

# Transport and Communications Architecture 2030 and 2050

Final report by rapporteurs



MINISTRY OF TRANSPORT  
AND COMMUNICATIONS



## **Ministry of Transport and Communications**

### **Vision**

Well-being and competitiveness through high-quality transport and communications networks

### **Mission**

The Finnish Ministry of Transport and Communications seeks to promote the well-being of our people and the competitiveness of our businesses. Our mission is to ensure that people have access to well-functioning, safe and reasonably priced transport and communications networks.

### **Values**

Courage, equity, cooperation

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Abstract

The Ministry of Transport and Communications appointed three rapporteurs to produce a vision of how bold development of the transport and communication system could be used to create favourable conditions for Finland's well-being, competitiveness and economy in 2030 and 2050.

The following vision has been defined in the work for 2030 and 2050:

1. New revolutionary technological breakthroughs that will transform the current transport and communication systems are about to happen globally.
2. Traditional traffic and digital solutions will merge.
3. Data will become the primary factor of production and competition.
4. Finland's greatest opportunities lie in quickly and comprehensively utilising the technological solutions being created globally.
5. These opportunities must be seized, as this would allow Finland's particular challenges in internal and external accessibility to be overcome in a sustainable manner.
6. Finland must make radical changes to its existing structures, operating models and decision-making.
7. The objective must be to make Finland the global leader of intelligent transport ecosystems.
8. This requires investment, readiness for change, risk-taking, new skills and a culture of experimentation.
9. Succeeding in this would bring sustainable economic growth, create new business and enable high-quality transport and communications services for citizens.
10. This change must be brought about in a way that benefits every Finnish citizen.

The report describes the dynamics and components of a functional transport and communications architecture: technology and knowledge, skills, infrastructure, pricing and taxation, regulation, safety, accessibility, open interfaces, risk-taking and market pioneering, public-private-people partnerships, and decision-making.

This is the English version of the Finnish report number 7/2017.

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# Part I Summary

Transport and communications have always served society and, thanks to technological breakthroughs, transport and communications have brought about a radical improvement in productivity throughout society.

Transport and communications are closely linked to general social change. Development is guided by global megatrends, the most significant of which are technological development, globalisation and worldwide climate and environmental challenges. In addition to these, demographic changes, urbanisation and new security risks are dictating the future of transport and communications. Great changes are also occurring in consumer behaviour. The key change factor revolutionising the operating environment of transport and communications is, however, technological development.

Information is becoming a critical production factor, and it will control future transport and communications architecture. It is becoming an important competitive factor and enabler of automation and services. Traditional security risks are being radically reduced thanks to new technologies. The security, reliability and data protection of digital systems, both at system level and in the end-user environment, are facing significant new challenges.

Technological development will very strongly affect the development of the transport sector in the coming decades. Finland is currently at a point of transition, where the fields of transport and communications are merging with each other as a result of technological development. This confluence is taking place through digitalisation, smart transport and increasing information.

The basic needs of transport and communications are not, however, changing. Finland's geographical location, dependence on foreign trade and the country's internal structure will continue to determine the needs for system development. Accessibility to and from Finland and the country's internal connections are and will continue to be important and decisive questions.

Finland must respond to the challenge of accessibility by the efficient connecting of transport and communication systems, and thereby by boosting logistics, services and transport. This will give also Finland a great opportunity to succeed in the production and export of new services and products.

The basic technologies of transport and communication are being created globally. Finland's possibilities of succeeding in such competition are limited. Finland's particular opportunity is to emerge as a pioneer in the rapid introduction and efficient application of new solutions. Finland also has the natural prerequisites to create solutions that transcend borders between sectors.

A high level of education, skilled users, an efficient society, critical ICT expertise, strengthening growth entrepreneurship, efficient platforms for digital solutions and effective cooperation between the private and public sectors are the factors by which it will be possible for Finland to become a successful and attractive operating environment. The high costs of logistics and transport are an incentive to take advantage of the latest technology and to boost the efficiency of mobility and transportation more rapidly than other areas.

In future there will be a movement from a road-centred approach to traffic to an ecosystem model. In an intelligent system, mere technology is not enough for success. The biggest win-

ners in the utilisation of technology will be those that can create the best operating environment, ecosystem. If it succeeds, Finland will have the opportunity to make transport and communications solutions a competitive strength, based on competitive expertise, products and services.

Transport and communication networks must therefore be developed in order to achieve synchronised overall benefits. Realising the vision requires the capacity, speed and reliability of the communication network to be at a world-leading level.

The transport infrastructure of the future must have the capacity to serve the need, it must be energy-efficient, be supportive of low-emission transport and must also take into account and utilise the development of automation in transport. The development of transport and communications infrastructure is primarily being controlled by demand and is using new models of funding. Society is responsible for the parts outside the demand-controlled transport and communications system.

Implementation of the vision requires that the quality criteria of the transport infrastructure be redefined. This definition must take into account, among other things, accessibility, the interoperability of systems, the efficiency of travel chains, transport automation and environmental friendliness.

Transport is moving from a standard system towards tailored solutions. In the system of the future, travel and transportation choices will be guided not only by smart systems, but also by dynamic pricing based on time and place. Through dynamic pricing and smart transport services, it will be possible to utilise the capacity of the transport network more efficiently, which will reduce pressure to invest in the network.

Transport and communication services will be produced on market conditions. Services will be tailored to meet the needs of the customer. Services will be produced taking advantage of information and open interfaces. Different forms of transport and technology will be combined in easy-to-use service packages.

The working group has specified a vision for the years 2030 and 2050: "Finland – the global leader in intelligent transport ecosystems". A summary of the vision is:

1. New revolutionary technological breakthroughs that will transform the current transport and communication systems are about to happen globally.
2. Traditional traffic and digital solutions will merge.
3. Data will become the primary factor of production and competition.
4. Finland's greatest opportunities lie in quickly and comprehensively utilising the technological solutions being created globally.
5. These opportunities must be seized, as this would allow Finland's particular challenges in internal and external accessibility to be overcome in a sustainable manner.
6. Finland must make radical changes to its existing structures, operating models and decision-making.
7. The objective must be to make Finland the global leader of intelligent transport ecosystems.
8. This requires investment, readiness for change, risk-taking, new skills and a culture of experimentation.
9. Succeeding in this would bring sustainable economic growth, create new business and enable high-quality transport and communications services for citizens.
10. This change must be brought about in a way that benefits every Finnish citizen.

# PART II Background to the work

## 1. The basis of the work

Transport and communications networks are the backbone of modern society. They have developed to meet the changing needs of commerce and citizens. Thanks to technological breakthroughs, transport and communications have brought about a radical improvement in productivity throughout society.

In autumn 2016, the Ministry of Transport and Communications appointed a group of rapporteurs to draw up a vision of the state of the transport and communications system in the years 2030 and 2050, and to investigate ways of reaching the desired state. The objective of this work was to create a vision of how bold development of the transport and communication system can create a favourable environment for Finnish well-being, competitiveness and the economy.

The assumption of the work is that, in the coming decades, a technological revolution will take place in transport and communications. Forecasting its content and impact is, however, an impossible task. For this reason, the working group has rather tried to create a vision of what kind of operating environment Finland should have in order to gain maximum benefit from it.

Transport and communication systems have principally developed separately from each other. As a result of digitalisation, they are integrating and in future will form a harmonised entity or architecture.

In the early 1980s, who could have forecast the breakthrough of the internet or the development of mobile technology. This vision is the best possible guess about the operating environment of the future and, on the other hand, is an objective that should be actively aimed for through the strategic decisions of society.

We assume that up to 2030 the focus of the development of the operating environment will be in the integration of old and new but, by 2050, we will live in a completely intelligent system.

The connections of transport and communications to the rest of society will deepen. Technology, environmental challenges and social needs in particular will constitute the operating environment of transport and communications. The extensive introduction of digital technology will revolutionise the system. The core of the change will be in the fact that we will move from a rigid standardised system to individual and flexible solutions.

In this work, the main focus of attention has been the construction of the vision, as a result of which, instead of examining individual transport projects and different forms of transport, requirements and indicators of transport and communications architecture as a whole have been evaluated. International and national emissions reduction targets concerning climate and environmental issues have been set such as they are as boundary conditions for this work.

The development of transport and communications is not an absolute value, but its significance arises from the fact that it efficiently serves economic development and national well-being. Transport and communications architecture has three basic aims: 1) to support eco-

conomic growth and competitiveness, 2) to enable effective national transport and communications services, and 3) to create new business. All the conclusions drawn from this work are based on promoting these three objectives.

## 2. Finland as part of a global operating environment

The well-being of a small and northern country like Finland is based on foreign trade. This, however, requires high-quality and competitive transport and communication connections, both into the country and out of it.

Although the world around us is changing, certain boundary conditions remain. Finland is situated on the northern edge of Europe, geopolitically on the border between East and West. Changes in the economies of and political power relations between Russia, China, the United States or the countries of the European Union significantly affect the development of the Finnish economy, foreign trade and the transport and communication system.

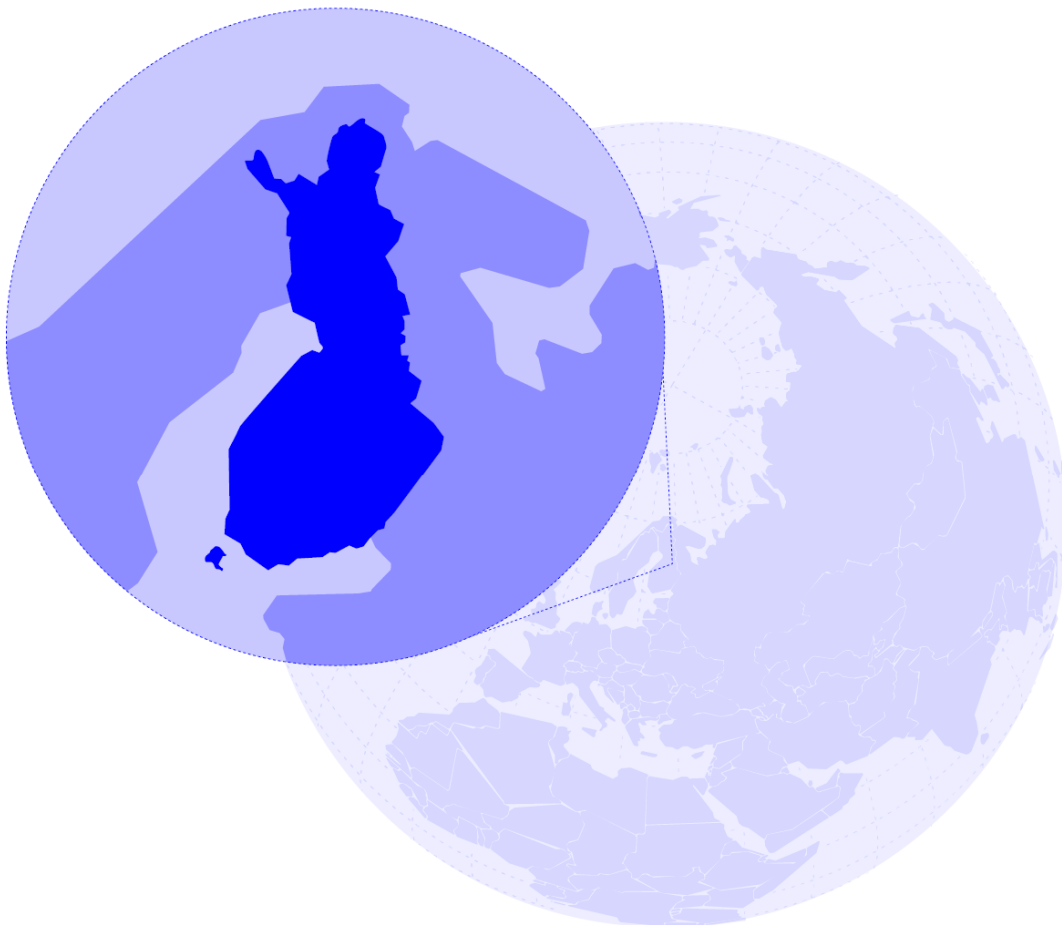


Figure 1. Finland as part of a global operating environment.

Finland is part of the European Union and the European single market. Regulation taking place at EU level also has an impact on the operating environment of Finland's transport and



communication. At its core has been the creation of a joint single market, and thereby an increase in the mobility of goods, services, people and capital between countries. Lack of a digital single market has weakened Europe's competitiveness in the development of digital solutions. According to estimates, an efficient digital single market could increase the GDP of EU member states by €415 billion.

Finland participates in international competition at a logistical disadvantage, and logistical costs in Finland are high on an international scale. Reaching competitiveness and well-being targets requires investments, particularly in three key areas: 1) the creation of efficient and high-quality connections to global markets, 2) taking full advantage of the potential of the Baltic Sea region, and 3) developing and streamlining internal connections.

In the future, maritime shipments, whose share of Finnish exports is about 90% and of imports 80%, will also play a key role in Finland's international transport. Overland connections to neighbouring countries also serve international transport.

In terms of international passenger traffic, air transport is the most important form, and it has enabled the growth in Finland of the tourist business, amongst others. Domestic flights not only serve the country's internal traffic, but also provide connections to international flights. Finland has exceptionally good and diverse international flight connections, which have developed thanks to Helsinki Airport being a hub.

## The basic starting points of Finland's internal transport and communication system

The logistical challenge of a large and sparsely populated country arises from its internal transportation and traffic. In internal transportation in Finland, road traffic plays a dominant role. Finland has dense networks of ports and airports, and they serve the entire country extensively. Rail traffic enables the efficient transportation of goods and passengers.

An extensive transport network, diverse needs for transportation and travel and, on the other hand, sparse traffic flows cause different challenges for the development of the overall system. Public funding used for the maintenance and development of the transport network has been inadequate, which has resulted in a growing repair backlog and a deterioration in the quality of the network. "Repair backlog" means the amount of money needed to get transport routes into a condition corresponding to present needs.

Finland's communication networks, on the other hand, are high-quality and geographically comprehensive on an international scale. Efficient communication networks have enabled high-quality and competitive communication services for both consumers and companies.

Fast wireless 4G networks already cover almost the whole country, and most Finnish households are already served by fast fixed broadband. Public funding is partly being used to finance construction of the broadband network in sparsely populated areas where construction on market conditions is not profitable, for example on account of low subscriber numbers and long distances.

Finland's mobile market is unique on a global scale. Telecommunications companies offer their customers high data transfer speeds and unlimited data transfer at a reasonable price. The number of wireless broadband connections in proportion to the population is the highest of all OECD countries. Per head of population, more mobile data moves in Finnish wireless networks than anywhere else in the world.

According to forecasts, fifth-generation 5G mobile technology will be in full-scale commercial use in the 2020s, and it will raise data transfer to a whole new level. 5G will enable wireless connections that are faster than at present, a shorter delay in data transfer (latency), and better network coverage, security, reliability and energy efficiency. Although 5G will be mobile technology, its introduction will also require an extensive optical fibre network.

Finland's different parts are very different from each other, and the requirements of the transport and communication network vary considerably between areas. Roughly speaking, in one part of Finland transport and communications needs related to natural resources and production are most important and, in another, the requirements of the transport and communication system are strongly related to the needs of transporting people and to goods traffic. In order to be able to survive in global competition, Finland must solve the problem of the people and resources being located in different areas.

### 3. Global megatrends should be utilised in building the operating model and Finland's future

Transport and communications are closely linked to general social change. Development is being controlled by global megatrends, the most significant of which are technological development, globalisation and worldwide climate and environmental challenges. In addition to these, demographic changes urbanisation and new security risks are dictating the future of transport and communications. Great changes are also occurring in consumer behaviour.

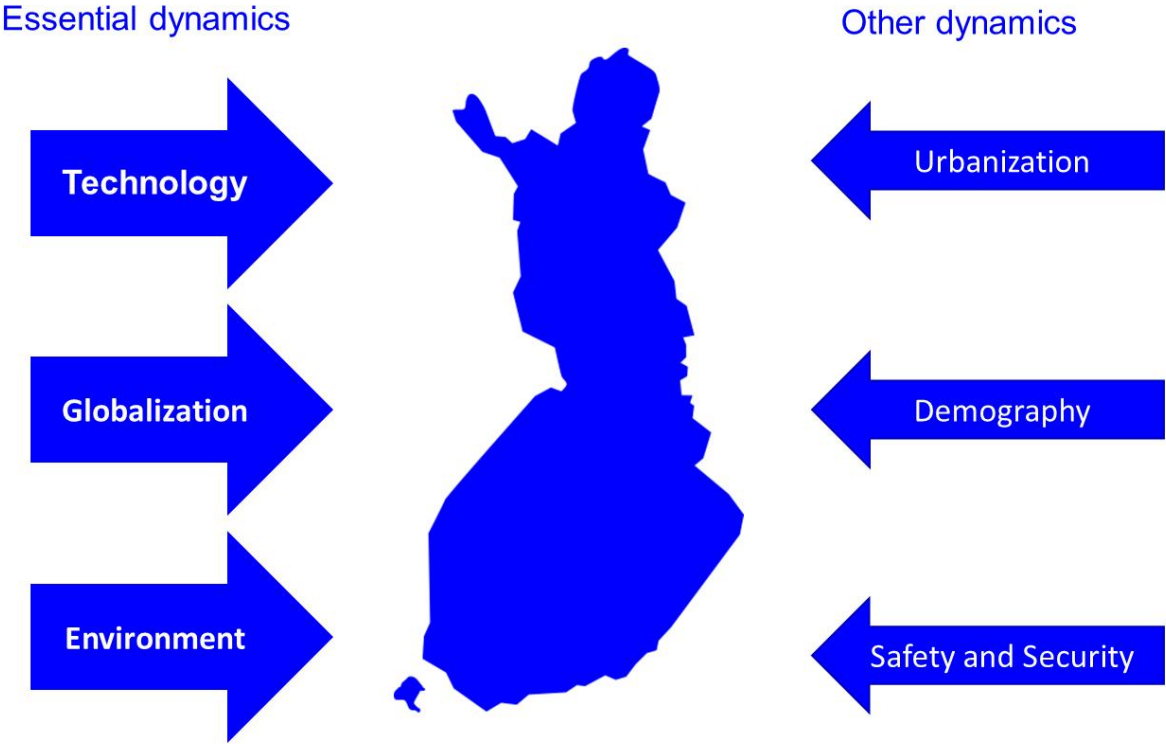


Figure 2. Forces for change in transport and communication architecture.

## Technological development breaking the traditional concept of mobility

The breakthrough of digital technology is taking place at great speed in different areas of society. "Digital revolution" means the development of information and communication technology, which radically changes established operating practices in society. Manifestations of this are, for example, the enormous growth in data volumes (big data) and the significant boosting of its ability to understand through things like artificial intelligence.

Historically, technological breakthroughs have produced innovations and improved productivity. In recent years, growth in productivity has slowed down everywhere. The core of the problem is not in technological potential. Digital technology, automation and robotics offer enormous potential to increase productivity and growth. Making full use of it, however, requires a radical revamp of operating models and decision-making. In the future, economic growth and capital will be increasingly closely tied to information, intelligence and services.

Technological development is the most significant of the factors revolutionising transport and communications architecture. Smart applications of digitalisation, automation and robotics are streamlining and changing traffic and transport in an unprecedented way. The explosive growth in the volume of data, the capacity to understand and the openness of information are enabling the utilisation of increasingly intelligent solutions in transport and logistics, and the development of new kinds of services and business models.

The following factors in particular are changing the transport sector: the development of personal communication devices, the growing importance of data, new transport services, data-controlled logistics, an interconnected transport system, the Internet of Things, and autonomous vehicles. As a combination of these, transport is becoming increasingly data-controlled. Vehicles and passengers use and produce real-time information, for example about the state of traffic, the location of vehicles or parking spaces and their experiences of services.

In an interconnected transport system, vehicles are in contact not only with each other, but also, for example, with traffic control systems. Such an interactive system improves traffic safety, promotes mobility and reduces emissions as a result of traffic optimisation. Autonomous vehicles, for their part, improve safety and increase productivity as, instead of driving, travel time can be used for other activity.

Digitalising transport improves the efficiency of the transport system, but also involves many as yet unresolved issues. Attached are the recognised strengths, weaknesses, threats and opportunities of the merging of transport and communications.

Table 1. The strengths, weaknesses, threats and opportunities of digitalising transport.

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Streamlining transportation and journeys</li> <li>• Real-time information about conditions and traffic</li> <li>• Improvement in traffic safety</li> <li>• Emissions reductions</li> <li>• Big data, open data and the extensive utilisation of data.</li> <li>• The Internet of Things (IoT) and intelligent towns where information moves between different elements (traffic, homes, etc.).</li> <li>• The better realisation of the equality of mobility than at present</li> <li>• More flexible and varied traffic solutions</li> </ul>	<ul style="list-style-type: none"> <li>• The utilisation of new technology in transport requires more efficient, faster and more reliable communication networks.</li> <li>• Requirements for infrastructure</li> <li>• Opening data interfaces and utilising data</li> <li>• The technical deficiencies of autonomous vehicles</li> <li>• Attitudes and slow changes in behaviour</li> <li>• The possibility to use information in a non-desirable way</li> <li>• Unresolved issues of data security and protection</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>• An increase in possibilities to travel</li> <li>• Diverse, shared and tailored travel services based on information</li> <li>• Easy to test standardised routes for automated public transport</li> <li>• More efficient use of time as a result of autonomous vehicles</li> <li>• Business potential logistics and transport services</li> <li>• Introduction of wireless 5G network</li> <li>• 3D printing, the possibility to make logistics more efficient</li> </ul>	<ul style="list-style-type: none"> <li>• The construction of an efficient communications network and network overloading</li> <li>• Vulnerability as a result of dependent relationships between communication, transport and different operators</li> <li>• Increasing risks of data security-, cyber- and data protection, and the abuse of information</li> <li>• Natural catastrophes and accidents</li> <li>• Military threats</li> <li>• The growing need for communication connections and frequencies (the capacity of the present wireless network is insufficient for IoT traffic and transport automation)</li> </ul>

Factors related to the transport revolution, such as automation and new transport services are making traffic flows more unpredictable for the time being. On the one hand, tailored traffic services, high-quality public transport connections and more efficient logistics can reduce traffic volumes. On the other hand, with transport taking place from door-to-door the automation of car traffic may even increase traffic for those groups that at present cannot drive the car themselves (such as children, the elderly or disabled).

New technologies may also change choices for locating functions. For example, 3D printing may increase the local production of products and the dispersion of functions. On the other hand, with the increasing use of consultants and an increase in new working practices independent of location, the position of home in relation to the workplace may lose its significance.

## Globalisation connecting Finland ever more closely to the rest of the world

Globalisation is thoroughly changing Finland. It is advancing the export of Finnish products and services to the world, accelerating the spread and adoption of new innovations and technologies, but at the same time exposing the country to intensifying global competition. Global networking, competition and interdependencies are increasing. For a country like Finland, competitive international transport connections are a basic condition for success in globalisation.

Globalisation is also leading to a structural change in the global economy. Changes are taking place in global power relations as a result of cooperative structures and trading relations between countries. The importance of Asia in the global economy is growing. China in particular is strengthening its position as an economic and political power. The significance of Europe in the global economy is declining.

At present the global operating environment is difficult to forecast. For an open and foreign trade-dependent society like Finland's, effective international cooperation and compliance with an agreed set of rules are of vital importance.

Trade in goods and raw materials has lost its growth potential, but on the other hand, the volume of data traffic, services, software and their related value are growing significantly. Although transport and data traffic are forecast to increase globally, great changes are taking place in their area of focus. The transport and communications system must respond flexibly to these changes.

## New solutions putting climate and environmental questions in the spotlight

Climate change and other environmental challenges are forcing people to change established operating practices and to find new solutions in the transport and communications sector.

The transport sector is a significant producer of greenhouse gas emissions. In Finland in 2015, traffic produced about 11 million tonnes of greenhouse gas emissions, which is about 1/5 of all emissions. More than 90% of greenhouse gas emissions from Finnish transport are generated by road traffic and, in the European Union too, that figure is 73%.

The aim of the Paris Climate Agreement concluded in 2015 is to keep the rise in the average temperature of the Earth clearly below 2°C, trying to limit the rise to just 1.5°C above pre-industrial levels, to strengthen adaptation and resilience, and to direct flows of finance towards low-carbon development. The Paris Agreement does not impose direct numerical obligations on emissions reduction from transport in Finland or elsewhere.

In summer 2016, the European Commission issued the so-called Effort-Sharing Decision concerning emissions reduction obligations. Transport is one of the key sectors covered by the decision. The transport sector is responsible for almost 1/2 of all CO<sub>2</sub> emissions from the effort-sharing sector so, on the basis of this, it will play an important role in achieving the reduction targets. The effort-sharing proposal issued to Finland by the European Commission as a target for the reduction in greenhouse gas emissions by 2030 is -39% from the level in 2005.

National climate and energy strategy outlines concrete measures and targets by which Finland can reach the energy and climate goals agreed in the government programme and the EU by 2030. Energy and climate strategy states that half the emissions from traffic must be cut by 2030 in comparison to the situation in 2005. Measures will particularly be targeted at road traffic. The objective is that, by 2050, road traffic will produce almost zero emissions.

Transport emissions reductions can be achieved in the following ways:

- By improving the energy efficiency of the transport system (walking, cycling, public transport, new transport services, MaaS, digitalisation, the utilisation of data, etc.)
- By improving the energy efficiency of vehicles and other means of transport
- By replacing fossil fuels with renewable and low-emission fuels and propulsion systems such as electricity, hydrogen, biofuels, natural gas or biogas.

As a result of the global operating environment, the regulation of air and sea traffic in terms of environmental objectives will mainly take place in the IMO (International Maritime Organization) and ICAO (International Civil Aviation Organization). Environmental and climate regulation relating to international shipping concerns, among other things, reducing CO<sub>2</sub> emissions, improving energy efficiency and limiting sulphur and nitrogen emissions. On the aviation side, in order to control CO<sub>2</sub> emissions a decision has been made to introduce an emissions trading system, the purpose of which is to ensure the carbon-neutral growth of air traffic, together with other means of emissions reduction.

## An important platform for new transport solutions in cities

Urbanisation is continuing. The population is being concentrated on growing urban regions and the growth areas are expanding geographically. People, trade and industry are also being concentrated in growth corridors between urban regions. The Metropolitan Region is maintaining its important role as the national driving force.

The regional concentration of functions is creating an agglomeration advantage for growth areas and is improving productivity, but is also creating problems with traffic congestion, which must be managed and controlled. The concentration of the population in urban centres requires urban transport to become low-emission and intelligent. Through urban planning, cities and municipalities have a major role to play in what kind of travel and transportation solutions are devised in cities and population areas.

It is estimated that the population in Finland's 10 largest urban regions will increase by about 500,000 by 2030. A shift in the focal point of the population will hamper the cost-effective organisation of transport and communication services in areas where the numbers of residents and users is declining. 'Servitisation' and the information and communication sectors are growing industries in population centres.

Innovation and new operating models are primarily being adopted first in large cities, from which experiences are also gradually being transferred to other areas. The cities can serve as development pioneers and driving forces in the promotion of new mobility and transport models. For the cities, much also depends on the timetable for putting the new transport solutions into practice

## Demographic changes challenge Finland in the production of transport and communication services

The population structure of the future will have a significant impact on the needs to develop transport and communications systems. In Finland, the population is expected to age. The

birthrate is constantly declining, but there are also significant regional differences. The average age of the population is increasing, particularly in eastern and northern parts of the country, mainly because the growth centres located in the south and on the west coast are attracting the young working age population.

According to the population forecast, the share of over-65s in Finland will be 26% in the 2030s, and more than 27% by 2050. This will increase demand for healthcare and social services and have an adverse effect on the dependency ratio. Social need and economic pressure to renew methods of service production are growing. The ageing population will set additional requirements for, among other things, the organisation of individual door-to-door mobility services and easy-to-use electronic digital systems.

## Values and attitudes in transition

Changes are taking place in the values and attitudes of consumers, which are also reflected in transport and logistics. The eco-friendliness of mobility is becoming an increasingly important factor in mobility choices, alongside traditional values of price and speed.

Owning goods is no longer necessarily of such importance, and instead a new kind of culture of sharing is being born. For example, a change is taking place in car ownership, with a move towards the shared use of vehicles. Owning a car can even be seen as a burden and an additional cost item, if reasonably priced and easy door-to-door mobility services are available.

On the other hand, the constantly changing digital culture, interaction and new ways of working are changing mobility needs and habits. Increasing leisure time and a higher level of income are increasing leisure-related travel in terms of both everyday hobbies and holiday trips.

## Preparedness to act in a changing and uncertain security environment

The security environment is in a constant state of change. Finland's foreign trade and transport and communication system are affected by the general security situation, not only in nearby areas but throughout the world. Geopolitical tensions have increased and their impact is also evident in the security situation in Finland and the Baltic Sea region.

The cyber world is creating new kinds of security challenges. Artificial intelligence and digital services of the future are controlling how consumers behave. The significance of data protection and security is being heightened as operations and devices transfer to the web. When transport merges with communication, data system security will become the core of traffic safety. In the cyber world, infrastructure, activity taking place in it and the transfer of data must be protected.

Information growing at an explosive rate has many kinds of purposes and operators have different kinds of interests in it. An interest may be the need of a consumer for a more efficient service or personal data protection, or the need of a company to develop a service or business-related competition. The rules of the game must guarantee that the benefits and security needs of all are equally taken into account. Society cannot function efficiently without secure and reliable transport and communication connections.

# 4. Transformation of transport already under way

In recent decades, transport and communications have developed separately and their starting points have been different. Now the same kind of technologically-driven disruption is taking place in transport and logistics that communications faced in the 1980s and 1990s.

Alongside technology, the change in the telecommunications sector was driven forward by regulation when the gradual liberation of competition created new rules for the sector. The situation particularly changed as a result of the 1987 Telecommunications Market Act, as a result of which Finland became a pioneer in Europe of open telecommunications markets. Thanks to this act, Finnish consumers rapidly had at their disposal new technological solutions and services and the cost benefits arising from them.

A developed telecommunications market, intense competition, the strong expertise of the telecommunications operators and tremendous development of services have also significantly aided the creation and development in Finland of an industry manufacturing telecommunications devices and mobile terminals.

A world-leading communications ecosystem was developed for Finland. Finland is still ranked at the top of the communications market in international comparisons.

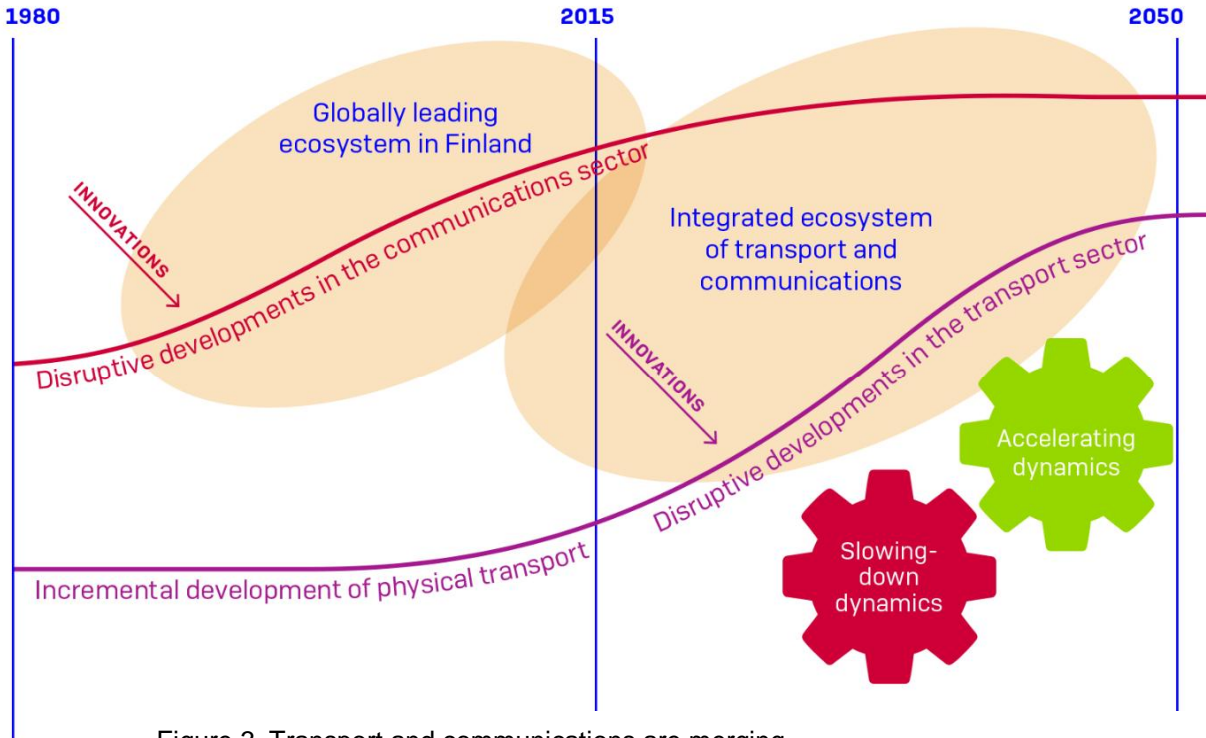


Figure 3. Transport and communications are merging.

At the same time, aims to improve productivity and efficiency have guided transport development. Unlike the telecommunications sector, the change in transport has been gradual. It has been guided by, among other things, improvement in the fuel efficiency of vehicles, improvements in vehicle technology and the growth in traffic volumes.



Finland is currently at a point of transition, where the fields of transport and communications are merging with each other as a result of technological development. Information has emerged as the driver of this merger.

Once they have started, disruptions occur quickly and transport and communications architecture must anticipate changes. If Finland is successful in preparing for transition proactively and boldly, it will be possible to develop an ecosystem for the country combining transport and communications.

Different forces of change affect the speed of development. Of the forces accelerating change, the strongest is technological change. On the other hand, change can be slowed down by, for example, cultural factors such as attitudes or slowly changing infrastructure.

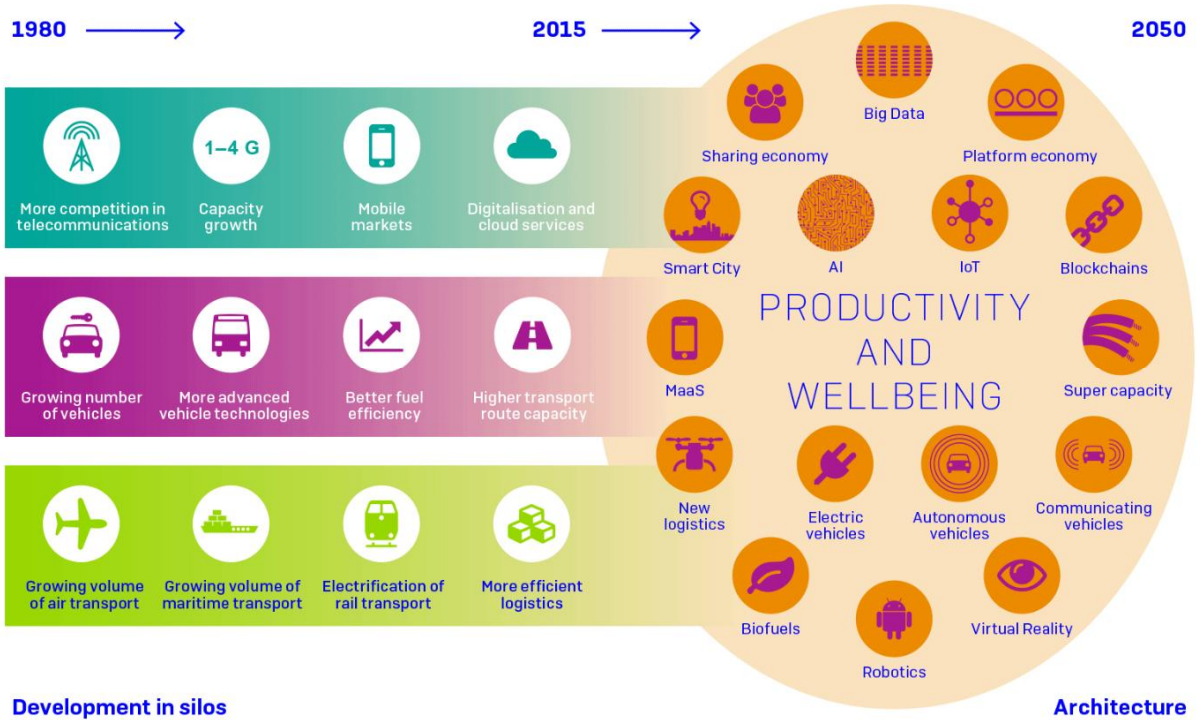


Figure 4. From silos to harmonised architecture

The overall architecture formed by transport and communications together includes many technological innovations and new operating models, which decisively influence how the operating environment of the future will be. The shared impact of the sectors will make it possible to achieve better productivity and social well-being.

Finland has a highly educated population and a positive attitude towards the development and introduction of new technology. Finland also has a strong background in internationally successful technology companies. Because of these factors, it is possible that the revolution will first take place in Finland.

## Part III Vision and conclusions

### 5. Opportunities for Finnish success – images of the future in 2030 and 2050

#### A country of diverse business

Finland's cornerstone is international trade. Finland must have high-quality and cost-effective connections to key market areas in order for its trade and industry to operate competitively both now and in the future.

In 2030, sea traffic will still play the most important role in Finland's foreign trade. Sea traffic enables Finland's foreign trade to take place in a cost-effective, reliable and environmentally-friendly manner all year round. A prerequisite for Finland's competitiveness is an efficient network of ports, and this efficiency must be constantly improved. The network of ports has adapted to the demands of shipping. Ports have formed centralised and competitive cooperative structures. Finland is a pioneer in shipping automation, which significantly improves the safety and efficiency of traffic.

Air traffic efficiently serves the needs of the whole country, Finland's international connections and the development of tourism. Flight connections meet the needs of tourism and business travel in areas without fast overland connections. Direct flight connections from elsewhere in the world and from Helsinki-Vantaa Airport to the airports of Lapland and to other areas important in terms of tourism have been advanced by means of new cooperative models and marketing. Travel chains and transport services to airports function smoothly.

The centres of population and resources have separated as the population has increasingly migrated south and resources have become distributed all over the country. Finland has responded to the transport and communication connection needs of different areas and the potential of all areas has been utilised. The extensive nature of the transport and communications networks and, on the other hand, the sparse traffic flows have forced Finland to seek new solutions, services and funding models to maintain and develop the network and to organise transport services. It has been noted that even connections with little traffic may be strategically significant in terms of certain functions.

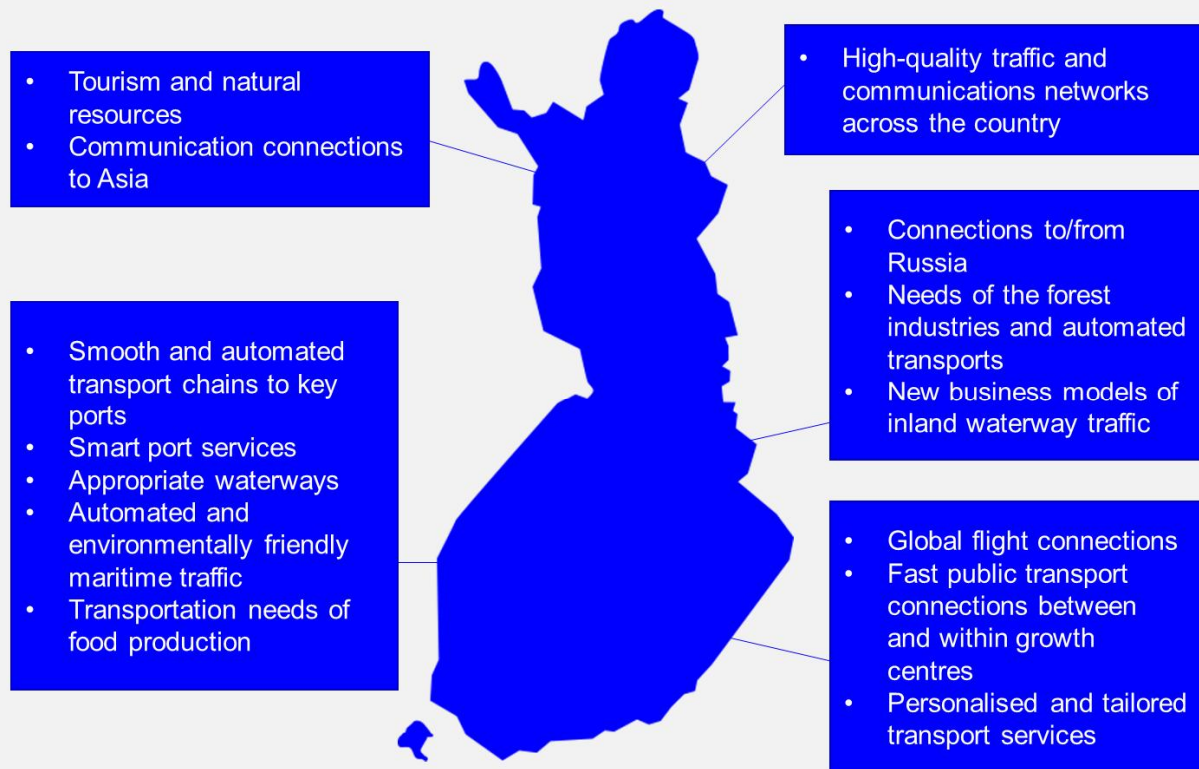
The sustainability of the financing system has ensured the quality and coverage of the transport network, the potential of the business sector and the exploitation of resources. In practice, this means the full-scale utilisation of new financing models.

Finland has responded to the challenge of accessibility by the efficient connecting of transport and communication systems, thereby significantly boosting logistics and transport. The maintenance of the road network and taking care of its condition takes place efficiently and proactively by adding real-time information and developing data collection methods.

#### **CASE: The forest industry as a test laboratory for automatic transport**

In its operations, the forest industry uses parts of the road network with little traffic, where surprising and exceptional situations caused by other traffic are limited. The development of a collection system enabled by automatic logistics and artificial intelligence could already be piloted in wood transportation by the forest industry on sections of the road network with little traffic.

## A country of diverse business



## A millisecond difference in communications

It is extremely important for Finland that the capacity, speed and reliability of the communications network are at a world-leading level in 2030. Finland has become a key link and hub in the global communications network between Europe and Asia. Finland has a relative competitive advantage on account of its geographical location, high-level ICT expertise and safe operating environment and, for these reasons, it has excellent prerequisites to serve as a hub of communications.

### **CASE: The North-East Passage cable**

In super-fast stock exchange trading, even a millisecond is important. The Baltic Sea undersea cable is part of a wider entity linked to the North-East Passage cable running between Europe and Asia. In 2030, the communication distance from Helsinki to Asia has been reduced as a result of the super-fast North-East Passage communication connection, and has made Finland an attractive place for trading and for digital services. The cable has raised the reliability and capacity of international communication connections to a whole new level.

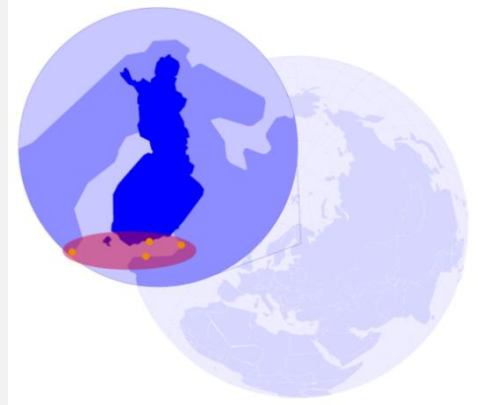
It has excellent prerequisites to serve as a hub of communications.

In 2030, Finland's transport network has comprehensive super-fast fixed and wireless broadband connections, which have responded to the explosive need for data transfer in the transport system. As a result of its reliable and high-capacity communications network, Finland serves as a pioneer in traffic automation and services. High-quality communications networks have also attracted to Finland data centre business and other data-intensive industry, such as operators in the financial sector. The reliability of the operating environment has given Finland a significant competitive advantage.

## The Baltic Sea's international growth area

Under the pressure of globalisation, Finland is positioning itself as part of the Nordic dimension and benefits from cooperation between Nordic regions. Regional cooperation takes place, for example within the framework of diverse policy influence and different cooperative pilot projects.

The Helsinki Metropolitan Region integrates Superfast transport connections as part of the international **Helsinki–St Petersburg–Tallinn–Stockholm growth and commuter area**. The region has diverse international connections to everywhere in the world. The growth area forms a unified commuter area enabled by superfast and reliable transport and communication connections. Public transport in the growth area is based on fast and high-capacity vehicles.



### CASE: Helsinki-Vantaa Airport

Helsinki-Vantaa Airport has improved its position as an aviation hub, particularly in relation to Asia, and has also strengthened its position among the large Nordic airports. The growing economies of Asia have increased demand for air traffic and for tourism in Finland. Fast and eco-friendly railway connections from Finland's largest growth areas to Helsinki-Vantaa Airport have improved. Land use around the airport has ensured the airport's growth potential.

## A revolution in travel to work – getting to work faster

The need for work-related travel has reduced by 2030. In the future, some work is done independent of location, but journeys to work have not completely disappeared. However, the time required for travel to work has been reduced and travel to work has become part of time at work. The commuter areas have expanded as a result of faster connections, which has facilitated the mobility of the workforce and improved the financial sustainability of society.

In urban regions, diverse transport solutions have been built on an advanced public transport system. The transport system serves as an entity in which it is easy to connect different forms of transport into a unified travel chain. It is possible to make journeys to work without owning a car.

With the need for work-related travel having declined, and as a result of alternative fuels and an energy-efficient urban structure and transport system, emissions from journeys to work have been reduced in accordance with climate and environmental targets.

### CASE: Growth triangle

Transport connections within city regions and between city regions are reliable and quick. Cities of Helsinki, Turku and Tampere are connected into one commuting area. The whole region is reachable in less than one hour. Transport services are accessible to all user groups equally and with fair price. The whole growth region is connected by fast rail connections to Helsinki-Vantaa Airport.

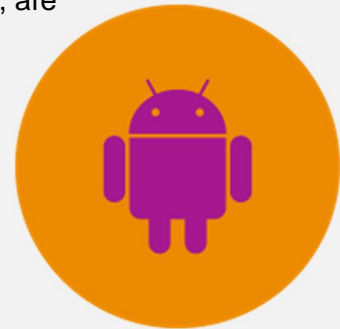


## The transport needs of people in sparsely populated areas and the ageing population taken into account

Fast communication connections have also enabled the use of electronic services, the performance of work and living outside population centres. The digitalising culture has increased engaging in business and social interaction in communication networks. In order to optimise transport in rural areas, comprehensive and real-time information about traffic, transportation and mobility needs has been exploited.

Automated and intelligent mobility services and logistics have streamlined transportation and brought services within reach of the customer. Drones, for example, are widely used to bring services directly to users, which in turn has reduced the need to travel. It has been ensured that the ageing population can also use tailored and digitalised mobility services.

All transportation subsidised by society can be used by all as an open transport service. Transportation is optimised using new solutions based on artificial intelligence. Optimised transportation has reduced costs to society and traffic emissions and has improved the level of service.



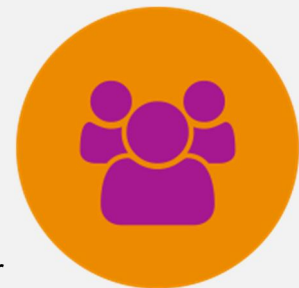
## The best experts in Finland

Finland is profiled as a leading Nordic centre of expertise through its high-quality transport and communication connections, digitalisation, pioneering approach, experimental culture, quality of life and system of education. Its universities, global operators in the sector, growth, company ecosystem and advanced test market create a foundation for the development of new services and the commercialisation of innovations.

Finland is an attractive area for experts and distinguishes itself internationally, not only because of its security, environment, system of education and living standards, but also its intelligent transport and communications system. Experts have enabled Finland to succeed in global competition.

In 2030, the experts in Finnish society are its own citizens, a diverse range of employees in the information sector and top-level global specialists. Finland has tailored and digitalised its education system, is investing in and enabling the constant development of the expertise of citizens and workers, and has opened its doors to top-class international experts.

Although Finland is not the only top-class country in technological development, it distinguishes itself in its multi-disciplinary expertise in application. In order to promote this, cooperation between the private and public sectors has been seamlessly built. Management training has also been revamped to serve the creation of systematic solutions.



## Data as a critical factor in production and competition

In 2050, data will serve as a medium of exchange in the same way that money does now. Data controls future transport and communications architecture. It has become an important competitive factor and enabler of automation and services. Finnish society receives most of its income from refined data. As a result of increasing volumes of data, the transport and communication system has become intelligent and can be used to control how to act in the system.

Each user of transport and communications architecture produces real-time data about his/her activities, which can be utilised in many kinds of services and products. By exploiting different services and artificial intelligence, the producer of data can sell or reassign it to a reliable party, and thereby receive the services that he/she wants to use.

The basis of the principle of MyData is the right of the individual to his/her own data and to use and exploit such data. MyData is first and foremost the sharing and utilisation of personal data and it is ensured that the rights of the individual are taken into account. Consumers can permit the use and reassignment of their data, and in return receive tailored and intelligent services better suited to them as individuals.

Above all, companies compete in the diverse utilisation of data. Companies use open public sector data as a basis for and to develop their services. Companies also offer their own data for the use of other operators and for further processing. All parties have benefited from the sharing of data. Data is at the same time a factor in production and a factor in competition.

By 2030, the key rules concerning data collection, ownership, management, distribution, processing and commercialisation have been decided upon. Finland has been an international pioneer in the creation of these rules. Principles related to the sharing of data concern, among other things, electronic trading, cross-border authentication and different kinds of payment systems, as well as artificial intelligence-based services, for example. The security, reliability and data security issues of digital systems have been resolved both at system level and in the user environment. Users have strong confidence in the principles of data ownership, management and distribution, as well as in data security and protection.

By 2030, Finnish companies have embraced the possibilities of a data economy and have worked boldly in the development of business that utilises data. The greatest winners are those that have succeeded in data collection, ownership and processing for many kinds of services and goods.



# 6. The march of innovations

The development of transport and communications systems is being directed by a growing number of innovations, which are revolutionising established operating practices. Some of the factors changing the system have already been identified, but there are also many factors, whose creation and breakthrough have not yet been recognised.

In addition to influential factors being recognised, it must be estimated what the transport and communication system of the future will look like under the influence of these factors and what the speed of change of different phenomena will be. The speed of change largely depends on the development of innovations and technology, but regulation, other steps taken by society and the speed of adoption by companies and consumers also have a significant impact. By way of the following examples, we try to describe the development trends and the future of transport and communications that arises from them.

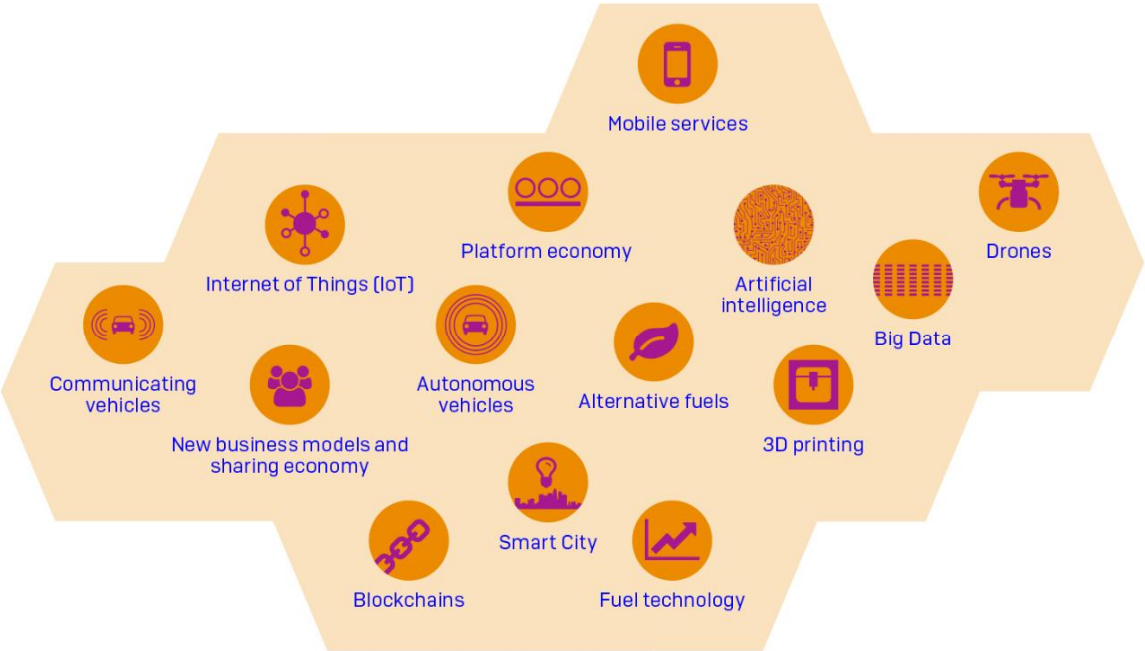
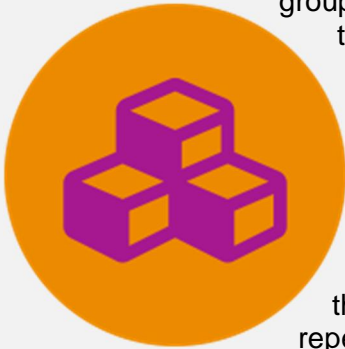


Figure 5. Several innovations affecting transport and communication architecture.

## Data as an enabler for the success of logistics

A revolutionary increase in productivity has taken place in logistics for operators bold enough to rapidly introduce new solutions. The technological revolution in transport has enabled the development of completely new kinds of database logistical business models, and has improved the cost competitiveness of transportation. The efficiency, forecastability and precision of logistics have improved radically. Travel chains and storage work smoothly and automatically. By boosting the efficiency of transportation, the use of transport infrastructure is optimised and the use of capacity improved. Real-time traffic information guides traffic from congested parts of the network onto alternative routes. Transportation is carried out using the form of transport most suitable for the quality of the shipment and most energy-efficient.

New logistics corresponds to the growth in online shopping, and to flexible "shelf-to-door and door-to-shelf" service chains. Collection and distribution transportation is streamlined by grouping and dividing shipments, which has improved, among other things, the fluency and ease of distribution transport in towns and cities. As a result of 3D printing, products are printed in places optimal in terms of production, which creates possibilities to boost logistics in many areas.



The management of data and data sources is key to the success of the logistics sector. The processing of data for the building of new services is a method by which service providers will build their output in the future. Data is trained for the desired task through repetition and through artificial intelligence.

## Automatic sea traffic

In the future, ships will sail on the sea without crew. Through intelligent solutions, transport will seek the quickest and most energy-efficient routes. The development of blockchain technology has enabled the intelligent automation of logistics, and is used to show, for example, the destination of a cargo container. Containers may invite tenders for their own transportation, and direct themselves in the most cost-effective and environmentally-friendly way to the right destination. As a result of efficient optimisation, only full loads will be carried on the sea, both there and back.

Port loading, unloading and storage services are also mainly automated, which has improved the efficiency, punctuality and reliability of travel chains. Ports offer new kinds of maintenance, logistics and information services to operators in the sector.

The environmental friendliness of sea traffic has improved through the introduction of more efficient shipments and low-emissions fuels such as liquid natural gas (LNG) and biofuels. Moreover, a large number of different innovations have been created for the use of shipping, as a result of which the fuel consumption of vessels has plummeted and burdens on the environment have been radically eased. Greenhouse gas emissions from shipping have been reduced by at least 40% by 2050.





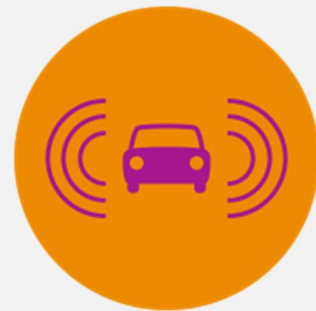
## The vehicle of the future

The vehicle of the future differs significantly from what it is today. The vehicle of the future is shared, electric, autonomous and connected up. In the first stage of change, vehicles are increasingly powered by electricity or other alternative fuels, such as gas, hydrogen or biofuels. By 2030, the efficiency and competitiveness of electric cars has improved significantly, but the scale of their introduction varies by region. The general acceptance of electric vehicles requires, among other things, improvements in battery technology, the reasonable price of vehicles and a charging network providing geographically sufficient coverage. The popularity of electric vehicles is also affected by, for example, benefits for drivers in terms of taxation, parking, charging and the use of lanes.

Automation is developing from public transport trunk connections to cargo traffic and ultimately to private car traffic. The automation properties of vehicles are gradually improving and, at a later stage, fully autonomous vehicles will drive in traffic. Automation has different levels, and fully-automated vehicles in which the system takes care of itself under all circumstances are expected to be launched in about 2020. Nevertheless, wider introduction is slower and varies region by region.

In the transition stage, both traditional and autonomous vehicles will drive in traffic. In a mixed system, not all vehicles are able to communicate with each other, so not all the benefits of automation will yet be achievable. In the transition stage, robot vehicles must be able to interpret the movement of traditional vehicles. Vehicles will be connected to each other through communication networks. In the future, the car too will be a communication tool, just as the mobile phone is today.

The wider introduction of autonomous vehicles requires that safety questions be resolved, prices be on a reasonable level and that people in general have accepted the introduction into traffic of self-driving vehicles. Such acceptance requires, among other things, an increase in understanding and information about autonomous vehicles. By 2030, 15% of all vehicles will be autonomous and, by 2050, almost all vehicles.



## New ownership and operators

A major revolution in vehicle ownership has taken place by 2030. An increasing proportion of both private and goods traffic has transferred to an operating model in which vehicles themselves are not owned but are used when they are needed. Ownership and possession of vehicles are centralised to operators in the sector. Currently private cars are used for all purposes. In future, the use of vehicles will be more efficiently tailored to the varying needs of mobility.



In future, the owners of vehicles and operators will function in the transport sector. The vehicles will be leased to the operators, who will offer diverse and tailored mobility services to customers. Some of the vehicle stock will, however, remain under traditional ownership. By 2030, every tenth new car sold will be for shared use and, by 2050, every second one. The proportion of shared vehicles will, however, vary according to the special features of different regions. Shared travel will proliferate more quickly in large urban regions, and more slowly in small settlements and rural areas.

## Smart urban transport

What will a city look like that was not primarily built on the conditions of vehicles and in which there are no parking spaces? New ways of travelling and new forms of logistics will shape the structure of intelligent cities. Small autonomous vehicles will serve the starts and ends of the travel chain, where high-capacity public transport cannot reach. New mobility services will offer the chance for new types of business and the entry of new operators onto the market.

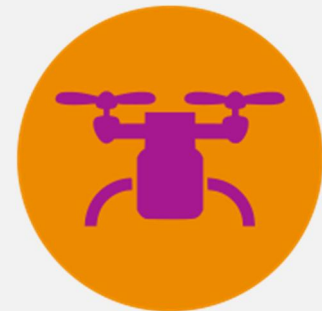
The services of high-capacity public transport will be sufficiently smooth, reasonably priced and competitive in terms of travel time, and private car traffic will not increase in cities as a result of the diverse range of services offered by autonomous vehicles. The introduction of autonomous vehicles will, however, increase the utilisation rate of vehicles, as they will mainly be a shared commodity.

An intelligent city particularly requires proactive and renewable town planning. As a result of the adoption of autonomous vehicles, the need for parking spaces will be reduced. Urban space will be freed up for functions that can make cities more pleasant and improve their competitiveness. Car parks can, for example, be converted into parks, terraces, shopping facilities or pedestrian streets for the use of city residents. On the other hand, a smart city needs new kinds of places for traffic to stop and load and unload passengers, so that transport services can be used flexibly and with ease.



## Airborne transport services

Unmanned aircraft or drones enable the development of a new kind of flexible logistics, such as the conveying of services and goods to areas of sparse population. Later on, new small unmanned aircraft will also carry passengers. Drones may, for example, be useful for the urgent transport of hospital patients or the distribution of medicines.



Intelligent air traffic control will ensure the controlled and safe development of airborne transport services. The growth in unmanned aircraft traffic has reduced congestion in and pressure on the overland network.

By 2030, products and services will be brought to the customer by means of an individual locating address. Dynamic address data will also transport products to the right location, regardless of whether the customer is at home, at the summer cottage or at work.

## Clean and emissions-free transport

The transport of the future will meet to the ambitious needs of emissions reduction. The solution of the future will be clean and emissions-free transport. Transportation and travel will be done using the mode of transport most suitable for the quality of the shipment and most energy-efficient.

The urban structure will reduce the need of the individual to travel, will enable the prerequisites for non-motorised transport, such as walking and cycling, and will support public transport. A pleasant living environment will encourage people to travel using low-emission modes of transport.

Low-emissions transport has also been achieved by developing vehicle technology and fuels and by fully utilising innovations. By 2030, alternative fuels are on the market and in extensive use. By 2030, at least 40% on road traffic is powered by alternative fuels. By 2050, road traffic is emissions-free.

Air traffic uses renewable fuels as much as possible and fuel efficiency has improved. The aim for air traffic is that, by 2050, at least 40% will be using renewable solutions or other solutions that reduce emissions.



Finland is a pioneer in the advancement of new services for transport and in the streamlining of transport, which has great significance in the resolution of climate-related issues. Because climate change and a deterioration in urban air quality are problems affecting the whole world, capabilities and technological expertise in the solution of environmental problems may constitute new export products for Finland.

## 7. Intelligent transport ecosystems

The basic technologies of transport and communication are being created globally. Finland's possibilities of succeeding in such competition are limited. Finland's particular opportunity is to emerge as a pioneer in the rapid introduction and efficient application of new solutions. Finland also has the natural prerequisites to create solutions that transcend divisions between sectors.

A high level of education, skilled users, an efficient society, critical ICT expertise, strengthening growth entrepreneurship, efficient platforms for digital solutions and effective cooperation between the private and public sectors are the factors by which it will be possible for Finland to become a successful and attractive operating environment. The high costs of logistics and transport are an incentive to take advantage of the latest technology and to make travel and transport more efficient.

In future there will be a movement from a road-centred approach to traffic to an ecosystem model. In an intelligent system, mere technology is not enough for success. The biggest winners in the utilisation of technology will be those that can create the best ecosystem for the operating environment. Functions as a whole are affected by the political choices of society, system users, cooperative structures, attitudes and physical structures. The ecosystem must offer a benefit to the customer.

A smart ecosystem is based on the high quality of all constituent factors and on seamless interaction between them. In practice, the performance of the ecosystem is only as strong as its weakest link. The ecosystem should be such that it attracts both international and domestic operators. The operating environment also supports risk-taking and accepts the possibility of failure. Finland must be a pioneer and build the best possible ecosystem. If it succeeds, Finland will have the opportunity to make transport and communications solutions into a competitive strength, based on competitive expertise, products and services.

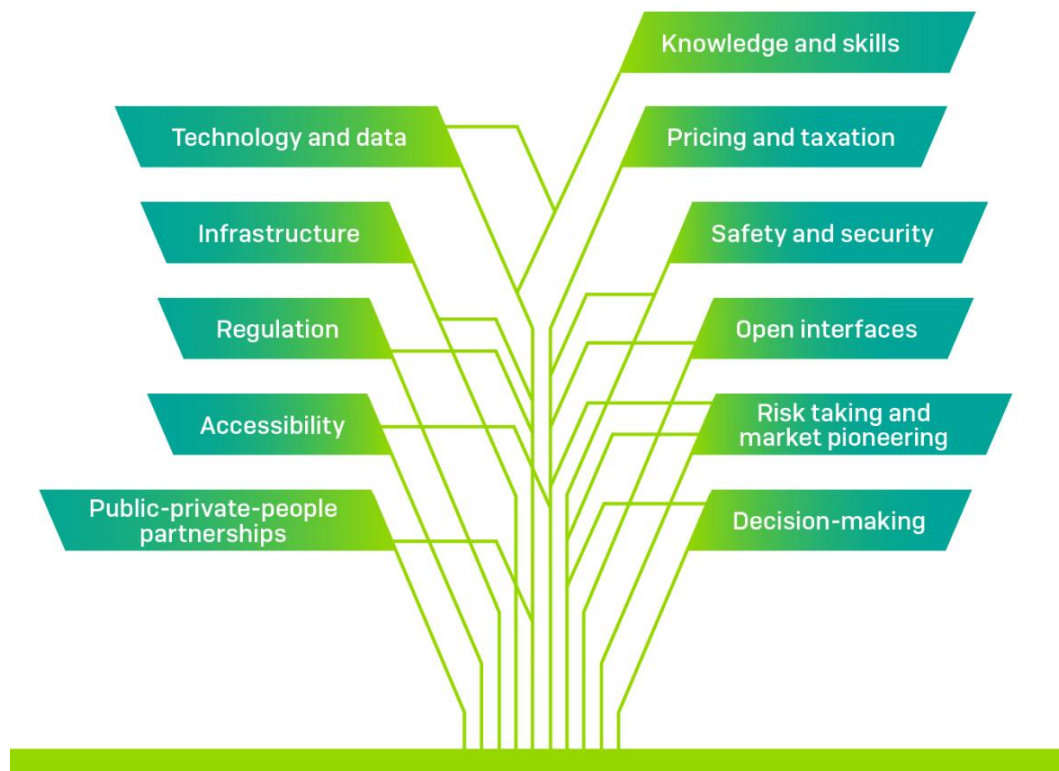


Figure 6. The constituent factors of the ecosystem of an intelligent system.

## Technology and data must be exploited to the full

The operating environment of future transport and communications architecture will be digital, automated, interactive and environmentally friendly. One of the aims, of the development of the ecosystem, is to be able to exploit data and technology to the full. By utilising technology and data, the productivity, efficiency and security of the system are improved. The exploitation, piloting and especially the more extensive introduction of new technologies must be actively promoted.

Investments in research and development activity must be strengthened. A requirement for the introduction and application of the new transport and communications solutions is high-quality research and development work by companies and universities, and the systematic building up of multidisciplinary expertise.

Information is a critical production factor of the ecosystem and a key to future success. Information can create new business and enable new services for transport. Information determines the efficiency of all transport and communications architecture. Deciding on the principles of data collection, ownership, management, sharing, commercialisation and utilisation is a decisive function of the ecosystem. If it so wishes, Finland can also be a pioneer in this.

In the new operating environment, technology platforms can be viewed as new kinds of networked marketplaces where services are built. From the point of view of transport and communications architecture, technology platforms may lead, for example, to new kinds of payment- or taxi-booking services. Effective technology platforms must be quickly adopted with the help of favourable regulation and fast-reacting and open-minded companies and consumers.

Finland must take advantage of the best technology developed globally and, on that basis, specialise in producing new applications broadly serving society. Finnish companies must be at the forefront of building new information-based business.

Technological development is rapid, so it is essential that social structures such as legislation and infrastructure are not bound to a certain technological solution, new or old. Transport and communications architecture must be technology-neutral. The transfer of new inventions from the idea stage to the market is not straightforward and depends on many factors. For example, the reactions of consumers varies widely and are difficult to predict.

## Success can be ensured through diverse capabilities

The transport and communications architecture of the future requires a new kind of expertise. Those operating in the ecosystem must quickly master the basic developing technologies based on which transport and communication services and infrastructure are being developed. In order for the ecosystem to operate as a whole, it must be ensured that each end user is able to utilise it. The competitiveness and practical possibilities of the ecosystem must be ensured through the expertise of the population, a capable workforce and top-level international experts in the field.



The ecosystem focuses on high-level expertise and training. According to need, a multidisciplinary training programme must be built based on, among other things, expertise in artificial intelligence, 'servitisation' and competence in economics and marketing. Particularly with regard to intelligent robotics, data analysis and automation, the increase in expertise requires cross-disciplinary projects and training. Training must serve applicable expertise on the side of data analysis, processing and utilisation, and in the development of open source code. In addition to adapting training programmes, the expertise of those already working in the profession must be improved in accordance with changing needs. Digitality in particular is a tremendous training challenge.

The capabilities of the ecosystem will increase if it succeeds in attracting different product development investments, innovative growth companies and leading companies in the sector. Finland must respond to global competition with the best experts, and be more flexible in opening doors and employment possibilities to top-class specialists in the field.

## The quality of infrastructure must be ensured with sufficient funding

Transport and communications networks must be developed in a synchronised way in order to achieve overall benefits. The benefits of the existing transport infrastructure will greatly depend on the quality and capacity of the communications network that supports it.

Implementation of the vision requires that the quality criteria of transport infrastructure will be redefined. This must take into account, among other things, accessibility, the interoperability of systems, the efficiency of travel chains, transport automation and environmental friendliness. One example of this is the connection of rail and air traffic which has a direct impact on international competitiveness and the quality of services for consumers.

Infrastructure must have a capacity to serve the changing needs of the business sector and citizens. It must be supportive of energy-efficient, low-emissions traffic and enabling of automation. Automation must be taken into account in the maintenance and development of existing infrastructure, and in the planning, construction and maintenance of new infrastructure projects. Urban planning and zoning must also take into account the automation of transport.

Taking care of the basic structure of transport infrastructure is one of the responsibilities of society. Finland must develop a new method by which basic infrastructure can be developed by means of technology in rapidly changing circumstances.

The development of transport and communication infrastructure is primarily controlled by demand. Society takes care of the parts not covered by the demand-controlled transport and communications system that market-based operations do not serve. These parts include 1) responding to the transport needs of sparsely populated areas, 2) maintenance of the parts of the transport network carrying little traffic, and 3) ensuring the capacity of communications where it would not otherwise be done.

New models of financing must be fully exploited. The funding of the future transport network will be based on both public and private finance. Private funding may be targeted at those parts of the network where demand-controlled development is profitable. This may mean, for example, new investments in the development of the rail network, in which user or traffic volumes are great, or the busiest parts of the road network. Private investments in the transport network may also be targeted at a situation in which only one operator will benefit from the investment. This is the so-called "winner pays" principle.

The infrastructure serves as a platform that can be adapted to changing situations and new technology. The infrastructure is independent of technology, service-centred, mindful of the needs of the individual and on equal terms for all those who use it.

## Pricing and taxation important means of control

The present pricing and taxation of transport are not on a sustainable basis. For this reason major changes are needed in pricing and taxation, but they must be made as part of a new operating model. Transport pricing and taxation should be seen as one of the rare and effective positive means of incentive and control of the new ecosystem.

Transport is moving from a standard system towards individual solutions. In the system of the future, mobility and transportation choices will be guided not only by smart data-based systems, but also by dynamic pricing based on time and place. Through dynamic pricing and smart transport services, it will be possible to utilise the capacity of the transport network more efficiently and flexibly, which will reduce pressures to invest in the network.

Dynamic pricing will, however, require an overall review of transport fees and taxation, which must particularly take into account environmental requirements, encourage cooperation between different modes of transport and react quickly to changing demand for services. In the first stage, dynamic pricing must therefore be introduced in the larger urban regions.

Car tax, vehicle tax and fuel tax are taxes based on CO<sub>2</sub> emissions. Such as it is, the present transport tax system based on CO<sub>2</sub> emissions will not work in the new operating environment for transport, when ownership of vehicles and operating practices change, or when the market is increasingly dominated by low-emissions vehicles (such as electricity-, gas- or hydrogen-powered vehicles). The cars of the future and changes in their ownership will not therefore sustain the present tax revenue from transport.

## An intelligent ecosystem needs intelligent regulation

Regulation has a decisive impact on how things function in an ecosystem. Regulation guides development in the right direction from a perspective of social objectives and ensures impartiality in the operating environment, cooperation between different operators and the creation of new operators.

Regulation must be predictable for operators, but sufficiently flexible for the creation of efficient operations. Regulation ensures safe operation and enables market access for new solutions.

Regulation must safeguard the rights of users, and ensure that the system functions in accordance with the law. The job of society is to enable the development of services and the market and to coordinate overall architecture, but not to be an active party in the production of services.

Finland must actively influence EU and international regulation so that the merging of transport and communications can be deepened and new kinds of activity developed. International and EU regulation is highly important in terms of implementing the vision.

Finland has the opportunity to intensify Nordic cooperation and to develop standards, for example, in cooperation with other Nordic operators. Regulation must also support a culture of experimentation. As a small country and with efficient cooperative networks Finland has

good possibilities to be a pioneer in the development of regulation and a test bed for new operating practices and technological solutions.

## The safety of the transport and communication system is the cornerstone of a well-functioning society

Traffic safety can be improved through new technology and automation. New kinds of safety issues are emerging alongside traditional traffic safety, linked to the data security and protection of the whole system and individual operators. As the intelligence of transport increases, so does the vulnerability of the architecture to new kinds of disturbances.

As the Industrial Internet connects up around the world, transport and cities are controlled by different artificial intelligences. Data hubs are particularly vulnerable with regard to data security. Data hubs and interfaces must be safeguarded by the deepest possible data security and risk management in order to ensure the safe workings of society. It is essential to create the ability to return systems to their normal state.

Security must be an element built into the system, which enables effective protection from cyber risks. Users must have confidence in the security of the system, if the benefit of it is to be maximised. There is no completely risk-free system, but it must be sufficiently secure. Cyber security is a business opportunity of the future, allowing the rapid refinement of innovations into different security products and services.

In addition to new security risks, traditional traffic safety must also be constantly improved.

## Accessibility creates competitiveness and equality

Transport and communication architecture must enable a competitive business sector and smooth everyday life. Accessibility is an indicator of ecosystem quality. When an ecosystem is created, accessibility improves. The definition of accessibility can be examined from different perspectives, but the key criteria for accessibility are time, the number of available connections and the price of mobility and transport.

Transport and communication services must basically be produced on market conditions, and services must be tailored to the needs of the customer. The transport services form flexible journey and travel chains using real-time and open data. Different modes of transport and technology are combined in easy-to-use service packages. Competitive operators are responsible for providing reasonably priced and tailored mobility and transport services.

In principle, the transport services should be subsidised by public funds only to the extent that they cannot be provided on market conditions. It must be possible to use the subsidy flexibly for different services so that services are created that correspond to the needs of users as well as possible.

All transportation subsidised by society will in future be organised efficiently utilising artificial intelligence and open data. Subsidised transport must be available to all as an open transport service. With optimised transportation, it is possible to reduce the costs to society and emissions from transport, and to improve the level of service for citizens and the accessibility of areas.



## Open interfaces create new intelligence and growth

The creation of new services and new business requires that interfaces enabling data and its transfer are open to the maximum extent. In order for it to be implemented, movement towards tailored services and dynamic transport price mechanisms requires the opening up of data. Open data requires that issues concerning the protection of privacy be resolved. Open data is a data bank that can be utilised and used for a diverse range of business. The public sector must be a pioneer in the opening of data banks. Much open data is already available but, in data management and utilisation in particular, there is still plenty of room for improvement.

With real-time data, it is possible to develop the up-to-date monitoring of means of transport like public or shared transport and thereby to improve the services provided. Data also serves as a basis for the planning of services and for artificial intelligence-based solutions. Its exploitation also enables the formation of new business models.

On the MyData principle, problems concerning privacy protection can be resolved so that individuals have a possibility to manage their own data and to specify how it is shared and utilised.

## Public–Private–People partnerships bringing cooperation to a new level

The transport and communications market of the future will have many new, as yet unknown, operators. The field of operators will become increasingly varied. At the same time as operators are competing with each other, they will also be engaging in increasing cooperation with their competitors. In order for traditional operators to maintain their productivity, they must find new strategic operating models and new products and services for the market.

Though Public–Private–People partnerships, it will be possible to introduce new innovative services, technologies and bold test platforms for both domestic and international experimentation. Finland has users, innovative companies and a favourable public sector ready for such experimentation. Innovative public procurements will promote the entry to the market of new operating models as well as better-targeted procurements from the start-up sector. Finland must make use of its exceptionally good prerequisites to develop quickly as a flexible platform for experimentation.

Diverse cooperation models must also be applied in transport and communications infrastructure investments and service development. Society has a responsibility for overall architecture but, in its implementation, the private sector is playing an increasingly important role. The private sector could participate more extensively in the development and funding of infrastructure as a partner to the public sector. On the other hand, users can participate in providing the services they use, for example by offering their data for the use of service providers. Each party then benefits from cooperative models.

## Risk-taking and being a market pioneer

The ecosystem must encourage users and companies to try out and introduce new solutions. Taking risks is worthwhile, if it allows a company to achieve a pioneering position in the market, and to improve and accelerate the scalability of business and the success of the company. Risk-taking also entails the possibility of failure. In the ecosystem, failure must be al-

lowed for it to be possible to develop the ecosystem in a technology-neutral way. At the same time, in the ecosystem regulation must, however, enable the development of new business models, for example.

It is, however, possible to share risk between different operators, which may mean targeted joint research and development projects supported by different operators, or the quest for larger investments in Finland by world-leading companies in the sector. In the same way, capital investments in the initial or growth stage of internationalising growth companies and other financial mechanisms and external resources, for example, could be developed to support the vision. Taxation is an important incentive for companies to make bold choices and procurements. In its procurements, the public sector can also take considered and justified risks to promote change.

## Strategic decision-making as part of transport and communication architecture

The ecosystem must be led in a way that transcends the divisions between administrative sectors in order to understand the overall impact. Responsibility for the overall development and execution of transport and communications architecture must rest with the strategic decision-making body. This body must have a picture of future development trends and the development needs of architecture. In order to succeed, transport and communications architecture needs comprehensive management, in other words a 'conductor'.



Figure 7. Transport and communications architecture needs comprehensive management.

## 8. Conclusions

### Vision 2030 and 2050

1. New revolutionary technological breakthroughs that will transform the current transport and communication systems are about to happen globally.
2. Traditional traffic and digital solutions will merge.
3. Data will become the primary factor of production and competition.
4. Finland's greatest opportunities lie in quickly and comprehensively utilising the technological solutions being created globally.
5. These opportunities must be seized, as this would allow Finland's particular challenges in internal and external accessibility to be overcome in a sustainable manner.
6. Finland must make radical changes to its existing structures, operating models and decision-making.
7. The objective must be to make Finland the global leader of intelligent transport ecosystems.
8. This requires investment, readiness for change, risk-taking, new skills and a culture of experimentation.
9. Succeeding in this would bring sustainable economic growth, create new business and enable high-quality transport and communications services for citizens.
10. This change must be brought about in a way that benefits every Finnish citizen.

The working group wishes to highlight several important factors that require particular attention in the development of strategy based on the vision.

### Data – a critical factor of production and competition

1. Data will control future transport and communications architecture. It is becoming a critical factor of production and competition and an enabler of automation and services. In 2050, data will serve as a medium of exchange in the same way that money does now. The winners will be those that have succeeded in data collection, ownership and processing for services and goods.
2. The increase in data is revolutionising our understanding of transport safety. Traditional safety risks are being radically reduced thanks to new technology. Enormous challenges are instead facing the security, reliability and data protection of digital systems, both at system level and in the end-user environment.

3. Clear rules must be specified for the collection, ownership, management, sharing, commercialisation and utilisation of data. In that way, the reliability of the system, the efficiency of the ecosystem and the privacy protection that it requires can be safeguarded.

## Nets and networks as a platform for growth

4. Transport and communications networks must be developed in a synchronised way in order to achieve overall benefits.
5. Achieving the vision requires the capacity, speed and reliability of the communication network in Finland to be at a world-leading level, both now and in the future.
6. Implementation of the vision requires that the quality criteria of transport infrastructure be redefined. This definition must take into account, among other things, accessibility, the interoperability of systems, the efficiency of travel chains, transport automation and environmental friendliness.
7. The development of transport and communication infrastructure is primarily controlled by demand. Society is responsible for the parts outside the demand-controlled transport and communication system. The system of financing the transport network will increasingly consist of both public and private funding. Private funding may be targeted at those parts of the network where demand-controlled development is profitable.
8. Mobility and transportation choices will be guided not only by smart systems, but also by dynamic pricing based on time and place.

## Customer-centred services

9. As far as possible, transport and communication services will be produced on market conditions. Services will be tailored to meet the needs of the customer.
10. Services will be produced taking advantage of information and open interfaces. Different modes of transport and technology will be combined in easy-to-use service packages. Competitive operators will be responsible for implementing the services.
11. Finland must be a pioneer of regulation, as an enabler of information-based transport services utilised by the business sector and consumers.

## Taxation – a positive enabler

12. In the future, the present need for repair and development of the basic infrastructure will not be covered by the taxation of transport based on the CO<sub>2</sub> emissions model. With vehicles increasingly becoming electric-powered, the diversification of fuels and the increase in shared forms of ownership, the present system of taxing and pricing transport will have to be reformed to better meet the needs of future transport. Overall impact must be assessed, particularly with regard to environmental requirements and the demand for transport.

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# Appendix 1. Persons consulted during the work

During their work, the rapporteurs consulted many different parties. In the preparation of the work, the following persons were consulted:

- Jorma Mäntynen, WSP Finland
- Marko Forsblom, ITS Finland
- Mika Aaltola, Finnish Institute of International Affairs
- Jussi Sarvikas, UPM
- Paavo Lipponen, Analyst of the North-East Passage cable
- Reijo Svento, Analyst of the North-East Passage cable
- Mika Pantzar, Consumer Society Research Centre
- Nils-Olof Nylund, VTT Technical Research Centre of Finland
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- Garrett Brinker, City Innovate Foundation
- Dustin Earle, Lyft
- Chi Lee, Lyft
- Sarah Hunter, Google X
- Petri Talala, Idean
- Jesse Maula, Idean
- Reilly Brennan, Stanford
- Winston Choe, ReadWrite Labs
- Michael Chu, Mc Kinsey Global Institute
- Sven Beiker, Mc Kinsey Global Institute
- Sean Ness, Institute for the Future
- Mike Liebhold, Institute for the Future
- Victor Brilon, Renovo Motors
- Chris Heiser, Renovo Motors
- Jason Stinson, Renovo Motors
- Paula Salomaa, Nordic Innovation House
- Jason Radisson, Nauto
- Gabi Holzwarth, Nauto
- Ville Kyrki, Aalto University
- Rauno Kuusisto, Finnish Defence Forces
- Sampo Hietanen, Maas Finland
- Taneli Tikka, Tieto
- Miika Murremäki, Posti
- Pekka Vauramo, Finnair
- Kari Savolainen, Finavia
- Mikko Kiviharju, Finnish Defence Forces
- Henrik Hololei, European Commission
- Jyrki Katainen, European Commission
- Matej Zakonjšek, Transport Commissar Violeta Bulc's Cabinet

- Nikolaus Von Peter, Transport Commissar Violeta Bulc's Cabinet
- Rami Metsäpelto, Finnish Transport Agency
- Kirsi Karlamaa, Finnish Communications Regulatory Authority
- Kari Wihlman, Finnish Transport Safety Agency

A consultation event about the work was held on 15 February 2017. The following parties commented on the work at the consultation event or gave a statement after it.

- Federation of Finnish Enterprises
- The heads of the responsibility areas for transport and infrastructure at Centres for Economic Development, Transport and the Environment
- Metsä Group
- Finnish Transport and Logistics SKAL
- Finnish Forest Industries Federation
- Finnish Association of Purchasing and Logistics LOGY
- Regional Council of North Karelia (EMMA project)
- Helsinki Region Transport
- Lauri Oinonen, Provincial Councillor
- Veikko Hintsanen, Sea Captain
- Markku Eestilä, Member of Parliament
- Sauli Hievanen, Central Organisation of Finnish Trade Unions SAK
- Mika Lautanala, Finnish Funding Agency for Innovation Tekes
- Arto O. Salonen, Metropolia University of Applied Sciences
- Anna-Liisa Tarvainen, Finnish Road Safety Council
- Kaisa Saario, Central Chamber of Commerce
- Suomen paikallisliikenneliitto (Finnish local traffic association)
- Antti Vehviläinen, Finnish Transport Agency
- Timo Niemi, Consumers' Union of Finland
- Tiina Lappalainen, Finnish Association of People with Physical Disabilities
- Anna-Leena Mäkilä, Finnish Port Association
- Markus Lassheikki, Central Union of Agricultural Producers and Forest Owners MTK