaround times, containers being ready in advance for customs and collection, and greater flexibility in the event of delays. Other anticipated effects are avoiding vehicles driving empty, fewer lorries on the roads, shorter loading and unloading queues, a reduction in engine idling and avoiding unnecessary transportation in general.

According to the Swedish Transport Administration's Government commission report on increasing freight transport by rail and ship, higher utilisation of cargo cars and holds can be achieved in a number of ways. One way is through horizontal cooperation between train operators, shipping agents and transport buyers; another is through more relevant information being provided.[50] The same conclusion is drawn in a report from a Government commission on horizontal cooperation and open data:

> *By sharing transport and traffic data, cooperation is possible for better utilisation of production resources. This could increase transport space utilisation. Consolidation of transport volumes enables longer and heavier vehicles and vessels to be used, and facilitates reloading to waterborne and rail transport. These are step 1 and step 2 measures from the four-step approach.*[51]

Combi terminal owners, such as municipalities and Jernhusen, should invest in more and different types of combi terminals, such as light combi terminals (sidings where train drivers can load and offload using a forklift). Although construction of new tracks will increase the capacity of the railway system, it is also costly and associated with long lead times.

Night-time rail freight transport between the three metropolitan regions has been offered in a pilot project, but so far not enough transport buyers have been willing to sign up. This may be due to old habits, insufficient information or previous negative experiences?[52]

49 Traffic Analysis, 2016, *Godstransporter i Sverige – en nulägesanalys*, Report 2016:7.

50 Swedish Transport Administration, 2019, *Åtgärder för ökad andel godstransporter på järnväg och med fartyg. Redovisning av regeringsuppdrag*, 2019:140.

51 Swedish Transport Administration, 2019, Swahn, Magnus. *Regeringsuppdrag: Horisontella samarbeten och öppna data*. Report 2019:110.

52 Hult, L., affärsutvecklare Kombiterminaler och Kjellström, O., Public Affairs Officer vid Jernhusen, samtal 4 mars 2019.

Emergence of new business models

»Continued investment to improve public transport together with other forms of combined mobility based on sharing and pedestrian/bike traffic.«

A business model describes how to produce, deliver and charge for a product. In order to achieve resource effectiveness and circularity, today's business models need to be transformed. This is true for an actor that decides to start offering add-on services and products or one that wants to adapt the existing core business to new circular conditions.

We need to rethink and reconstruct many of our processes, structures, habits and behaviours. To guarantee long-term sustainable success, we need to have a holistic perspective on what we are doing, understand how all of the parts interact and impact each other and ensure that our value chains are sustainable for the long term. Including and working in cooperation with all stakeholders is crucial, because no one actor can create the necessary change alone. All of these aspects must be included when new business models are developed.

Transportation business models are undergoing a transformation – from selling vehicles or vessels to offering mobility as a service (MaaS) and logistics as a service (LaaS). To utilise existing capacity in the transport system more effectively, new structures and technologies are needed that can facilitate coordination and collaboration between transport operators, passengers and freight forwarders.

To ensure that new mobility services are resource-effective, new business models based on sharing are needed. Data and digitalisation are essential aspects in the development MaaS and LaaS that promote sharing. There are different transport sharing variations in, for example, public transport (bus, metro etc.), trains, ride-share/carpooling or sharing private cars.

PLENTY OF SPACE

- A train has space for the same number of passengers as six buses or almost 140 cars. The climate impact of a bus is less than 25 percent that of a car in a densely populated area per passenger kilometre, and the climate impact of a train is only 1 percent in comparison.
- A commuter train holds 1,800 passengers and is 214 metres long. If each of those passengers were instead to travel by individual car, there would be a 7.2 km traffic queue.
- A metro/underground train holds around 1,200 passengers. If each of those passengers were instead to travel by individual car, there would be a 4.8 km traffic queue.
- A bus that holds 77 passengers is around 15 metres long. If those 77 passengers instead each sat in their own cars, there would be 308 metre traffic queue.
- A person traveling by car to work emits more than 45,000 times the carbon dioxide of a person taking the metro, tram or train.

Source: WSP 2017, Swedish Transport Administration 2019.

MaaS IN HELSINKI

Finland is far ahead in terms of MaaS. A new transport law in the form of the Act on Transport Services has been adopted, facilitating digitalisation and opening the way for new integrated mobility services. The main purpose is to provide customer-centric transport services. Public sector actors in Finland are testing innovative solutions in practice in order to evaluate them.

Data is essential for the development of MaaS and LaaS

Achieving more resource-effective mobility for both freight and people requires the collection of and access to data, as well as principles for how data can be reliably shared taking into consideration both commercial and regulatory aspects. Technical solutions are also needed to manage the connection of freight and transport resources, as well as sensors and/or actuators to control and measure mechanical systems. Most importantly, a rapid expansion of the 5G network is needed. There is a significant risk that Sweden – and even the whole of Europe – will fall behind both the USA and China in this area.

Data sharing is, however, not without complications. There are obstacles such as competition legislation and regulations like the General Data Protection Regulation (GDPR) to ensure privacy for individuals. Certain information should definitely not be shared without restriction, such as on shipments containing dangerous goods. Unrestricted access to data does not necessarily lead to the development of solutions for increased resource effectiveness. In 2019 the EU approved the revised Open Data Directive (re-named the Open Data and Public Sector Information Directive), which encourages member states to make data available.[53] Some countries, such as Finland, release all traffic data, while others, like Germany and France, are opposed to doing so. A report from Mistra SAMS compared how a number of cities handle mobility data. The cities are trying different ways to process data on how people move around in order to improve mobility by planning routes and the physical city so that they support new needs.[54]

Singapore and London are using their existing administrative structures and allowing technology to drive development. In Helsinki and Oslo the transition to new mobility is seen as disruptive, and brand new systems and regulations are being introduced, As a result, collecting and processing data will initially take longer. In Helsinki the new national legislation that makes transport data available is the basis for new MaaS services. Singapore is using data to meet needs in society by, for example, providing new routes where there is demand, with a focus on digitalisation of both the public and private sectors. London has had a strong "open data" strategy for five years based on the conclusion that shared data facilitates innovation that would not otherwise happen. London's transport data is not, however, connected at the national level but is only for the London region. Norway[55] is working on processing transport data from all public transport companies through a state-owned company with a monopoly to achieve the greatest possible benefits for society, instead of only the actors that collect transport data being able to use it. This is based on the belief that more people will choose public transport if it is easy to find what is offered.

MaaS solutions must be reliable, easy, impartial and flexi-

53 European Data Portal. 2019, *Introducing the new Open Data and PSI Directive* (https://www.europeandataportal.eu/en/news/introducing-new-open-data-and-psi-directive; accessed 17 October 2019).

54 Gullberg, A., Isaksson, K., Kramers, A. H. and Kriukelyte, E., 2019, *The transport sector in transition – different pathways of handling transport data in urban regions of Helsinki, London, Oslo and Singapore*, KTH funded by Mistra.

55 EnTur (https://www.entur.org/om-entur/; accessed 3 October 2019).

ble.[56] There are three ways for transport operators to start taking control over the MaaS platforms in their city:

1. Mobility as a private service: The offerings of Uber, Bolt and Lyft etc. which provide a number of different vehicles in their respective platforms. They can quickly build a large user base and thereby attract capital to offer an enhanced service to their customers.
2. Mobility as a "neutral" service: This is offered by third-party platforms and includes MaaS Global's Whim and MiGo, bringing together private and public traffic operators in the same platform.
3. Mobility as a public service: Public transport operators in a city are all public and private operators using a platform that they control, giving commuters the choice of all the city's mobility solutions.

Integrated mobility services require data from transport providers. Transparent marketplaces require open data. Finland and Norway have chosen different paths, while Sweden is currently somewhere in between. A system was tested with Samtrafiken as the owner of a national platform (similar to Norway's model), but it was unsuccessful due to different objectives among public and private actors, and the fact that the Swedish Act on Public Procurement (LOU) and the Defence and Security Procurement Act (LUFS) currently do not permit it. Now Samtrafiken has been given responsibility by the Swedish Transport Administration for a national data hub for all traffic data, to which all operators – both public and private – must deliver their data. Sweden is also complying with the EU's new Open Data and Public Sector Information Directive. Going forward, Sweden should also develop a clear strategy to ensure that our country has focused legislation to promote the development of resource-effective transport solutions in Sweden and thus also Sweden's competitiveness.

WHAT ADVICE DO YOU HAVE TO SWEDISH POLICYMAKERS? ANNE BERNER, MINISTER OF TRANSPORT AND INFRASTRUCTURE, FINLAND

"Don't regulate competitiveness, instead regulate the use of data. Make a legal clause for open data through open APIs for all companies that want to participate in the transport sector, like the new legislation in Finland. Opening up data for service providers and transport operators should be compulsory. There should be the same ticket and payment system for public transportation across borders in the same way as the airline and hotel industry."

Source: Mistra SAMS 2018.

Public transport

To make it easier for people to use public transport it needs to be easy for the consumer to buy tickets across municipal and county borders. In order for municipal or regional public transport systems to be able to offer the same service, common standards and interfaces need to be in place. In an initiative run by Samtrafiken, 30 or so actors in the sector have worked together and agreed on an interface for a national payment and ticketing standard. In August 2019 the Government appointed a committee of inquiry to look into a national ticketing system for all public transport. The inquiry report, which will be presented in April 2020, will contain a proposal on the structure and operation of a national ticketing solution and how it can be introduced by 2022. The project would, however, like to point out that only 2 percent of all public transport trips in Sweden cross county lines, i.e. where this has not already been solved.

New business models could increase accessibility and reduce the cost of car transportation, resulting in increased

56 Douglas, R., *Autonomy*, speech during the Prague Data City Congress, 30 May 2019 (https://urbanmobilitydaily.com/mobility-as-a-public-service-in-cities/?utm_source=AUTONOMY+-+Whole+audience+B2B&utm_campaign=ca5fb30c05-EMAIL_CAMPA; accessed 23 September 2019).

in car travel. The growth of Uber in New York and several other cities in the USA has, for example, resulted in a reduction of underground travel and significantly increased traffic congestion in the cities.[57] What does society need to do to encourage increased sharing, more public transport travel and resource-effective mobility in general?

The subproject believes that an overhaul of the legislation is needed in order to support continued development. Similarly, the regional public transport authorities should work with Samtrafiken and other private operators:

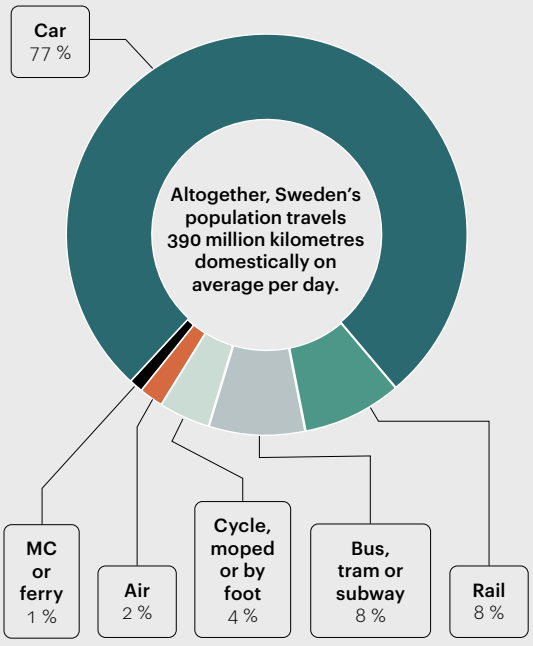
- to ensure that open data is made available in a competition-neutral way,
- to ensure that publicly financed public transport services facilitate the introduction of new mobility services in an easy and transparent way (e.g. first and last mile), and
- to produce sustainable and long-term business models.

Combine public transport with mobility services

To develop urban transport efficiency, public transport needs to be made more efficient and attractive so that passengers will choose public transport wherever possible. New mobility services such as electric scooters, autonomous and other ride-share vehicles, bike pools etc. should be made available at hubs such as bus terminals, train stations and metro stations.

In recent years there has been rapid development of new mobility services, which has opened up a changed market for new actors. At the same time it is evident that legislation, regulations and attitudes have not been able to keep up with the rapidly developing trends. Among other things, the definition of public transport needs to be reinterpreted, including its implications for regional public transport authorities in the development and operation of combined mobility services.[58,59] There are institutional aspects that make it more difficult to develop combined mobility services. They include a lack of methods and tools for long-term innovation partnerships between public and private

SWEDEN'S POPULATION TRAVELS AROUND 40 KILOMETRES A DAY ON AVERAGE WITHIN THE COUNTRY



57 Fitzsimmons, E. G., 1 August 2018, "Subway Ridership dropped again in New York as Passengers Flee to Uber", in *New York Times* (https://www.nytimes.com/2018/08/01/nyregion/subway-ridership-nyc-metro.html; accessed 23 September 2019).

58 Mukhtar-Landgren, D. and Smith, G., 2019, *Perceived action spaces for public actors in the development of Mobility as a Service*, European Transport Research Review 11:32.

59 Smith, G. et al., 2018, *Mobility as a Service: Development scenarios and implications for public transport*, Research in Transportation Economics 69, pp. 592-599.

sector actors[60] and the problems of how to share customer responsibility and distribute customer information.[61]

Mobility services will not lead to a reduction in climate emissions, nor will they increase resource capacity utilisation unless they are accompanied by regulation. It is therefore vital to implement pilot projects for MaaS services as a policy tool to demonstrate and test how policies can be integrated. This is one of the things proposed in the national road map for combined mobility.[62] Among other things, a common vision should be established for how to ensure that combined mobility contributes to long-term policy goals.[63]

Another activity that is proposed in the road map from KOMPIS is a pilot project for self-driving vehicles. As these vehicles will reduce operating costs for transport providers, they have the potential to accelerate development in shared mobility and MaaS services.

The project believes that within the important area of combined mobility the following are needed:

- a clear definition of public transport and its implications for regional public transport authorities for the development of combined mobility,
- continued initiatives to promote public transport together with other forms of combined mobility based on sharing; for example, car sharing, bike pools and ride-share solutions,
- removal of barriers and creation of control mechanisms that ensure sustainable development,
- combined efforts and building on the work carried out in a variety of individual projects, such as KOMPIS (Vinnova), Energy Challenge from Sweden, Swedish Mobility Program (Samtrafiken) and Mistra SAMS (Mistra), and
- continued investment in research and evaluating the effects of implementations and pilot projects in cities as well as rural areas.

Ride-share and private car-sharing solutions

A ride-share car replaces five privately owned cars according to an average of several studies.[64] Parking spaces are also freed up. A study shows that if one ride-share car replaces seven cars, 85 sq. m. of parking space will be released.[65] Several proposals were put forward in IVA's last report on resource-effective business models to make ride-sharing easier by overhauling the parts of the law that are hindering the transition. This includes making parking spaces available for ride-share vehicles, a legal definition of a ride-share vehicle in order to introduce legislation to promote them, a VAT rate in line with other modes of transport, such as taxis, and a change in what is tax deductible for companies so that

60 Smith, G. et al., 2019, Intermediary MaaS Integrators: A Case Study on Hopes and Fears, Transportation Research Part A: Policy and Practice.

61 Smith, G. et al., 2019, Public–private innovation: barriers in the case of mobility as a service in West Sweden, Public Management Review 21(1), pp. 116-137.

62 KOMPIS, Samverkansprogrammet för Nästa generations resor och transporter, 2018, Färdplan – Andra lägesrapporten Nästa generations resor och transporter, revision 2, November 2018.

63 Smith, G. et al., 2018, *Mobility as a service: Comparing developments in Sweden and Finland*, Research in Transportation Business & Management 27, pp. 36-45.

64 Martin, E., and Shaheen, S., 2011, "The Impact of Carsharing on Household Vehicle Ownership", in *Access*, number 38, 2011.

65 Nyblom, Å., and Åkerman, J., 2014, *Kunskapssammanställning om bilpooler, bostadsparkering och attityder till delat bilägande*, KTH.

AVOIDING TRANSPORTATION IS THE MOST RESOURCE-EFFECTIVE SOLUTION

In Tullinge, a suburb of Stockholm, there is a so-called Living Lab where the Mistra SAMS research project is looking into how new digital solutions can help to improve resource effectiveness and reduce carbon emissions. Tullinge residents are offered an opportunity to work at a remote location in a quality-assured workspace – a so-called job hub. Space is reserved in advance using a digital platform the participants have access to. Several services will be offered, such as ride-sharing and an electric bike pool. Companies with employees living in the area may be interested in renting space for their employees, as may municipal authorities who stand to benefit by being more attractive employers. Local businesses will also benefit from people staying within the municipality during the daytime.

Source: Mistra SAMS 2019.

ride-share vehicles can be fully deductible, similar to other transport services.[66,67] Unfortunately the proposals have not yet turned into action. Several of the leading commercial car-sharing companies have stopped operating in Swedish cities because it is not profitable. The most recent example is Volvo-owned Sunfleet, which ceased operations in August 2019. It will, however, be replaced by a similar service provided by the new company "M" – Volvo Car Mobility. M is a car-sharing service that will offer more mobility services but at a significantly high price than Sunfleet.

In addition to ride-sharing, people are sharing their cars with each other. According to a report from research organisation RISE Viktoria, private car sharing is more common in Norway and Denmark than in Sweden, partly because cars are more expensive in our neighbouring Nordic countries. According to the report, in order to promote ride sharing, more clarity is required in laws and regulations so there is less room for interpretation by individuals and salaried employees. Car sharing needs to be worthwhile and easy to declare in tax returns. Without financial incentives and the removal of obstacles like the tax laws, there is a risk of car sharing between private individuals being considered too complicated, and this opportunity for resource effectiveness in the transport sector will be lost.[68,69] One problem with private car sharing is that people often need the car at the same time, such as during school breaks and holidays. Public sector actors such as municipal and country authorities could support this solution as they use vehicles at different times.

Logistics as a service

A market for freight exchanges has been emerging for a number of decades now to increase the degree of cooperation and data sharing around transportation. They are virtual marketplaces where transport companies can search for or offer empty cargo space, as well as fourth-party logistics – external actors who offer a service of organising, coordinating and improving the efficiency of logistics flows for several different companies.

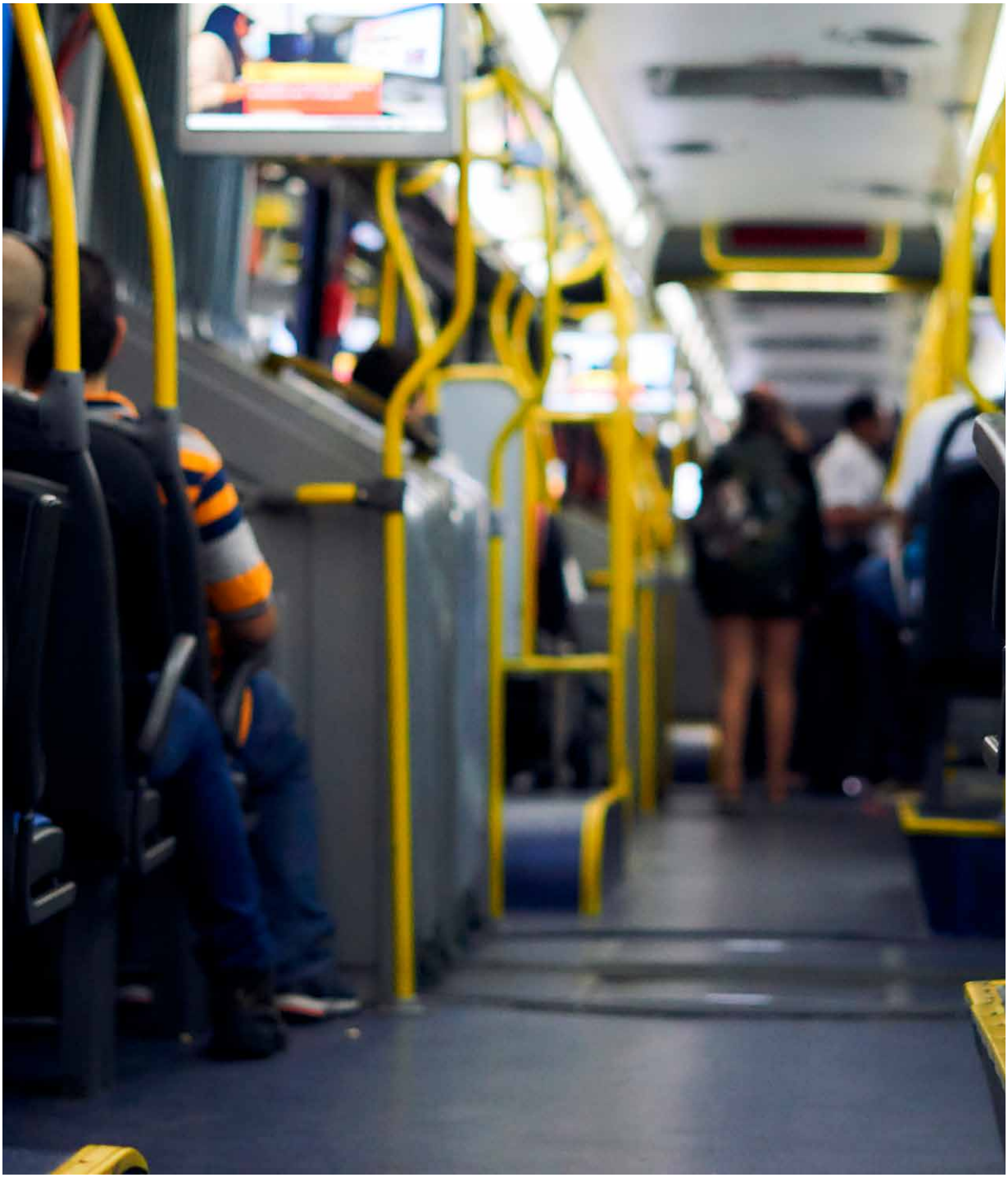
One drawback with freight exchanges is that they often focus on matching transport buyers and sellers, and do not always consider efficiency a priority. Freight exchanges seldom differentiate, for example, between urgent shipments and less time-sensitive ones, which can reduce opportunities to achieve high space utilisation.

66 The Royal Swedish Academy of Engineering Sciences (IVA), 2016, *Capital Goods – a sector report*.

67 Goldmann, M., and Steorn, N., 2017, *Bilpoolsboom – Så går det till! 2030-Sekretariatet*.

68 Olsson, L., and Schnurr, M., 2018, *Regelverksinnovation för P2P bildelning i Sverige*, RISE.

69 Vinnova, *Bildelning blir enklare efter smart policyarbete* (https://www.vinnova.se/m/smart-policyutveckling/bildelning-blir-enklare/; accessed 17 October 2019).



The significance of the financial sector’s role

»Educating financing actors and companies in resource effectiveness and circularity would facilitate the financing process.«

The financial sector wants to see long-term and profitable circular projects in a range of industries. Financial investors require profitable business cases and well-planned and structured projects with a long-term technology perspective. The financial sector also wants to see long-term and reliable strategies.

Today, however, there are no clear goals, indicators or benchmarking of resource effectiveness initiatives that make it easier for the financial sector to evaluate business models.

As part of its regulations the EU has decided to produce criteria for a taxonomy per industry. The EU's taxonomy is a classification tool to classify economic activities based on their climate properties. It is a voluntary system aimed at promoting the necessary investments, e.g. in the form of green bonds, in the enterprises of actors that are trying to make their operations greener.

The financial sector is an important force in the transformation towards more resource-effective mobility. The chapter below first discusses financing of infrastructure projects, which are usually publicly funded. It goes on to discuss financing of private entities in the mobility sector as well as all companies that transport goods. Finally, the financial sector's criteria for providing funding are discussed, as well as what businesses require of the financial sector to obtain resource-effective financing.

Financing the infrastructure

Significant investment will be needed for the anticipated conversion of the transport system to finance the infrastructure for the mobility transformation, such as electrified roads, charging infrastructure, repair and upgrading of railways, and reloading terminals for intermodal transportation. The aspects of resource-effective mobility that the participants in the project's financial sector workshop considered important to finance over the next five years are primarily:

- fossil-free fuel and electrification,
- demand-driven public transport,
- local and shared carpools/ride-sharing,
- digital infrastructure for mobility services, and
- airspace and landing locations for drones.

Longer-term requirements:

- infrastructure reconstruction to include mobility hubs,
- data collection platforms for personal data so that public transport operators can analyse demand,
- 5G infrastructure for vehicle connectivity,
- sustainable mobility in sparsely populated areas,
- high-speed trains and even better maintenance of existing railway, and
- Hyperloop, a transportation system under development to transport goods and passengers at a very high speed in capsules through a system of tubes with very little air resistance.

The infrastructure financing needs are enormous. What options are there for infrastructure investment over and above tax revenue investments? It is important to bear in mind that there are often factors other than securing financing that slow down the process of infrastructure investment; for example, regulation and permit processes relating to charging stations, parking spaces for ride-share vehicles etc. (This aspect is not, however, covered in his report.)

The majority of Swedish infrastructure is built using public funds and only a few projects are based on public-private partnerships (PPP). PPPs involve long-term contracts between the public sector and private companies to provide public services such as roads. In Sweden the Arlanda Line is the only PPP solution for infrastructure being implemented by the Government (RIR 2016:3). The private companies are responsible for financing and building the facilities and

then delivering the required services over a pre-determined period, often between 20 and 30 years. The facilities are then taken over by the Government.[70] The private company or consortium in the PPP also requires compensation for the risk it takes on. The company usually raises funds in the private capital market. Long-term contracts and high risk exposure mean that credit institutions usually charge high fees and interest to cover the type of credit risk associated with PPP projects. The borrowing costs for PPPs are also often higher than when the State is the borrower.

> *A transition from today's infrastructure financing model – i.e. an investment comes out of the national budget in the year it is made – to a public-private partnership (PPP) with a repayment solution will create space in the budget during the first few years of the new arrangement. The possibility of building new products is, however, reduced once the repayments grow in size. PPPs do not, therefore, constitute a new source of funding for infrastructure construction. Designed properly, on the other hand, PPPs drive new and more effective solutions in a sector of the economy with weak productivity development. Analysis of PPPs indicates that there are time savings and fewer instances of costs exceeding budgets, while it has been difficult to identify actual cost savings.*[71]

Sweden has the lowest percentage of PPP solutions in Europe. In Norway and Finland PPP financing is a way to secure investment infrastructure more quickly.[72] In Sweden there are some objections to PPPs, the main argument being that the Government can borrow capital more cheaply than private sector actors and that PPP-funded solutions are therefore more expensive. Private sector actors may, however, be prepared to take on higher risk, which means that investments can be made more quickly than if decisions are taken via the public budget. Another objection against PPPs is that they tie the hands of future generations of politicians because they are in effect forced to spend tax revenue on the decisions made by politicians from the past.

One variation is *procurement of functions* where functional criteria describe *what* is to be achieved rather than *how* something is to be achieved. The criteria are often linked to goals and indicators such as desired effects and results. Expressing needs in the form of desired functions, effects and results makes it possible to come up with proposals for solutions. These solutions can have positive effects such as savings, better quality and increased efficiency, as well as improved competitiveness.[73]

The Faculty of Engineering (LTH) at Lund University and consulting firm WSP have produced a report funded by the Swedish Transport Administration in which they examine ownership and management of Swedish infrastructure. Swedish infrastructure has an estimated value of SEK 4,000 billion. There is also a substantial need for new infrastructure. Privatising suitable infrastructure, such as existing infrastructure, could free up public funds to develop higher-risk projects. There is private capital, such as in pension funds, where fund managers are looking for returns in the transport sector. The private sector can drive digitalisation, electrification and innovation in areas where public sector actors are, in some cases, limited in the extent to which they can focus on innovation. Certain infrastructure is better suited for private investment, such as metro stations where commercial development can lead to better service for passengers, while other infrastructure is best run by public sectors actors, for exam-

70 Arnek, M., Hellsvik, L., and Trollius, M., 2007, *En svensk modell för offentlig-privat samverkan vid infrastrukturinvesteringar, Rapport framtagen av en för Banverket, VTI och Vägverket gemensam arbetsgrupp. VTI rapport 588.*

71 Riksdagen, 2007, *Offentlig-privat samverkan kring infrastructure – En forskningsöversikt*, 2007/08:RFR2.

72 Marckert, P., Nordic Investment Bank, at a Resource Effectiveness and Circular Economy workshop on the financial sector, 7 May 2019.

73 National Public Agency for Procurement (https://www.upphandlingsmyndigheten.se/omraden/dialog-och-innovation/funktion/; accessed 23 September 2019).

ple where there is a risk of a private monopoly or where infrastructure is associated with security risk.[74]

One question the project has asked is how Swedish infrastructure policy can optimise the benefits from private investment capital. Should the Government allow more private financing through, for example, the procurement of functions or privatisation of existing infrastructure to enable faster financing of sustainable and resource-effective infrastructure investment? Can private sector actors help to make public transport and stations more attractive for passengers that normally travel by car? The financial sector wants to invest in green bonds, preferably in infrastructure such as electric roads. The project believes that to increase knowledge about green infrastructure, the Government should invite more actors to participate in finding solutions for sustainable transport of the future.

Another actor that could finance infrastructure investment is Nordic Investment Bank, NIB. Public funding in the form of guarantees, conversion loans or targeted loans could speed up the transition to more resource-effective mobility.

Financing companies that offer resource-effective mobility

The financial sector could help improve resource effectiveness in mobility by financing private enterprises that offer sharing services such as ride-share, electric scooters, mobility hubs etc. Many of these sell services or sharing instead of products. RISE Viktoria has studied the economic and financial consequences when companies shift from a traditional, linear business model to a circular one. They include the following:

- The company ties up more capital in an inventory of products that will be rented out, which impacts the balance sheet.
- Cash flow is more stable in the long term, but in the short term not as strong as with linear sales.
- Rental models require a different pricing model and perhaps also new second-hand markets.
- Products that will be retained longer by the company and rented out need to be of higher quality and designed for circularity.[75]

These factors impact the capital requirement. In the short term more capital is needed for the transition to a circular business model as capital is tied up in inventory. Companies will probably require a higher equity/assets ratio in the future as well, i.e. a higher degree of self-financing than in the past to be more resilient to the increasing pace of change.

Businesses have options in terms of types of financing depending on the company's maturity, ranging from equity, contributions and business angels, to Almi loans, bank loans, venture capital and green bonds. In general enterprises need to become more familiar with the various types of financing offered by the financial sector to understand which types of assets and principles can help bring in capital at each stage.

The Swedish Agency for Economic and Regional Growth offers a transport subsidy to compensate companies in the northernmost counties of the country for cost disadvantages they face due to the transportation distances. The Agency has run a pilot project focusing on transport grants with a resource effectiveness aspect included. The pilot project helped small companies to insource external expertise to make their transport processes more effective and sustainable. Measures included product flow optimisation, switching to a different transport solution, stable delivery times, shorter lead times, cost reductions, co-loading, internal logistics and warehouse management, and packaging optimisation. One of the companies says the following: *"What we learned was that it takes a relative-*

74 Bergström, F. et al., 2019, *Aktiv ägarstyrning av transportinfrastruktur – en framkomlig väg?*, Lund University.

75 RISE, 2019, *Finansiering av cirkulära affärsmodeller – risker och möjligheter*.

ly small financial investment to achieve significant results and effects in circularity and sustainable transportation"[76]

Standard metrics for resource efficiency

Clear goals and measurements for resource-effective mobility would make it easier for the financial sector to evaluate business models. A long-term perspective would also be achieved, which is an essential aspect of the transition to a more resource-effective transport system – at both a national and sector-specific level within the transport sector. The project proposes active investment by the Government in activities and projects aimed at increasing resource effectiveness and circularity. The metrics being developed for the EU's taxonomy for sustainable investment could be used here. It is, however, important to invest in various ways in projects aimed at making operations more resource-effective, and not only in those that are already "green".

The financial sector's information and data requirements in order to evaluate and provide financing will be higher for service-selling companies. One proposal is to start with the framework for each industry in order to produce relevant indicators for the industry. An example of an indicator relevant to resource-effective mobility is a manufacturing company's transport processes and vehicle emissions.

The indicator "C" has been created[77] and is used to measure what portion of a product has "circulated", i.e. left a previous life phase and entered a new one. A circulated part could, for example, be a tyre on a lorry that has been retreaded. C is always between 0 and 100 percent. This indicator works well as a measure of the degree of circularity for simple products that had considerable use before being put back into the market, such as the recycled materials in products, remanufacturing, renovation and use of components in new applications. C does not, however, take into account the lifetime of a product, nor the emissions from the product's usage phase. The C indicator is therefore not suitable as a way to measure circular economy strength in so-called produce-as-a-service systems and the sharing economy. It is also hard to apply to direct re-use of products, such as in second-hand sales.

Reasonable time and administrative requirements for gathering data should be taken into account when producing the types of indicators proposed. Actual outcomes should be subsequently followed up in order to make a comparison with theoretical calculation models and assumptions.

What does the sector want from the financial sector?

New business models will emerge and changes will be made when companies transition from selling products to selling mobility services, such as lorry manufacturers selling tonne kilometres instead of vehicles. Financial actors need to adapt to these new circumstances. A need for more information, advising and cooperation between companies and financial actors will arise and an increased understanding of mobility and new mobility trends would facilitate the financing process. To supplement financial ratios in results and balance sheets, a deeper knowledge is needed of a company's business model and long-term business. This is because a ride-share solution is different from a traditional sales model as it involves selling a service and a new perspective on repayment schedules and capacity, residual value and security.

76 Swedish Agency for Economic and Regional Growth 2019, *Checkar för hållbara och effektiva transporter* (https://tillvaxtverket.se/amnesomraden/regional-kapacitet/transportbidrag-till-norra-sverige/checkar-for-hallbara-och-effektiva-transporter.html; accessed 28 August 2019).

77 RISE, 2019, *Finansiering av cirkulära affärsmodeller – risker och möjligheter*.

Among the ways financing resource-effective mobility and circular business models is different is that investment risk is not assessed in the same way. Aspects that may need to be taken into account are:

- Understanding the residual value of the product and how the residual value can be maintained through new business models where a product is remanufactured repeatedly. How is a car's residual value affected by electrification? How are business models being affected by fewer young people getting a driving licence?
- Understanding ongoing technology shifts and if the infrastructure is in place.
- Understanding who the customers are – or perhaps the customers' customers – and if there will be any change in the chain in the transition from a linear to a circular business model.
- It is possible to make comparisons with examples from other sectors if there is no history or existing market for the business model.
- Can risk be diversified in new ways? One option is *loan guarantor circles* – a type of crowdfunding solution.
- It is possible to find alternatives to traditional guarantees where, for example, a private individual can be a guarantor for a financial actor?

Both financiers and businesses need to be educated in resource effectiveness and circularity in order to have a better understanding of the commercial considerations in connection with a transition to selling a service. Industry organisations and legislators could work together to propose relevant indicators for individual industries and across industries.

In a document with the heading "Accelerating the transition to the circular economy – Improving access to finance for circular economy projects", the European Commission points to seven categories of incentives and their consequences for financing that it thinks would lead to a successful transition to a resource-effective circular economy. Coordination is needed here, as well as a logical order in the transition process.

One of the incentives:

- Improve knowledge of the economics. If a circular business is significantly different from previous models – e.g. renting instead of selling – it is important for financing actors to understand these differences in order to correctly assess the value of the business model. Cash flows are, for example, changed significantly and assets remain on the balance sheet, which means that:
  - solvency will be lower,
  - a time shift in cash flows will increase credit risk,
  - customer loyalty is different compared to a in linear transaction,
  - break-even happens at a different point in time,
  - the initial capital investment and financing needs are higher, etc.

It is imperative for financing actors to understand the difference between linear and resource-effective and circular business models.

Selling mobility services involves complex business models that require a certain degree of maturity. Companies may therefore be reluctant to switch from classic product sales to service sales; companies that could offer a service may not be prepared to abandon their old business model. Assets remain on the balance sheet.

To encourage transport sharing, both suppliers and customers need easy and efficient insurance options. This applies to private individuals who want to rent out/share their car as well as business customers who want to use a transportation service. Sellers of a service will, of course, want to be able to insure their vehicle during the rental/sharing period, and the service buyer will want be insured during the shared trip. Insurance companies should therefore be encouraged to produce new insurance products adapted to sharing services.

Scania's new self-driving, battery-powered concept vehicles could, by using the same chassis but switching modules from passenger to freight, take commuters to and from work in the morning and evening, deliver goods during the day and collect waste overnight.

The need for innovative environments

»To promote innovative resource-effective mobility resource effectiveness needs to be one of the procurement criteria, knowledge of resource-effective mobility needs to increase among procurement officers and standardised metrics need to be developed.«

Our definition of innovation is knowledge that is turned into new value, which involves the development of products, services or organisations in both the private and public sectors. Innovations can range from industrial robots, payment systems and energy efficiency to leadership, business models and healthcare.[78]

In Sweden we are good at creating a climate and an environment for research and innovation, but we are not as good at the scaling up part. If Sweden wants to continue to be at the forefront, we need to ensure that promising innovations have the necessary conditions in which to grow and help our country retain and develop research and commercial enterprise within our borders. This applies to both innovation from academic environments as well as intrapreneurship and entrepreneurship.

Having innovative environments within and across different industries is key here. These environments could, in a very simplified description, consist of networks where, within a limited geographical area, there is access to 1) universities to provide expertise and academic excellence in a given field; 2) public funding and risk-sharing in research and innovation projects; and 3) multiple enterprises in the given sector. The latter also requires access to a functioning market with customers for the innovative products and services. This is particularly important in promoting the growth of SMEs.

It can be a challenge for enterprises to focus on innovation as part of their core business – particularly the implementation phase. It may be easier to hive off a company to test and drive a new business model. This allows the company to define a new customer base and adapt its offering to it, and enables the business to grown from the outside.

In order to handle the challenges that the transport sector will face in the coming decades, Sweden needs to further strengthen its capacity for fast and innovative development. We need to increase the number of innovative environments that harness the full potential within the country in transportation in several focused areas.

Sweden holds a strong position globally in the automotive industry, which is also Sweden's largest export industry. In Sweden there are two dominant regions for the automotive industry which are home to international corporations and universities: Västra Götaland in the west with 42 percent of all automotive employees, and Östra Mellansverige in mid-east Sweden with "Fordonsdalen" (Vehicle Valley) and 31 percent of all employees in the industry. There is also a cluster in eastern Sweden around Kalmar. Mobility innovation is critical for the continued development and growth of these clusters and regions. In order to meet the demands from both policy-makers and customers for increased resource and transport efficiency in combination with electrification, digitalisation and autonomous driving, the private and public sectors need to invest large sums in research, development and innovation. Much of the innovation work is being done by companies, but collaboration in publicly funded programmes is also important. Examples of these types of programmes in the transport sector include the strategic innovation programmes Drive Sweden, InfraSweden 2030 and Innovair, as well as the FFI automotive strategy research and innovation programme.

Sweden also has a number of innovation environments focusing on various aspects of mobility. One of the foremost examples of a successful innovation environment where companies, academia and public sector actors have come together is Lindholmen Science Park which is mainly fo-

78 The Royal Swedish Academy of Engineering Sciences (IVA), 2011, *Innovationsplan Sverige*.

cusing on future mobility. At Lindholmen there a collaboration platform for the maritime sector called Lighthouse, where joint research, innovation and development between four universities and the public and private sectors is taking place to produce secure and sustainable solutions in the waterborne transport sector.

Knowledge and analysis

In addition to the above-mentioned networks in a specific geographical area where there is expertise and academic excellence, available financing and numerous enterprises, "soft variables" are also needed to create a true innovative environment. These include openness, trust, culture, talented and creative individuals, and practical collaboration. The project's workshop on innovative environments also identified several examples of innovation that can promote resource-effective mobility. These include new digital platforms, MaaS, better coordinated intermodality and new public transport solutions.

Clusters act as knowledge and talent hubs where knowledge is exchanged, needs and requirements are identified and solutions are proposed. Bringing together large and small enterprises in multiple industries, researchers and public sector actors in a multi-disciplinary network, creates opportunities to identify not only new customers but also entirely new solutions to problems. Examples of this are the CLOSER project DenCity3 involving 128 participants and 27 different organisations, and Drive Sweden with more than 100 partners.

The foundation for innovation is, however, always people. A mixed heterogeneous environment where different skillsets work together, including those outside traditional technical areas, also promotes thinking "outside the box" and thereby increases the likelihood of innovation.

The project proposes the measures below to increase innovation in resource-effective mobility.

Increased coordination of public funds for innovation programmes

Public funding of research and innovation programmes/projects in the transport sector is channelled through several different actors. To ensure 1) that programmes are focused on the important challenges while also complementing each other, and 2) that the results reach out as far as possible and thereby have the highest possible impact, the subproject has determined that there is a need for increased coordination and a common vision. Vinnova has a key role to play here. A forum for innovation in the transport sector initiated through the IVA *Transport 2030* project previously took on part of this role.

Swedish R&D programmes and calls for grant applications should be designed to reflect priorities and schedules in international programmes – in the immediate future primarily Horizon Europe. This will enable them to play a better role in stimulating Swedish participation in international research partnerships in both the short and longer term, and thereby promote increased international competitiveness.

Test, demonstration and accelerator environments

As many solutions for resource-effective mobility solutions require collaboration between multiple actors, large test and demonstration environments are needed to ensure that products/services are ready to enter a market. One example of this is *Elvägar* (Electric Roads), a programme funded by the Swedish Transport Administration and run

by Siemens, Scania and others, or *AstroZero*, which is a full-scale test and demonstration facility for active road safety solutions. *AstroZero* is jointly owned by RISE and Chalmers University of Technology.

Linked to the test and demonstration environments are *accelerator environments*, i.e. the next step after the incubator stage. An accelerator environment gives a start-up an opportunity to come into contact and build a relationship with large corporations. One example is Lindholmen's MobilityXlab where, following a selection process, start-ups can test their ideas with large participating corporations such as Volvo AB, Ericsson, Volvo Cars and Veoneer.

An increased focus on test and demonstration facilities as well as accelerator environments is necessary in order to develop mobility innovation effectively. Resources need to be allocated for this purpose in the Government's next research and innovation bill. In the same way as research today requires access to large, complex and therefore expensive research infrastructure, innovation also needs innovation infrastructure like test and demonstration environments. For an area that is as broad and multifaceted as transport, it is particularly important for new ideas and concepts to be tested under real-life conditions. In this context it would be of value to test research results in planned new city districts and neighbourhoods, such as in Uppsala and Skellefteå, and in other places where there are ambitions to implement resource-effective solutions.

Innovation procurement and standardisation

Innovation procurement is described by the Swedish Transport Administration as promoting the development and introduction of creative and sound solutions, i.e. innovations. Innovation procurement is divided into three categories: development-promoting procurement, procurement of new solutions and procurement of research and development services. The advantage of innovation procurement over traditional procurement is that there is no precise specification of what will be delivered, which creates more space for innovation.

Authorities should to a far greater extent be able to procure innovation rather than services that solve specific problems. One example is the Swedish Transport Administration's research and innovation initiative, TripleF Fossil Free Freight, aimed at aiding the Swedish freight transport system's transformation, and a programme of the Swedish Transport Administration/Lighthouse focused on sustainable waterborne transport. The purpose of innovation procurement here is to provide the Swedish Transport Administration and society with knowledge and identify test projects. Public authorities and organisations should to a greater extent and wherever possible focus their procurement activities on innovative, resource-effective mobility to help promote innovation in this area and thereby contribute to achieving the goal of a fossil-free transport sector.

The public sector should also use its purchasing power and to a greater extent require new business models like combined mobility. An example of this would be the police force purchasing *mobility* rather than police cars. The providers will then be responsible for delivering a system that is reliable. The public sector could also promote more ride-sharing by setting a good example. Public actors use vehicles at different times of the day than regular car owners so car sharing can reduce congestion and increase efficiency in vehicle use.

The Public Procurement Act (LOU) normally includes transportation of goods and services. According to the National Public Agency for Procurement, three million meals are served daily in Sweden in the healthcare, school and care sectors, and a large percentage of these are transported from one place to another. The Agency has established standards regarding sustainability with respect to freight and passenger transport and vehicles etc. Most of the criteria are related to carbon and other types of emissions, but there are no resource effectiveness requirements. There is also a lack of knowledge about resource effectiveness among municipal and Government procurement officers, which needs to be remedied.

Swedish regions and municipalities are substantial purchasers of freight transport services. Public transport, which is largely fossil free, should serve as a model for continued efforts by municipal authorities towards logistics that use

resources in a smarter way. The public transport system works well in most places regardless of whether it is managed by the municipality itself or procured from a private actor. There are many opportunities to make freight transport not only fossil-free but also more resource-efficient. An overhaul of the competition rules to promote more co-loading could involve removing obstacles preventing greater space utilisation.

Another important obstacle for procurement of resource-effective mobility services is the lack of reliable and standardised metrics for resource-effective mobility. Standardisation in itself is also a crucial factor in the ability to scale up innovation, and especially with respect to innovation procurement in this area. What is needed is both increased awareness of the significance of standards for innovation and increased resources to produce standards for resource-effective mobility. The Swedish Institute for Standards (SIS) should, similar to its current initiative to produce standards for a circular economy, also take the initiative to produce standards for resource-effective transportation. The resources to enable SIS to do this should come from public sources.

Conclusion

The entire transport system, including all modes, must become more resource-effective. This requires development in society towards a more transport-efficient system. New mobility solutions are needed that place a greater emphasis on public transport as well as improved space utilisation and utilisation rates throughout the transport chain, facilitated by digitalisation etc. Similarly, behaviours around and perspectives on transport solutions need to be changed through knowledge-building to promote more conscious choices. More efficient vehicles, fossil-free energy, a transition from road to more energy-efficient modes such as rail and waterborne transport, as well as similar technology-based solutions – these are also important factors in reducing carbon emissions and climate impact. Finally, we need leaders that are not afraid to take decisions and turn them into action, as well as regulation that facilitates investment horizons that reach across mandate periods and party lines.

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