



Ministry of Transport
and Communications

Robots on land, in water and in the air

Promoting intelligent automation in
transport services

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



Ministry of Transport and Communications

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<p>Abstract</p> <p>Prime Minister Sipilä's Government Programme outlines open-minded utilisation of digitalisation in the entire society as a key to improving Finland's competitiveness. Digitalisation is also changing the mobility of people and goods in many ways, including the related business models. This development is reflected in the increase of intelligent automation in transport, in other words automatisisation. It offers opportunities to improve the safety, efficiency and sustainability of transport and goods services.</p> <p>This first draft plan describes applications and opportunities in intelligent automation in transport and the prerequisites for further development of automation. The plan identifies measures that can improve Finland's capabilities and possibilities as automation makes headway.</p> <p>The Government Programme stresses deregulation and easier arrangement of experiments. Even the current Finnish legislation allows experiments of automated cars on the roads if test number plates are used. Help in practical matters relating to experiments is provided by the single contact point set up for this purpose in the Finnish Transport Safety Agency, Trafi.</p> <p>In the field of aviation, the Finnish Transport Safety Agency is drafting provisions on unmanned aircraft systems. The aim of this work is at light and modern regulation. Innovative solutions are being developed to meet the challenges of unmanned aviation: operators in the sector are networking and they are actively informed of opportunities provided by legislation.</p> <p>In maritime transport, the relation between regulation, both national and international, and use of automation must be examined. Regulation should be developed to allow automation experiments. Already at this point experiments relating to automated vessels can be carried out in national transport and in Finland's territorial waters. In rail transport, a proactive approach in the development of international regulation is needed to enable experimenting. For example, new railway safety equipment could speed up the development of automated control of trains.</p> <p>Finland has every possibility to become the world leader in the development of transport automation: it possesses a clear vision, traditions in information and communications technology, expertise in robotics and work machinery, and skills to operate in winter conditions. Finland has a chance to become known as the Arctic test environment for transport automation: if it works in Finland, it will work anywhere!</p>	

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Foreword

Prime Minister Sipilä's Government Programme notes that open-minded innovation based on experimentation and digitalisation are key to Finland's competitiveness. Another important goal is accelerating the creation of innovation and service platforms in transport and travel.

We in the Ministry of Transport and Communications strongly feel that intelligent automation plays a key role in the digitalisation of transport, which will in many ways revolutionise both travel and transport services and the business models of companies offering these services. While the automation of transport is not a new phenomenon, it is now progressing rapidly, and in another few years robots on land, in water and in the air will be part of our everyday lives. The most important drivers for transport automation are expectations of improved safety and productivity.

This plan has multiple aims; it takes a look at the potential offered by the general development of robotisation and its current status in Finland. However, its main focus is on providing an overview of the state of play, potential and challenges of intelligent automation and giving some indications of how we can make a determined effort to take the position as world leaders.

This plan is the first draft on the theme. Rather than being written in stone, it is to be continually updated. We are delighted at the high number of stakeholders who have already participated in its preparation, and new views and ideas are continuously welcome. In particular, we would like to encourage the stakeholders to come up and experiment with new ideas, learn from their mistakes and try again. The way forward is through open cooperation, so please feel free to join us: this is where the work begins!

Helsinki, 1 September 2015

Kirsi Miettinen
Director of Unit, Transport Safety and Automation Transport Policy Department

1. Introduction

Robotisation plays a significant part in the rapidly progressing digitalisation development. One of the most startling manifestations of digitalisation is that it will eliminate a large share of the current jobs: the Research Institute of the Finnish Economy (Pajarinen & Rouvinen, 2014) estimates that one job out of three will disappear in Finland. A particularly visible role in this development will be played by robotisation: quite a number of tasks performed by humans today will be carried out by means of artificial intelligence tomorrow. As digitalisation progresses, however, it will also result in a classical example of creative destruction: it will produce new jobs in novel types of work of the future. The countries on the front line of digitalisation will also stand to benefit from it the most. Consequently, we should actively strive to be on the leading edge of this development if we wish to hold on to the welfare of our country. Open-minded utilisation of digitalisation is also highlighted as a key factor for improving Finnish competitiveness in Prime Minister Sipilä's Government Programme.

Finland has everything it takes to become a leading country of digitalisation. Some of these capabilities are related to general factors, including the extensively high level of education of Finnish people. Others, on the other hand, are directly associated with digitalisation, such as traditionally strong expertise in radio technology and a pioneering role in mobile technologies. In the international context, we also have extremely solid competence in an area that has turned out to be essential: creating information-based services. Open data and crunching big data are areas in which we are doing exceedingly well.

Digitalisation fulfils its true potential when its various areas develop to reach an adequate standard and when compatible areas combine to form larger entities. For example, the advancement of cloud services and big data tools have enabled completely new combinations of different information resources. While development in a single area would not have made a crucial difference, when put together, cloud services, big data, wireless communication and robotisation add up to a winning combination that will change the ways in which we work and spend our free time. Finland has extensive expertise and strengths in all of these sectors (Figure 1), but so far we have not managed to realise their full potential.

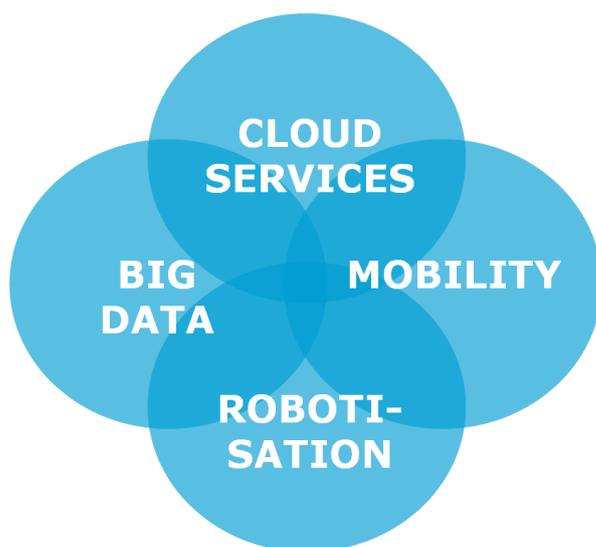


Figure 1. The winning combination of Finnish expertise

It must be said that in the field of robotics we are behind the leading countries. Glimpses of light can be seen, however; in such areas as working machinery and mining automation we have already made it to the forefront of development, even on the global scale. As regards promoting the automatisisation of transport, on the other hand, a strong shared willingness already exists to grasp the possibilities that are within our reach.

In order to promote the rapid adoption of new solutions, we must take risks and accept mistakes; this is also the message of Prime Minister Sipilä's Government Programme. Nothing is perfect at first, and nothing will be perfect if we limit our experiments to a laboratory setting. Finland must take brave strides to embrace new technologies. For this purpose, the Government Programme also encourages agile innovation by facilitating experimentation and utilising the results of these experiments. A change cannot be brought about without hard work.

Robotisation or automatisisation may mean a variety of different things. In this report, intelligent automation, and its increased use, or automatisisation, refer to modern robotics where a device or a system is capable of increasingly autonomous action, perception, learning and decision-making through artificial intelligence, sensors and the Internet of Things combined with software. A robot may look like a vehicle or a working machine in appearance, but it may also merely comprise a software robot.

2. Vision on the significance of intelligent automation in 2025

- Some of the world's leading centres of expertise focusing on intelligent automation in transport will be found in Finland.
- Transport robots operating on land, in water and in the air will be part of our everyday life, and they will have resolved many challenges related to the servitization of transport in cities and sparsely populated areas.

3. Goals

- To achieve a strong shared determination in Finland to become one of the world's foremost actors in the field of intelligent automation of transport.
- To create an enabling regulatory framework that will draw actors to Finland.
- To create a well-functioning and viable business ecosystem for intelligent automation in transport.
- Relying on significant existing competence areas, to create an internationally unique information-based infrastructure for intelligent automation in transport in which our Arctic expertise will also be fully exploited.
- To create and use numerous services based on the intelligent automation of transport.

4. Intelligent automation in transport

Automatisation, or the increased use of intelligent automation, offers significant possibilities for more streamlined and effective travel and transport (Figure 2). A gradual increase in the intelligent automation of private and public transport vehicles will improve the safety and comfort of travel. In logistics, on the other hand, unmanned aircraft systems and automated terminal solutions may improve efficiency. These steps forward will be enabled by more intelligent infrastructures, collection and utilisation of information, and advanced information system solutions. As the Figure shows, automated transport is not a new idea.

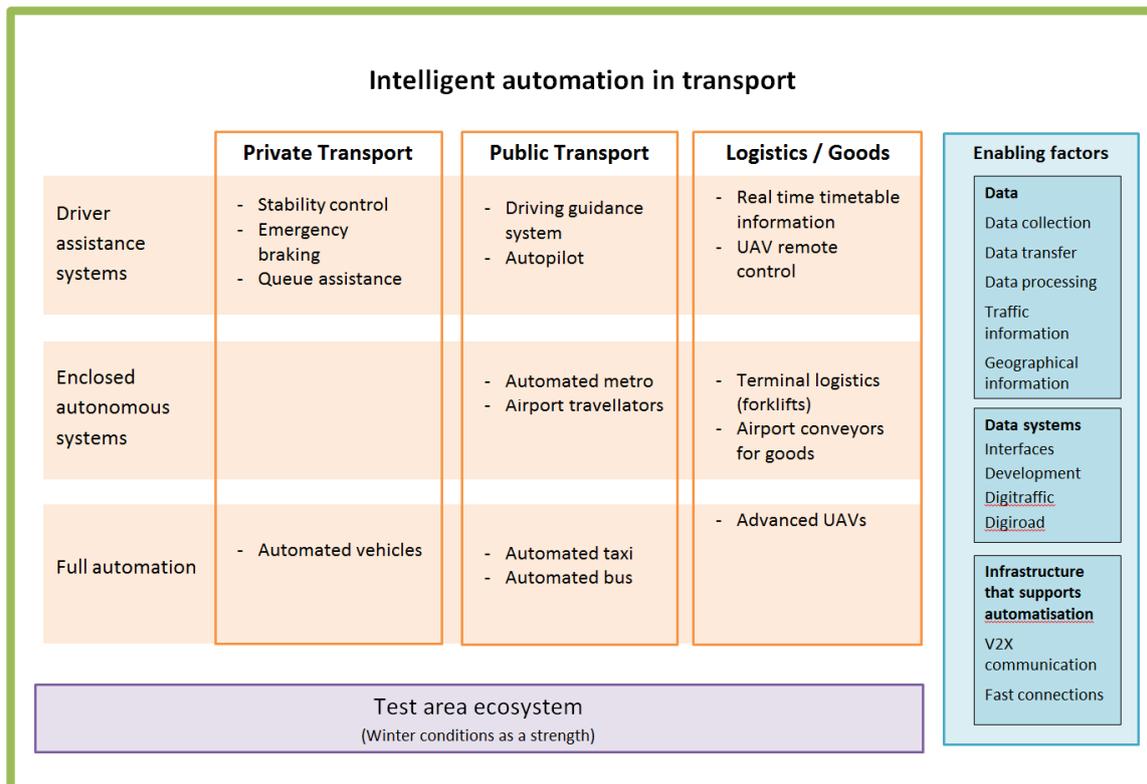


Figure 2. Intelligent automation in transport

4.1 Finnish strengths in automated transport

4.1.1 A strong existing commitment

A reasonably solid shared determination to promote the automated transport has already been reached. This makes it possible to analyse the operational environment and identify and remove obstacles. A key element in a well-functioning operational environment is the status of regulation.

In short, it can be said that while our current legislation already is quite permissive in terms of intelligent automation of transport, all obstacles have not yet been identified. Other actions and priorities that will boost Finland to a position as the leading country of intelligent automation of transport should also be explored.

4.1.2 Information and communication infrastructure and expertise

Finland has genuinely good existing communication infrastructure, which is a must for advanced automation of road transport. Development of the infrastructure should

continue in the future, and new ways should also be found to secure communication between vehicles and the infrastructure in all circumstances. Finland has excellent capabilities for developing communication systems, including vehicles that communicate with each other and the infrastructure (*V2X, vehicle-to-any communication*), and determined efforts to promote these capabilities further should be made.

On the global scale, we have extremely solid information security expertise and a very high level of data protection. Finland has also gone further than other similar countries in opening up public sector information resources and, in general, creating good practices related to open data. We also have outstanding expertise in the processing of big data, and our information resources consisting of different map and register data, for example, are unique in the world. Finland has magnificent capabilities for developing information-based services and systems for transport.

4.1.3 Expertise in robotics

Finland has solid expertise in robotics in certain fields, including forestry and mining machinery. In these sectors we also have actors of international significance. We might not as yet have success stories of a similar calibre in the transport sector, but we do have highly interesting actors. We have several suppliers of significant components, including maps, sensor technology or software, and abundant potential for activities of this type. We also have actors engaged in developing full service concepts, and innovations in other sectors of robotics have potential that could be exploited.

4.1.4 Arctic expertise

Advanced automation of road transport cannot become widespread in Finland or anywhere else unless we can back up visual perception by information transferred by data communications. Automatisations increases sensibility to conditions, and challenging road conditions often form an insurmountable obstacle. However, Finland could be profiled as a country of Arctic expertise, and especially test areas and trials associated with infrastructure development. Finland has extremely convincing expertise in such areas as ice, weather and marine safety services, and the utilisation and development of these could generate further business opportunities. The thinking should be "if it works in Finland, it will work anywhere".

4.2 Road transport

4.2.1 Levels and definitions of automation

In the context of road transport automation, we often talk about both automated and autonomous vehicles (Innamaa et al., 2015). An automated vehicle is one that can at least partly perform a driving task without a driver. The word autonomous, on the other hand, refers to the ability of an automated vehicle to operate independently and without a driver in a dynamic traffic environment, relying on the vehicle's own systems and without communicating with other vehicles or the infrastructure. These terms are used rather inconsistently, and autonomous vehicles are often referred to when automated vehicles in a broader sense are intended.

Another category is formed by remotely controlled vehicles. This means that the operator is in contact with the vehicle through wireless remote control and operates the vehicle through a real-time drive simulator or other similar user interface.

Automation in road transport progresses gradually. The six-step classification of SAE International is currently used in most cases to describe its different levels (Table 1).

Level	Name	Definition	Execution of steering and acceleration; deceleration	Monitoring of driving environment	Fallback performance of dynamic driving task	System capability
Human driver monitors the driving environment						
0	No automation	Full time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	–
1	Driver assistance	The driving-mode specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment with the expectation that the human driver perform all remaining aspects of the dynamic driving task	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial automation	The driving-mode specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that human driver perform all remaining aspects of the dynamic driving task	System	Human driver	Human driver	Some driving modes
Automated driving system monitors the driving environment						
3	Conditional automation	The driving-mode specific performance by an automated driving system of all aspects of the dynamic driving task (including latitudinal and longitudinal control) with the expectation that the human driver will respond appropriately to a request to intervene	System	System	Human driver	Some driving modes
4	High automation	The driving-mode specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene. If the human driver fails to take control of the vehicle, the system steers the vehicle to the side of the road in a controlled manner and stops it	System	System	System	Most driving modes
5	Full automation	The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions	System	System	System	All driving modes

Table 1. Different levels of automation in road transport (SAE, 2014; Innamaa et al., 2015)

The role of the human driver at different levels of automation has been described as follows (Innamaa et al., 2015):

1. The system only supports one aspect while the driver takes care of other aspects AND monitors the driving environment.
2. The driver must monitor the driving environment.
3. The driver may disengage and undertake other tasks while driving, but if necessary, they must take control of the vehicle, in other words start driving it.
4. The driver may even be asleep, as the system gives a warning if the driver needs to take control of the vehicle.
5. No driver is needed.

On levels 1-4 of automation, the driver must have the possibility of safely taking over the control of an automated vehicle in all situations.

4.2.2 From Driver Assistance Systems to automated vehicles

An automated vehicle strongly relies on Advanced Driver Assistance Systems (ADAS), integration of ADAS systems, communication between vehicles and vehicles and the infrastructure, Connected Intelligent Transport Systems (C-ITS), fusion of data produced by system sensors and an analysis of collected data.

All major car manufacturers already offer optional driver assistance systems as a factory installation. Examples of these systems are adaptive cruise control, low speed collision avoidance, lane departure warning systems, blind spot information systems, parking assist systems and speed limit sign recognition systems. (Lumiaho & Kutila, 2015)

According to the SAE classification, we have currently reached level 2 in the automated transport (partial automation), but level 3 vehicles (conditional automation) may reach the Finnish roads in two or three years and no later than 2020 (Figure 3).

Technology related to the automation of road transport is evolving extremely fast at the moment, which is why estimates of when automated vehicles will be released and appear on the roads vary greatly (Lumiaho & Kutila, 2015). In general, it is expected that the first vehicles with full or advanced automation, which will only operate within limited areas, will be released in the 2020s. According to some estimates (KPMG, 2013), optional equipment packages for "autonomous driving" as factory installations in new cars may be available as early as in 2019. The same estimate suggests that by 2025, there may be a sufficient range of standard equipment and options available to support automated operation and vehicles of levels 3 and 4. Fully automated vehicles that operate on public roads among other traffic are unlikely to be in the market before the 2030s. Most authorities believe that fully automated vehicles will only come into more extensive use around the year 2040 (e.g. LeBeau, 2015). It should also be noted that the latest Google prototypes no longer have controls of the current type. However, in order to test these vehicles on public roads Google has been forced to install temporary controls in the vehicles.

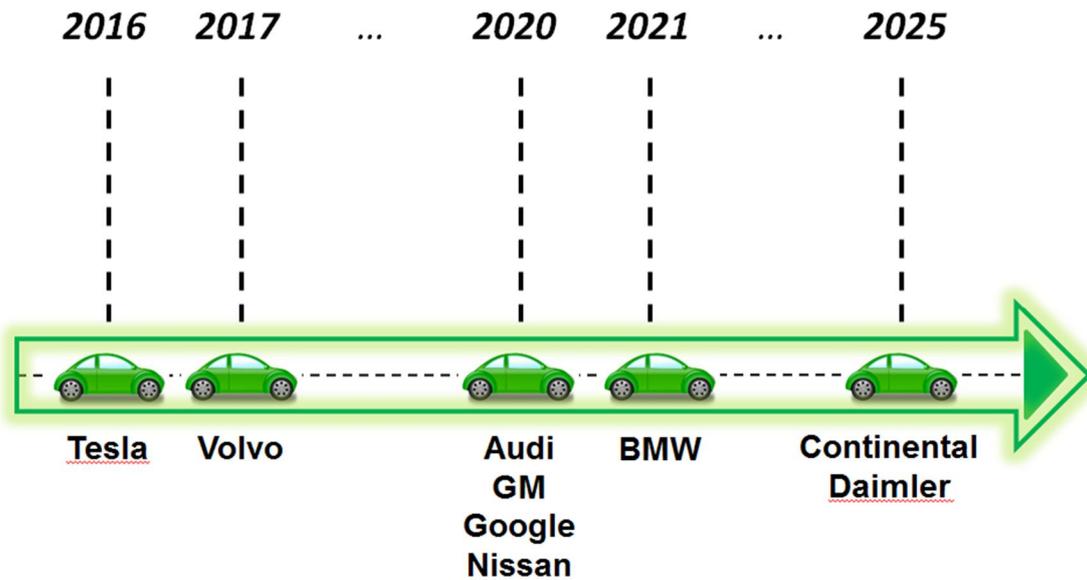


Figure 3. Car manufacturers' estimates of when automated cars will be released (EPoSS, 2014).

Different sensor technologies, including short and medium range radar systems, cameras, ultrasound sensors and lidar, or light detection and sensing equipment, play a key role in the advancement of automation in road transport. In an automated car, an electronic horizon is created based on data input from the sensors, representing the vehicle's situational picture and perception of the world around it. The advancement and utilisation of sensor technology is particularly vital for enabling automated driving in challenging conditions, including fog, rain or snow falls. (Lumiaho & Kutila, 2015)

In addition to sensors, highly accurate digital maps and reliable and accurate positioning are cornerstones of automated driving. They allow the vehicle to detect its position in proportion to its surroundings, which the sensors are unable to do. Through satellite positioning, the car may be placed accurately on the map, and in a shadow zone, relative positioning based on 3D maps and sensors may be used. (Lumiaho & Kutila, 2015)

It is likely that more advanced automation (level 3 and beyond) will firstly be introduced in motorway sections between exits and, on the other hand, in service concepts offered in urban areas where low speeds are used (20–40 km/h). The development of automation and the concept of travel as a service are also strongly interlinked. New types of travel services could be the most natural area for the wider introduction of cars capable of higher level or fully automated driving.

4.2.3 Impacts and potential

The advancement of automation is believed to have huge potential in road transport. When measured in fatalities, injuries, emissions into the environment, money, time savings or increased well-being, it is believed that more progress can be achieved through the advancement of automation than any other single factor. However, little reliable research in its impacts is available so far. (Finnish Transport Safety Agency, 2015)

In some 90% of road accidents, human error is at least a contributing factor. It is believed that the automation of driving could help to reduce these human errors; on the other hand, new types of accidents caused by failures of software and sensors are also likely to ensue from automation (Figure 4). Automated driving is also expected to reduce fuel consumption, exhaust gas emissions and congestion due to a more proactive driving technique. (Finnish Transport Safety Agency, 2015)

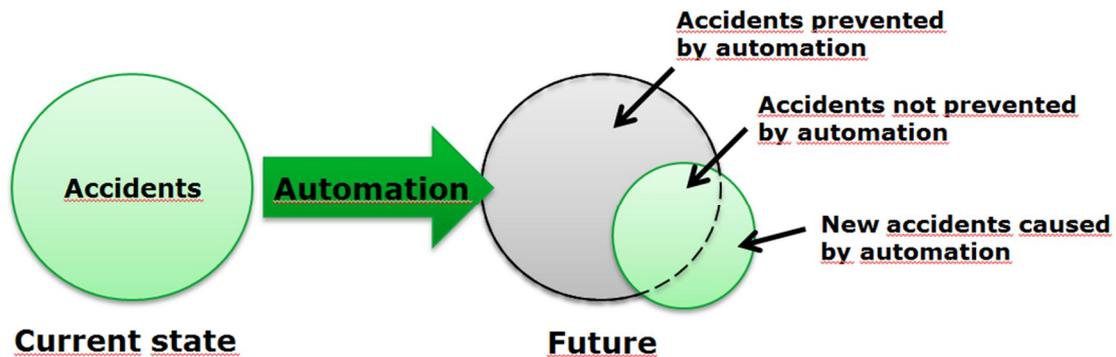


Figure 4. Driving automation will prevent accidents but also cause new types of accidents (Finnish Transport Safety Agency, 2015).

Innamaa et al. (2015) have examined the development of technologies for the automatisisation of road transport and its impacts in Finland. Positive impacts of transport automation on traffic flows will be seen at level 3, or conditional automation: the throughput of the network will improve, shockwaves will dissipate faster, speeding will be reduced and traffic efficiency will be improved. In the context of the transport system, clear impacts will already be visible on level 2, where improved safety will reduce traffic disruptions and congestion. This will improve the predictability, comfort and environmental friendliness of transport.

On levels 4 and 5, greater positive impacts will be expected. People who are unable to drive today's car models may begin to use automated vehicles. It has been suggested that as automated cars become sufficiently common, narrower lanes may be introduced, thus improving the throughput of transport corridors.

On standardised routes, for example in housing estates and sparsely populated areas, robotic vehicles may lower the cost of transport services and enable a better service level. Fully autonomous robotic vehicles that can choose their route freely will enable driving as a service, and private cars can thus be extensively abandoned. The impacts on urban structure, the capital costs of motoring and time use could amount to EUR 10–20 billion annually (Linturi, 2013). Several similar calculations have been produced (e.g. Spieser & al., 2014). The potential impacts of fully autonomous vehicles on the equality of mobility will be extremely important and essentially facilitate travel for a very extensive part of the population. (Linturi & Kuittinen, 2015)

In addition, automated transport will free the time drivers currently spend on driving for other uses. In 2009–2010, for example, an employed person in Finland spent on average 14–15 minutes a day travelling to or from work (Liikennejärjestelmä.fi, 2015). According to the British Department for Transport (DfT, 2015), the typical driver spends 235 hours

a year behind the wheel. The benefits of freeing up this time for other uses will only be maximally realised on automation levels 4 and 5 where the driver can disengage from actively monitoring the operation of the vehicle.

4.2.4 Challenges of the near future

The Finnish car stock is one of the oldest in Europe, and its rate of renewal is slow. The average age of cars used on the roads in Finland at the end of 2014 was 11.4 years, while the corresponding average age in the entire EU area is some 8 years. Consequently, Finland will be one of the last countries to see the benefits of automation realised. The rate of replacement of vehicles intended for consumers is slow, and this rate in Finland is clearly slower than average. The majority of vehicles taken into use in Finland today, the most recent models of which represent automation level 2, will still be used in 2025. Of all vehicles on our roads today, approximately 60% will still be used in that year. It can thus be predicted that human drivers and computer-controlled vehicles will continue to coexist on our roads for a lengthy period of time.

In order for Finland to achieve a genuinely pioneering position, the renewal of our car stock should be speeded up significantly, for example by means of tax incentives. The Government Programme indeed refers to a 20% reduction in car taxation. While this reduction will mainly target low-emission cars according to the Government Programme, it is also likely to have a positive impact on car stock renewal.

In terms automated car technology, as the greatest challenge is seen developing automated vehicles' capability of monitoring their surroundings: the car must be able to perceive what is happening around it and respond reliably in different traffic situations. Challenging weather conditions, including snow or heavy rain, currently disrupt the operation of automated cars. Recognizing traffic lights in different lighting conditions has also proven difficult. Neither are automated cars as yet able to respond to a signal to stop given by a traffic warden, such as a police officer. Detection of obstacles on the road also remains a major challenge. An effort should thus be made in Finland to launch public-private partnership projects aiming to solve these challenges.

As noted above in section 4.2.2, it is possible that level 3 automated cars will already be seen on Finnish roads in two or three years' time. We have reason to expect that the operation of cars at this stage of development will to a great extent be based on perception of the car's surroundings by means of sensors. This will place new demands on the transport authorities and, in particular, road maintenance operators in terms of actions and costs due to the more stringent requirements regarding the condition of road infrastructure.

Road infrastructure

As the level of automation improves and vehicles become more intelligent, the significance of digital transport infrastructure will increase. Detailed and multidimensional maps and accurate geographical information that include roads, road markings, traffic signs and signposts, road markings and traffic signs that are in good condition and easily visible, up-to-date and high quality information on road and traffic conditions and, potentially, sensors embedded in the road surface will be some of the preconditions for high level automated driving, especially in varying conditions. The progress of automation will also have major impacts on the planning of infrastructure projects, and it will place new types of requirements on conventional infrastructures. How their design should be developed, and what kinds of requirements will affect existing physical infrastructures, are questions that have not been explored so far.

It is obvious, however, that the maintenance and international harmonisation of road markings and traffic signs will necessitate additional inputs. The costs of winter maintenance in particular will also go up if roads need to be extensively kept in a condition that enables automated driving round the year. It has also been suggested (Carsten & Kulmala, 2015) that particular lanes reserved or built for automated cars could be used, which may be needed especially in the transition phase as the road is shared by conventional cars operated by human drivers and vehicles of different automation levels. Automated vehicles would drive along more or less exactly the same lines, which could result in new types of problems with wear and tear on the pavement and a need to solve these problems. Testing of different pavement materials and techniques of producing road markings that can be more easily detected by sensors even in difficult conditions is urgently needed. There is a great need to find cost-effective solutions.

Road maintenance operators cannot afford to equip the entire road network for automated driving of level 3 and higher, and stepwise progress in road infrastructure will thus be needed, for example beginning with the motorway network. The Finnish Transport Agency and the Finnish Transport Safety Agency have initiated a study on the particular requirements placed on road maintenance operators and transport authorities by level 3 automation. As part of this study, cost-effective methods for equipping road infrastructure for automated driving will be sought. The study is due to be completed by the end of 2015.

Impacts on demand for transport

Automated transport will have significant impacts on the future transport system. It has been estimated that the number of vehicles needed will decrease dramatically and congestion will be substantially reduced. An OECD study (2015) examined a transport system based on automation. The study calculated that in Lisbon, the entire traffic volume of the city in 24 hours could be managed with 10% of the current number of vehicles, and the transport needs of the peak hour could be met with 35% of the current number of vehicles. The study is naturally based on certain presumptions, but it does point the direction and gauge the extent of the change. Even if the traffic volumes remained the same, the demand for transport could be met more optimally, considerably reducing congestion. An important development in terms of land use is that the need for parking spaces and similar areas in city centres would be reduced considerably or even be eliminated, which would free up significant land areas for other uses in urban centres.

In practice, a transport system based on automation will change the way in which the impacts of transport projects are assessed. Our current calculation system anticipates growing traffic volumes and unchanged travel behaviour. A complete review of the planning and assessment of transport projects will thus be needed as the automation of transport advances. It is likely that rather than projects aiming to improve capacity, we will need projects that set out to improve the current transport infrastructure in the future.

Action: The Government Programme policy indicating a reduction in the car tax will be implemented and its impacts on promoting automation will be established.

Action: The study on the most immediate measures required to enable automation, especially at level 3, will be completed and these measures will be implemented on a rapid schedule, proactively if possible.

Action: Availability of accurate information on existing driver assistance systems in registered vehicles will be ensured in the future in order to facilitate a more precise assessment of the impacts of these systems and increasing automation on transport safety and the smooth running of traffic.

4.2.5 The role of information in enabling intelligent automation

Various stakeholders have conflicting views of the role played by information in the realisation of fully automated cars. Some actors are striving to develop vehicles that work autonomously, or do not need data input from other vehicles or external information systems. An autonomous car of this type fully relies on its own sensors and capabilities of perception.

Others believe that access to information of an adequate quantity and quality will be a precondition for automated transport. In road transport, for example, automated vehicles need more extensive information about the road condition, the phase of traffic lights and other road users around them than what can be detected by sensors integrated in the vehicle alone. The view based on communicating vehicles seems to prevail among Finnish and European companies and experts.

Finland has long traditions of information and communication technology expertise. In the future, developing infrastructures required for the most advanced level of automation relying on data could be a special strength for Finland. While data and information infrastructures are important, this does not mean that developing vehicle sensors and other perception technology would not also be vital for the advancement of automation. The use of information interchange makes automation considerably safer, as it allows the vehicle to obtain more information about the traffic situation around it and, on the other hand, the accuracy of the vehicle's perception can be verified. The development of information network solutions would also be likely to reduce the demands placed on physical transport infrastructures. This would be significant for the global advancement of automation.

Two alternatives based on different principles exist for implementing short-range communication between connected vehicles. In the more conventional implementation, short-range data transfer technology is used, necessitating the installation of separate transmitters and receivers on vehicles and also on the roadside. It is considered an expensive and labour-intensive solution, as the entire road network would have to be equipped with this technology, and its maintenance would bring significant additional costs.

The idea underlying the second alternative is to use the existing mobile telephone network for communication between vehicles and the infrastructure. A solution of this type is being developed in the NordicWay project launched in May 2015, in which Finland participates with the road transport authorities in Sweden, Norway and Denmark. This project is pioneering on the global scale. Finland's strength regarding this implementation alternative lies in existing high-quality telecommunications infrastructures.

Needs to develop information infrastructure

We should note that even if the Finnish telecommunications network, and the mobile phone network in particular, are top class especially on the European scale, the current capacity and reliability of the network are not yet sufficient to support advanced transport automation. Goal-oriented investments will thus be needed in the wider spread of ultra-fast fibre optic connections and the fourth-generation (4G) mobile network as well as the development of a fifth-generation (5G) mobile network in Finland. The commercial launch of 5G mobile technology is estimated to take place at the end of the

decade. 5G technology is expected to support up to a hundred times faster connection speeds, shorter delays and improved security and reliability. This technology is estimated to reduce user-experienced delays in connection speeds to one millisecond and support functionality at speeds of up to 500 km/h. These developments would contribute to enabling automated transport. The Internet of Things and communication between machines and devices will also take up plenty of capacity, and the transport sector and car industry will thus be significant users of 5G technology in the future. Under a Government Decree, frequencies may be allocated to the product development and testing of new technologies. The development of 5G testing networks in Finland has been launched in the 5thGear programme of the Finnish Funding Agency for Technology and Innovation Tekes. Finland must exert influence in European and international forums to ensure that adequate frequencies of the right type will be allocated to 5G technology use. In the future, Finland must allocate the requisite frequencies for these technologies, coordinate their use with the neighbouring countries and, if necessary, also ensure that national legislation enables the use of the frequencies as required by 5G technology.

A more extensive terrestrial fibre-optic network will also be needed to serve the base stations of the mobile phone network, in particular for 5G technology. The fibre-optic connections built so far are not adequate even in urban areas. In the years to come, it will thus be necessary to consider and implement various actions that would encourage telecommunications operators to invest in fibre-optic networks, or otherwise promote the building of fibre-optic connections. Fibre-optic connections should also always be put in place as other basic infrastructures of society are built or modernised. Efforts to reduce the building costs of fibre-optic networks will include the pending legislation on shared construction and use of networks and the relevant structures.

In order to achieve the mutual and external interoperability of cars and other vehicles, it must be ensured that the vehicles and their drivers have access to adequate data that is in the correct format and easily available. The main factor affecting data accessibility is whether open or closed source code is used. The data must be converted into a format that is compatible with devices. Data transfers must also be managed smoothly.

In the future, information on traffic and conditions needs to be much more accurate, up-to-date and higher in quality than today. A high-quality and up-to-date digital description of the road network is also needed which includes, as far as possible, information about infrastructure shortcomings, road markings and traffic signs.

The data, and especially data needed for the most critical functions, must also be produced on real time. The data must also be reliable to permit genuinely automated or autonomous operation. It must be possible to prevent unwanted capture and modification of data. Data compatibility between different systems and countries is also vital.

It appears that a fully automated car would require a demanding and highly detailed 3D model and a more accurate set of data on the traffic environment. The major map service actors, including Google and HERE, have capabilities for producing such models. The integration of national geographical information and data on road property including traffic signs in these models that serve the car industry should be examined. Vehicles and the infrastructure will be important producers of traffic information, and particular attention should be paid to interfaces of these data types.

All these are areas in which Finland could become a pioneering country. In order to do so, we need inputs from both society and companies, not forgetting efficient cooperation across all silo boundaries.

Action: The construction of fast and reliable terrestrial and wireless connections necessary for automated driving on roads will be promoted. This process should start with the busiest roads.

Action: Communication systems between cars and between cars and road infrastructure will be developed further, utilising existing radio technology expertise and projects already launched (including NordicWay) in cooperation between different actors.

Action: In telecommunications, the priority of real-time traffic information services critical for safety will be ensured in cooperation with the largest telecommunications operators.

Action: A frame of reference that sets out the information base needed for the automation of each form of transport will be created. In an effort to build a digital information base, the adequacy of national resources of different data types (geographical information services, information administrated by the authorities, service providers' data) for the needs of the digital information base for automated transport will be examined, and the necessary steps will be taken to guarantee its adequacy.

4.2.6 Road transport regulation

The European rules of the road are based on the international Vienna and Geneva Conventions on Road Traffic. Finland ratified the more recent one of these convention, or the Vienna Convention, in 1985.

Chapter II of the Convention lays down Rules of the Road that are the foundation of safe international road transport. Under the Convention, Contracting Parties shall take appropriate measures to ensure that the rules of the road in force in their territories conform in substance to the provisions of the Convention. In Finland, the provisions of the Convention on Road Traffic have been implemented through the Road Traffic Act (tieliikennelaki, 267/1981).

Article 8 of the Convention on Road Traffic, which is part of the Chapter on Rules of the Road, contains provisions on drivers. According to this article:

- Every moving vehicle or combination of vehicles shall have a driver;
- Every driver shall possess the necessary physical and mental ability and be in a fit physical and mental condition to drive;
- Every driver of a power-driven vehicle shall possess the knowledge and skill necessary for driving the vehicle; however, this requirement shall not be a bar to driving practice by learner-drivers in conformity with domestic legislation; and
- Every driver shall at all times be able to control his vehicle.

For the purposes of the Convention a driver means, among other things, any person who drives a motor vehicle or other vehicle.

While the Finnish Road Traffic Act does not contain a separate definition of a driver, it is based on the assumption that a human driver is responsible for the vehicle in all situations. This is clear from several individual provisions.

The lack of detail in the Vienna Convention and the Finnish Road Traffic Act give scope for an interpretation according to which it is not necessary for the vehicle to be operated by a driver controlling it from the inside of the vehicle. This interpretation makes allowance for the remote control of a vehicle, for example in case of a remotely controlled parking assistance system. In the context of this interpretation, however, it is important to note that the driver's liability and other obligations related to driving a vehicle apply whilst the vehicle is under remote control.

On this basis, immediate legislative amendments have been deemed unnecessary in Finland. Should legislative needs emerge, they will be responded to quickly, taking any international obligations into account. The increase of automation has been recognized in the on-going overhaul of the road traffic legislation. Both in national and international legislation, it is important to take the vehicle's level of automation into consideration when setting marginal conditions for the use of a vehicle on the road. At the same time, compliance with the obligations laid down in the Personal Data Act that concern the processing of personal data and the planning of their processing must be ensured in activities related to the automation of road transport where personal data are processed or collected. As the commercial potential of road transport automation increases, questions related to the application of technology neutral data protection regulation will emerge, and for this reason, device manufacturers and operators should take data protection into account as early as possible when planning their activities. (Tarhonen & Nyström, 2014)

At the moment, stakeholders in the transport and vehicle sectors do not have sufficient awareness of the status of legislation in Finland. As a consequence, extensive information activities will be needed, both nationally and internationally.

An update in the Vienna Convention is currently being prepared which would permit technical driver assistance systems. Technical systems of this type can assist the driver to the point where physically driving the vehicle is not necessary in all traffic conditions. A complementary provision about to enter into force decrees that technical devices assisting the driver are compliant with the Convention if the driver is able to turn off these devices and take control of the vehicle. In addition, Finland, Sweden, Belgium, France, Italy and Spain are preparing a proposal for amending the Convention to permit automation that goes even further than the aforementioned provision.

Finnish legislation allows advanced experiments in road transport automation

Action: Creation of the best regulatory environment in Europe, or in the world, for testing and introducing automated driving will be ensured. Any corrective action that is required will be taken without delay. In connection with the overall reform of the Road Traffic Act, it will be ensured that no legislative obstacles remain.

Action: Finland will actively exert influence in international forums to ensure that international provisions enable the development of automation.

Action: Information will be extensively disseminated, both in Finland and abroad, on the opportunities offered by the current status of regulation.

4.2.7 Approval of vehicles for road use to facilitate testing

In the testing phase, obtaining type approval for automated vehicles is not mandatory. Such experiments are likely to involve vehicles adapted from type approved cars. When new, such vehicles are approved for registration following the procedure for individual approval. The question of type approval actually only becomes topical when vehicles without control devices of the current type start being manufactured on a large scale.

For the purposes of testing automated cars, a vehicle may be registered for use on public roads in Finland either through the normal registration procedure or by using a test plate certificate, or so-called test plates.

In the normal registration procedure, each vehicle is inspected and registered individually. A derogation granted by the Finnish Transport Safety Agency is required if the vehicle does not meet the applicable technical requirements. The normal registration procedure offers better possibilities for making sure that experiments are safe, as the vehicles are inspected individually.

A test plate certificate is granted to an operator rather to an individual vehicle. Test plates are mainly intended for tests associated with the product development of a vehicle or its equipment and for vehicle transfers.

4.2.8 Standards

A key role in requirements applicable to vehicles is played by the UN Economic Commission for Europe (*UNECE*) WP.29, which prepares E rules for vehicles. These rules are complied with in type approvals, for example in the EU and Japan. The policy of the working party is that as technology is undergoing such a rapid change, there is little point in drafting any regulation at this stage. Making sure that technical development is not accidentally slowed down by excessively precise norms is another argument for the lack of standardisation. The situation is being actively monitored, for example in a Working Group on Intelligent Transport Systems, in which Finland has so far not been represented.

It has been estimated that a total of over 80 standards related to Connected Intelligent Transport Systems (*C-ITS*) have been or are about to be completed. We must note, however, that in the early stage where the large-scale introduction of such systems is only being considered in theory, the solutions of different European pilot projects are not necessary directly compatible. Among others sources, descriptions of standards prepared for Connected Intelligent Transport System can be found in the document "N196 v2.0 C-ITS Release 1 list of standards" (CEN/ISO, 2013). (Laitinen, 2015)

NMT and GSM in the mobile phone sector have been cited as good examples of open standards that have genuinely helped to develop the sector (Ventä et al., 2015). Similar development is needed in the field of general robotics and especially in transport automation. The creation of open standards is a precondition for development in the sector and the possibilities of small and medium actors operating in this market. In order to trigger this development, investments by the public sector and cooperation with private actors are also required.

Action: The Finnish Transport Safety Agency and the Finnish Transport Agency will increase their inputs in promoting the creation of open international standards. Merely monitoring the situation is not enough.

4.2.9 Questions of liability and insurance

The currently valid Motor Liability Insurance Act contains no obstacles to insuring automated vehicles (Motor Insurers' Centre, 2015). Either the owner or the holder must have an insurance policy for a vehicle. In addition, Finnish motor insurance includes unlimited liability for personal injuries, which is exceptional in the international context. For example, Google collected five million dollars to cover possible damages for its trials in California. Unlike almost every other European country, Finland also provides protection for the driver: in other words, the insurance covers not only the injured party's personal injuries and damage to property but also the driver's personal injuries. After the overhaul of the Motor Liability Insurance Act, the limit of indemnity for damage to property was increased from EUR 3.3 to EUR 5 million. This generously exceeds the limit of EUR 1 million required in EU directives. Consequently, the cover offered by the Finnish motor insurance system is essentially different from motor insurance in other EU Member States.

In other EU Member States, the restrictions of motor insurance cover result in a need for additional insurance cover. This additional cover is, as a rule, offered by non-life insurance providers. New actors have also entered the market. Both Google and Volvo have announced that vehicles to be tested will be insured through their own insurance companies, and insurance providers owned by the manufacturers will thus change the insurance sector. It should be noted that in Finland, vehicles of this type would have to be insured in compliance with the Motor Liability Insurance Act. (Motor Insurers' Centre, 2015).

In Finland, traffic accidents caused by a faulty product are also covered by motor insurance. Consequently, the injured party would not be any worse off in Finland even if the damages were caused by a purely technical fault. Under the new Motor Liability Insurance Act, however, from 1 January 2016 an insurance company could claim back any compensation it pays out from the vehicle manufacturer or importer. For comparison purposes, we should note that in many countries liability is carried by vehicle manufacturers, while the role of motor insurance is reduced or eliminated. The special features of the Finnish motor insurance system will not immediately lead into this development. There will be no need for additional cover in Finland, as compensation under motor insurance takes priority over other social protection systems, and liability is not dependent on negligence. (Motor Insurers' Centre, 2015).

Challenging new questions of liability could well ensue from automated transport. An example of this is the question of who is allowed to repair automated cars, and how errors made during repairs can be minimised. Insurance cover may perhaps also be needed for these new types of repair activities. It may also be necessary to consider the responsibility of a software producer and other issues of liability. However, these issues can be resolved, as the Finland's example shows, and the difficulty of liability questions should thus not be overemphasised.

Action: The Finnish motor insurance system will be used as an international example of how liability questions related to automated cars can be managed simply.

4.3 Aviation

4.3.1 Conventional cockpit automation

Autopilots have been commonplace in aviation for some time. Key elements of intelligent cockpit automation are technical reliability, high performance and indicators of system status.

The two main concepts for implementing technical reliability, examples of which are automated approach and landing systems, include:

- Fail Operational implementation, where the task can be completed even when the system fails. Typical implementation options are three parallel and independent systems, or similarly, a duo-duplex system.
- Fail Passive implementation, where pilot intervention is required in case the system or one of its components fails. Implementations are based on a single system, or systems that are redundant in part only.

Better performance can be achieved by well-implemented automation than by manual control. For this reason, using automation is mandatory, especially in conditions of poor visibility.

The intelligence of cockpit automation could be described as the system's built-in ability to assess and display its own status. This "status image" directs the operation of the system. It is also displayed to the pilots as observations, positive or negative indications in the prevailing situation.

In cockpit applications, automation is deemed to produce clear added value in form of safety, for example as protective systems. Rather than controlling the aircraft, human capacity may be used for monitoring and controlling the overall situation. High-level cockpit automation is associated with strong integration of systems, where interdependencies are extremely difficult to perceive in case of a fault. Cases where the system reconfigures itself in order to maintain performance or analyses problems in a fault situation could probably be referred to as intelligent cockpit automation.

4.3.2 Unmanned aircraft systems

It is apparent that the principles of cockpit automation will be followed in the development of unmanned aircraft systems - perhaps, however, with the goals of cost-effectiveness and performance in mind.

The rapid development of unmanned aviation has taken all aviation sector stakeholders by surprise, from authorities to actors putting unmanned aircraft systems into commercial use and hobbyists. New needs for unmanned aircraft systems are being identified continuously, and they are becoming more common extremely fast.

As a concept, a "*model aircraft*" is not the same as an unmanned aircraft system, even if the two devices were exactly the same. The distinguishing factor is their purpose: an aircraft that flies without a pilot used as a hobby or a sport is a "*model aircraft*".

The regulation on unmanned aircraft systems applies to aircraft operated for other purposes than a hobby or a sport. In these cases, the flying device is as a rule used for official activities, business, trade or as a tool for a professional task.

At the moment, commercial activities are typically based on the use of data collected and stored by sensors on an unmanned aircraft. As sensors may be used such devices as laser scanners, video cameras, infra red or thermal cameras and conventional cameras.

In the future, commercial activities could also involve the transport of goods; new applications are being discovered continuously, and a strong growth in the business in this sector is predicted in the future. Current uses include mapping, agricultural control, inspections of pipelines and power lines, filming of events, shooting of films and, in the future, logistics tasks.

Unmanned aircraft systems could perform many light duties for which conventional aircraft are used today. This will result in significant costs savings. Unmanned aircraft systems can be used for tasks that are too risky for a human crew - for example, because of danger caused by activities on the ground or challenging weather conditions.

Unmanned aviation also has close links with activities in near space. Finland has special expertise in the design and manufacture of devices, software and scientific instruments for satellites and space probes. The estimated annual turnover of Finnish companies that apply space technology is EUR 240 million. The data produced by their instruments are used for scientific and commercial purposes, for example in remote sensing and application of geographical data.

Finland participates actively in the efforts of the International Civil Aviation Organization (ICAO) to enable the utilisation of near space. Locations cited as possible test flight centres in Europe for near space aviation include Kiiruna and Kittilä.

4.3.3 Regulation

The Finnish Transport Safety Agency is drafting regulation on unmanned aircraft systems. The drafting progresses in small steps, without forgetting safety aspects. The aim is at regulation on unmanned aircraft systems that is as light and modern as possible to ensure that it will not become an obstacle to developing these activities. The promising possibilities for new types of industrial production and economic activities offered by unmanned aircraft systems need to be supported by an enabling and innovative operating environment.

The Finnish Transport Safety Agency keeps Finnish actors informed of developments in international regulation. National solutions are likely to be temporary, as the EU is drafting common statutes on unmanned aircraft systems. The Finnish Transport Safety Agency plays an active part in the drafting of international statutes and lobbies for the adoption of Finnish principles of light regulation in these forums.

The following principles have been suggested for future regulation:

- Minimum regulation, a key role for actors in the drafting process
- Regulation will be developed as indicated by the needs of the actors and evolving situations
- Risk-based approach
- Unmanned flights may not put anyone at risk
- The necessity for and benefits of each new register, approval or permit will be assessed before their introduction
- Regulation will have an enabling approach in concrete terms that encourages experiments

Advanced intelligent automation in civil aviation results from an extensive international standardisation process that has taken decades. This has led into the certification of instruments and systems and the adoption of uniform methods.

While active efforts to develop international regulation on unmanned aircraft systems are being made in the European Commission, the ICAO, the Joint Authorities for Rulemaking on Unmanned Systems (*JARUS*) and the European Aviation Safety Agency (*EASA*), due to the rapid spread of unmanned aircraft systems, regulation has as yet not caught up with the preferences and needs of the sector. Finland should actively exert influence in appropriate international forums to ensure that the planned regulatory framework will not prevent the development of unmanned aviation systems. In this work, the permissive regulation in Finland can be used as an example of a good operating model.

Data protection legislation

Unmanned aircraft systems may have functions that can be used to collect personal data (Tarhonen & Nyström, 2014). This may bring up questions related to the protection of privacy and data protection. The point of departure for the examination of these questions should be the valid general legislation. Applying the Personal Data Act to unmanned aircraft systems is not quite as simple as all that, however, as the systems can be used for many different purposes. What plays a key role for the use of unmanned aircraft systems is the fact that a sound file, photograph or video image recorded by the system may comprise personal data. The criterion is the possibility of identifying individuals. An analogy can be found in CCTV surveillance, for example, where the material recorded by a conventional security camera is a personal file to the extent that any persons may be identified in the footage.

Observing the environment and collecting data on it may be an essential part of the commercial use of unmanned aircraft systems. The collected data may also become part of a customer register, for example when an online shop uses an unmanned aircraft system to deliver a parcel to the customer. When evaluating the data protection obligations, the purpose for which the aircraft systems and the data collected by them are used is essential. In commercial use where personal data are processed and collected, the obligations laid down in the Personal Data Act concerning the processing of personal data and the planning of their processing must be met. In addition, it must be ensured that the rights of the data subjects are implemented, including their right to verify personal data collected on them. As the commercial potential of unmanned aircraft systems increases, questions related to the application of technology neutral data protection regulation will emerge, and for this reason, the device manufacturers and operators should take data protection into account as early as possible when planning their activities. (Tarhonen & Nyström, 2014)

The Personal Data Act does not apply to private use, and its application to journalistic and artistic use is limited. These situations are not completely outside the scope of the legislation, however, as regulation under criminal law, including defamation or the spreading of information that violates against the protection of privacy may apply, regardless of the original use of the collected data. (Tarhonen & Nyström, 2014)

Action: As aviation regulation is drafted at the international level, the transport administration sector will seek to strongly influence the development of international and EU regulation to ensure that a light, risk-based approach to aviation regulation will be adopted.

Action: Domestic aviation regulation will be continuously compared with regulation in other countries to ensure that it stays on the leading edge of international development.

4.3.4 Impacts, challenges and potential

The users of unmanned aircraft systems and drones typically are other than conventional aviators, and the challenge thus lies in being able to reach the actors as well as in creating and continuously developing a safety culture. From the safety perspective, the risk of collision in low-altitude aviation is also a challenge, especially due to military aviation activities. Apart from aviation safety aspects, transport sector regulation is not the only type of legislation relevant to automation in aviation.

From the legislator's viewpoint, the challenges in the development of intelligent automation in aviation include the poor availability of information on the operators, the numbers and functionalities of the aircraft systems, as well as accidents. The sector is undergoing a rapid development, and this necessitates close cooperation with its actors. The national legislator should also strive and be able to promote its views in the development of international regulation. The risk is that forthcoming international regulation, including approvals and permit procedures, will be too detailed and restrictive.

Aircraft system manufacturers have been slow to launch production because of an underdeveloped market, lack of standardisation and rules, and the difficulty of organising test flights. While the technology has advanced rapidly, further development will be required before extensive use of unmanned aircraft systems above crowds and in urban areas will be safe.

Automation in aviation offers many opportunities. The potential benefits of unmanned aircraft systems in official use have been recognised. Their potential for commercial use is even greater. This potential is increased by the low volume of air traffic in Finland compared to the extent of the airspace and the fact that unmanned aircraft systems were accounted for in the Aviation Act reform of 2014. Close cooperation between the authorities and the stakeholders enables appropriate and practical regulation.

In the transport of goods, unmanned aircraft systems may meet transport needs, especially those that require speed, reducing the need for storage and local transport, which would contribute to reducing other traffic and especially road transport. In various surveillance, mapping, surveying and assembly tasks as well as in moving goods around, robots will potentially offer great added value. Examples of these tasks are moving tools and components and food serving and search duties of different types.

Above all, Finnish stakeholders would like to see an enabling national approach to their activities. It should consist of proportionate regulation implemented with minimum bureaucracy, which would also make possible operation in the international market. The actors would like fast processes for granting any permits that may be required, and clarity in questions of insurance: when is insurance needed, what type of insurance is required and where can you get it. The authorities must be able to respond to these needs with agile permit processes.

Action: Innovative solutions will be devised to the challenges of developing unmanned aircraft systems, which may benefit the sector in the international context: the development of anti-collision systems could be cited as an example, and contests could be used as a tool.

Action: The Finnish Transport Safety Agency will encourage the networking of new types of actors operating with unmanned aircraft systems, actively inform them about enabling regulation applicable to them, and provide efficient advisory services.

4.4 Maritime transport

4.4.1 Intelligent automation

Ships already feature plenty of process automation similar to a typical factory floor environment in the form of different warnings and functions that permit the adjustment of machinery. They also already have a fair amount of more intelligent automation in partially automated systems used for energy production, the generation of propulsion power and the manoeuvring of the vessel. Today the work of crew members on the bridge responsible for controlling the vessel at sea to a great extent resembles working in a control room. In other words, while the technology needed for the automation of ships already exists to a high degree, the available systems have not been integrated on a single platform, and for various reasons, all the potential already created by automation is not yet being utilised on vessels.

The challenges faced by shipping, both in the EU and globally, include a predicted significant increase in transport volumes, more stringent environmental requirements, and a looming shortage of trained seafarers in the future. The preconditions for using an automated vessel include advanced technological and communication solutions not only on board but also on the shore. A vessel that is partly or fully under remote control from the shore must have efficient and reliable sensor technology to detect and avoid obstacles. The vessel's systems need to know the accurate position, speed, direction and route of the vessel. While automation would increase the efficiency and competitiveness of controlling and operating a vessel, the current international conventions continue to prevent the operation of remotely controlled vessels. (MUNIN, 2012)

It has been suggested in the literature that the introduction of unmanned vessels will bring further savings. The costs of the crew needed on a vessel account for some 30% of the daily operating costs. These costs could in practice be eliminated, or reduced to a fraction of what they are today. It has been estimated that fuel costs of vessels could be reduced by 15–20% if no energy were spent on maintaining such systems as heating, electricity and the water and sewage systems in the crew facilities. The removal of the crew facilities would also increase the cargo space by 15%. (Levander, 2014). If the crew facilities and the related systems were no longer needed, completely new ways of designing vessels would become possible, enabling more efficient loading. The benefits that new designs would bring, or their impacts on activities on shore, have not even been assessed as a whole yet.

Remote control of a vessel with adequate equipment may be considered safer than manoeuvring the vessel from the bridge. This is based on reducing the impacts of human errors. Certain tasks related to controlling the vessel could be performed from the shore. The current view is that the autonomous decision-making systems would be located on board the vessel (MUNIN, 2012). In practice, operators steering a vessel by remote control from a command centre on shore could operate several vessels at the same time. Captains currently spend five per cent of their working time on controlling the vessel while the rest is spent on paperwork. If remote control were introduced, paperwork could be done elsewhere, and the captain's competence could be put to a better use. (Levander, 2014) The vessel and the on-shore control centre would be linked by intelligent automation solutions, including an unmanned bridge and engine room, a shore-based command centre and communication architecture.

One of the greatest practical challenges in the use of remotely controlled, unmanned vessels is achieving a degree of reliability in energy production that makes maintenance personnel unnecessary. At the moment, service operations necessary to keep the vessel going or measures to maintain the energy production system are carried out almost on a daily basis. In order to ensure the uninterrupted passage of the vessel, many other measures related to undisrupted operation are of course also required, such as reducing

the fire risk. Another problem awaiting solution is securing communication links in exceptional circumstances.

Automation will increase further in shipping and the associated shore activities. For example, it will be seen in port logistics as the Internet of Things (IOT) spreads wider and information networks are used more extensively in anticipating and carrying out service and repair operations on vessels. A cloud service open for all actors is seen as a possibility that would promote the more efficient and wider use of the extensive information resources of the marine industry and Baltic shipping. It would enable new innovations, applications and commercial operations by various actors. The possibilities of giving the marine industry and Baltic Sea actors access to a cloud service (the so-called Intelligent cloud of the Baltic Sea) in order to promote the utilisation of open data are currently being studied in cooperation between the authorities and stakeholders.

4.4.2 Regulation

The current interpretation of international provisions is that completely unmanned vessels are in breach of the regulations, as minimum levels have been laid down for the numbers and competence of crew members. In domestic traffic, on the other hand, the authorities have extensive possibilities of approving alternative arrangements, as long as their safety can be guaranteed.

Shipping regulation has not fully kept up with technological development. It has thus been noted that whereas all technologies needed to build and manage a remotely controlled vessel already exist, they are not being exploited, high costs being one of the reasons.

It is at the moment unclear whether or not national regulation is sufficiently permissive considering future needs. National regulation is to a great extent based on international provisions, and it is thus also necessary to establish the areas of international regulation on which influence should be exerted in order to achieve greater flexibility.

Action: The extent to which national and international legislation block the development of intelligent automation in shipping will be examined. It will be ensured that national legislation is permissive, and influence will be exerted on the development of international regulation.

4.4.3 Impacts, challenges and potential

A vessel is so large a system that it is not worth examining the replacement or automation of certain actions taken during the voyage, or even enabling automation in cargo handling, more extensively before a specific new innovation has been produced.

System specifications and requirements may in many parts be extremely restrictive: for example, the type approvals of navigation systems set restrictions on the data that can be displayed or used in them. Communication between vessel and shore systems has also not been standardised. The e-navigation strategy currently being prepared by the International Maritime Organisation IMO will go some way towards clarifying this issue in the future.

Whether or not vessel automation can work also depends on land infrastructures to a great extent. In this respect, there are major variations between different countries, even in the Baltic area alone. Port states have no obligation to provide land infrastructure of a certain type. An unmanned vessel would also require great many assisting devices, including cameras and laser radars. The positive side of this equipment is that it is more accurate than the human eye.

Automated vessels could be easy targets for piracy. One identified future threat is that pirates could use their own computers to seize control of a vessel. As with the automation of other forms of transport, solving liability questions and making the necessary amendments in international conventions will be a drawn-out process.

Identified development needs associated with the intelligent automation of shipping include understanding how the results of efforts to develop technical systems for autonomous vessels can be used during the transition and development phase. The best ways of promoting efficiency, safety and sustainability in shipping over the short term should also be identified. In order to enable automation, perception of the environment, new definitions of maintenance and operative concepts, and more advanced bridge applications should also be developed.

Action: Intelligent transport services that enable automated traffic will be promoted, including the Finnish Transport Agency's ENSI project, which will facilitate improved communication, including exchanges of route data between vessels and stations on shore.

Action: Fairway infrastructure will be developed and equipped with intelligent sensors in order to facilitate safe navigation for automated traffic.

Action: Finland will actively exert influence in the IMO to ensure that e-navigation, which will strongly promote automation, will be introduced internationally as soon as possible, and an effort will be made to create a market for Finnish companies developing the relevant technologies.

Action: Finland will take part and join in on the development of the EU's Common Information Sharing Environment for the maritime domain. The reform of information management in shipping will be used as a national example and the requisite architectural changes will be implemented.

4.5 Rail transport

4.5.1 Intelligent automation

Fully automated, or remotely controlled, trains refer to a carriage or a combination of carriages separated from other traffic and railway users. They may use a completely segregated rail network, as in metro traffic, or only operate on certain stretches, including traffic between airport terminals. In English literature they are referred to as *people movers*, and in Finnish usage, such terms as a horizontal elevator have been coined. (Lumiaho & Kutila, 2015)

In rail transport, intelligent automation has focused on access control, automatic train control and safety at level crossings. An approaching train must trigger protective measures at a level crossing without human action. Examples of these include the use of safety and warning devices and systems where road traffic and rail traffic use a level crossing at different times. Railway yards also use plenty of computer-controlled automation, especially in interlocking systems. (adapted from Lumiaho & Kutila, 2015)

Interlocking systems on the Finnish rail network are very modern by international comparison. In this respect, we should note the relatively long useful life of interlocking systems: relay-based systems have a life span of 50–60 years, and even computer-based systems have a life span of up to 40 years. One reason for the comparative

modernity of interlocking systems in Finland is that the latest technology has always been introduced as soon as it has become available, which has been made possible by not being dependent on major automation suppliers. In countries where the majority of interlocking systems are procured from a single large domestic supplier, the development has usually been more slow due to a form of vendor lock-in. Finland, together with Sweden, are also the world's leading countries in the computerised remote control of interlocking systems. As one contributing factor for this has been seen the long distances in our country, and the ensuing significant cost benefits of remote control.

Approximately 90% of the Finnish rail network consists of a single set of rails, for which reason optimisation is a vital part of traffic control. Traffic controllers are assisted by systems that support decision-making, but in this area, plenty of potential remains for developing artificial intelligence. More intelligent support systems mean more efficient recovery from emergencies and disruptions, which occur frequently and are quite a regular feature of Finnish rail traffic. Consequently, there is highly significant potential for developing the automation of traffic control centres in rail transport.

Optimisation of train energy consumption by means of intelligent automation is another potential source of benefits. The amount of energy required by different control operations of a train could be included as one parameter in decision support systems, either in the traffic control centre or in the engine as part of an operator assistance system.

A train travelling without an operator represents highly advanced automation. Individual functions of the train, including starting, acceleration, cruising, deceleration and stopping have been developed greatly. A key requirement associated with the operation of unmanned trains is the ability to keep the tracks clear of any obstacles, mainly humans and animals. (Lumiaho & Kutila, 2015)

4.5.2 Regulation

The regulation of urban rail transport, or metro and tram traffic, has been left at national discretion in the EU. Regulation applicable to these means of transport and their systems is currently being drafted in Finland. This regulation would bring rail operation and rail network management within the scope of a licensing and supervision system. The planned legislation will stress the actors' individual liability and risk management measures as well as enable the actors to introduce operating models that are the most appropriate for their activities, supporting the independent and risk-based development of these models. While the regulation does not directly take a stand on automation, neither does it place any obstacles in the way of its development.

More stringent international requirements applicable to system approval have been introduced, which contributes to the difficulty of launching new experiments. The cumbersome approval process will also be an obstruction to the export efforts of Finnish actors. Practical examples of this could already be cited.

Action: Finland will exert influence on the international regulation of rail transport in order to enable development and experimentation, with the EU's Shift2Rail project as an example.

4.5.3 Impacts, challenges and potential

Assessing the potential operative and cognitive risks and discontinuities of the various forms of rail transport is a clear development need. The restrictions, challenges, values and opportunities that are relevant to such aspects as the full separation of rail and other

traffic, innovative materials, access control in autonomous rail transport and new types of rail transport systems should be better understood.

A key challenge to promoting intelligent automation in rail transport is safety devices on the state rail network that are obsolete or missing. This results in discontinuities that affect the development of automatic control of trains.

Action: Investments in replacing obsolete or missing safety devices will be accelerated in order to develop the automatic control of trains.

4.6 Logistics

Finnish actors have solid expertise in the design and manufacture of automated forklift systems used in warehouses and logistics centres, and Finland is one of the world's leading countries in automated container handling in ports and the associated heavy-duty field robotics. The value of automation and robotics in this sector for Finnish companies is EUR 100–200 million. Some two thirds of this volume is manufactured in Finland, while the rest is produced in the companies' overseas units. The main part of product development, however, takes place in Finland, and global driver companies operating in Finland have created a wide-spread supplier network around them, which comprises a great volume of expertise in demanding automation and robotics, for example in the fields of navigation, tracking, perception of the surroundings, remote operation, control of machine groups and communication. (Ventä et al., 2015)

Automation in ports is only taking its first steps. It involves major projects and deliveries of complete systems, and Finland has already gained a good foothold in this sector of robotics that shows great potential. The sector is developing rapidly, however, and it is thus essential to identify its real development needs and the measures indicated by these needs in order to keep up Finnish companies' ability to innovate and be competitive. In addition to machine manufacturers, major automation and software suppliers will also be competing for these deliveries. (Ventä et al., 2015)

Robotics in ports, large warehouses and logistics centres will without exception involve deliveries of major systems. Large entities or areas will be automated at once, machines operated by humans will no longer be needed, and the relevant areas will be closed to other traffic and outsiders. In addition to an individual machine, suppliers will need an ability to provide control systems for large groups of machines, or even ERP systems for an entire warehouse or port. The end customer's emphatic need for standardisation of interfaces between machines and systems, which allows the systems of different manufacturers to operate in the same environment, will add to the challenges. (Ventä et al., 2015)

Automation is expected to have a major impact on heavy vehicle traffic globally. For instance, automation is believed to alleviate problems related to the availability of labour in the sector. Technologies for the automation of heavy goods traffic already are rather advanced, even if challenges also remain. Initially, these challenges will be tackled by experimenting with heavy vehicle platooning. Full use of automation in heavy goods traffic may also require legislative changes, including regulation of driving times and rest periods.

In logistics, robotics will be driven forward by the same drivers as industry in times gone by: the goals of improving productivity and safety. The main gauges for measuring productivity in warehouses and ports are the throughput times of goods and percentages of losses. The ability to control automated machines and production of information are the only factors that can help to push productivity up to new levels. High turnover and

low levels of education of operators create additional needs for increasing the automation level. (Ventä et al., 2015)

Safety standards do exist for automated forklifts, or wire-guided trolleys, and they can to some extent operate in the same facilities with humans. The development of heavy-duty robotics for logistics is still slowed down by a lack of established solutions. Typically, the machines move around in an enclosed area. They are monitored and, if necessary, operated from a control room situated in that area. An individual movement or work stage is often performed under remote control. An ability to use automated heavy machinery at least in part together with machines operated by humans would be a major step forward, but it has as yet not been possible to define safety standards that would promote the introduction of these new solutions. The manufacturers and customers in the sector are continuously working together, and as the volume of deliveries increases, the sector may gradually be ready for standardisation. (Ventä et al., 2015)

Identified development needs related to logistics include, in particular, promoting the use of automated vehicles in urban logistics as well as in distribution and collection services. In addition, the obstacles to and potential for introducing and using unmanned and remotely controlled aircraft systems should be mapped.

5. Intelligent automation experiments in transport

5.1 Road transport

Automated vehicles are tested in dedicated testing areas designed for this purpose and in road and street conditions. The testing areas must permit preparing for different traffic situations and conditions. The experiments must allow the testing of technical systems and communications as well as their effectiveness, delays, sensitivity to interference, recovery from disruptions and reliability as well as user reactions, including usability, user interfaces and user acceptance. (Lumiaho & Kutila, 2015)

As technologies advance, experiments will first be carried out within an enclosed testing area, as taking an instrumented vehicle with advanced or full automation directly to public roads carries too high a risk. (Figure 5) In the initial stage, a few cars need to be equipped with new technology to test perception, data transfer and driver behaviour. Unfinished test models will not be available from car manufacturers. (Lumiaho & Kutila, 2015) The testing areas also have another function: they can be used to influence the way in which future drivers will receive automated vehicles.

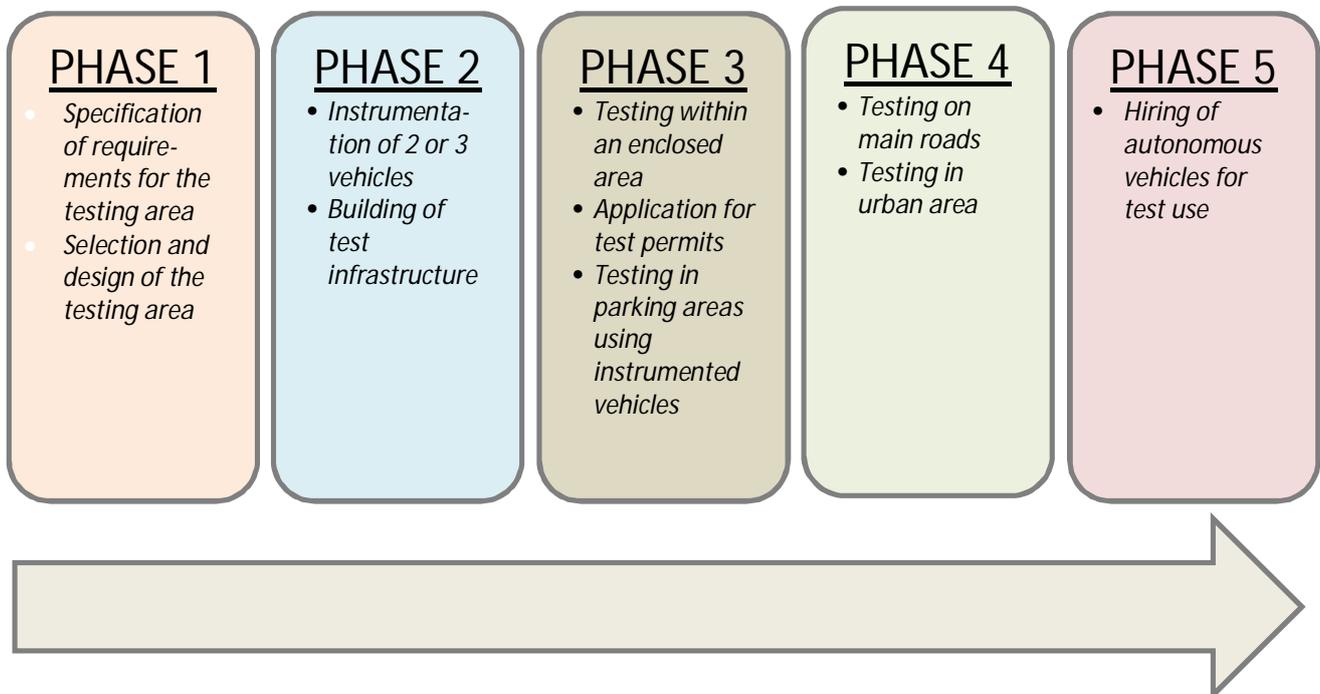


Figure 5. Stepwise progress of the testing environment (Lumiaho & Kutila, 2015).

Developing experimentation in Finland

Working testing areas and experimental business related to road transport can already be found in Finland. These should also be used in the planning and implementation of experiments to test intelligent automation in road transport. The Test World, for instance, has served as a tyre testing area for car manufacturers since the 1990's, and tests in winter conditions can also be performed in the Arctic Research Centre.

Finland has also participated in a number of EU research and development projects in which extensive field tests of vehicles have been arranged, for example in the Tampere region. As a result of such projects, strong competence in organising and managing field tests has also been accumulated in Finland, and this competence should be more effectively utilised and marketed.

At the moment, automated cars are rather vulnerable to challenging weather and road conditions. This gives Finland an opportunity to be profiled as a versatile testing environment for winter conditions, the foundation of which is permissive legislation. In order to develop experimentation, efficient networking between the actors will be needed to turn the entire country into an Arctic testing environment where different stakeholders can focus on their core expertise. The goal is to draw actors to Finland, for instance by means of joint marketing efforts. This will be facilitated by the single contact point for automated vehicle trials established in the Finnish Transport Safety Agency in early 2015, which provides information for parties interested in experimentation and, if necessary, assistance in planning and organising trials.

So far, little or no information is publicly available in the world on the organisation of experiments with automated vehicles and the associated requirements. Information on testing in winter conditions is practically non-existent. For this reason, we should establish the requirements for developing this type of testing activities in Finland and the existing strengths that can be utilised for this purpose. In addition, solutions for the functioning of automated cars in Arctic conditions can be developed in research and development projects.

As part of the EU-funded CityMobil2 research project, automated buses that operated without a driver and transported some 10 persons at a time were tested in connection with the housing fair in Kivistö, Vantaa in summer 2015. Further plans include developing automated buses of the same type that would also work in winter conditions.

Manufacturers of heavy goods vehicles, including Scania, have already experimented with platooning in different parts of Europe, including in the Netherlands. Finland should strive to be part of these trials, capitalising especially on our Arctic approach.

Action: An ecosystem of testing areas and competence will be created, and the infrastructure required for experimentation will be developed.

Action: An operating environment called "the Snowbox" that will draw different automation experiments and transport services will be created in Fell Lapland (the Aurora project).

Action: The actors will work together to develop a snow plough that operates automatically, and under remote control in difficult situations, which can be used for such purposes as developing the winter maintenance of transport routes and advancing Arctic competence in Finland.

Action: An effort will be made to improve public transport services using automated vehicles. In the early stages, easy routes will be selected, and the vehicles will travel at low speeds. The ability of public transport vehicles to operate in the winter will be developed. Tuusula, for example, could be used as a test location.

Action: The Finnish Transport Safety Agency's single contact point for automated vehicle trials will be marketed actively at international events.

Action: Finland will participate in the European Platooning Challenge, an experiment that will take place during the EU Presidency of the Netherlands in spring 2016.

5.2 Aviation

Using an unmanned aircraft system with a pre-programme route to inspect the condition of power lines is an example of experiments initiated in the field of unmanned aviation. In this experiment, the data collected by the aircraft are analysed and saved automatically. (Ahjopalo, 2014)

Arranging experiments with unmanned aircraft systems is straightforward under the Finnish Aviation Act, which grants unmanned aircraft systems a derogation from compliance with aviation rules in areas that are closed to other air traffic or segregated for the operation of unmanned aircraft systems. The Finnish Transport Safety Agency is embracing its role as an enabling authority by analysing projected uses together with the actors in order to ensure that the activities are safe and compliant with the requirements.

Action: Using unmanned aircraft systems, experiments will be carried out where limited applications of commercial goods transport activities are permitted. Such applications could include the distribution of medicines in the archipelago and transport of goods in sparsely inhabited areas. Safe distribution warehouses in shared use for goods to be distributed by quadcopters at a walking distance from the end customers will be designed together with the planning authority for quadcopters used for local distribution.

Action: The Finnish Transport Safety Agency will facilitate the arrangement of small-scale trials organised on a short notice more easily and at a lower cost.

5.3 Shipping

The regulations of the International Maritime Organisation IMO give little scope for experiments in international waters.

In domestic traffic, Finnish authorities have extensive possibilities of approving alternative arrangements in order to test automatisation in maritime transport, as long as safety can be guaranteed. These possibilities are remarkably good in domestic traffic and also for non-SOLAS vessels. Such automation experiments in domestic waters are already being planned in different parts of the world.

The easiest and most sensible starting point for trials is cargo transportation. Other types of transportation can also be facilitated, for example with a single person on board. In reality, this would be the most probable scenario for experiments, as the purpose in the testing phase is to observe reliability and make sure that the vessel can operate safely.

The AAWA Initiative project develops solutions for future intelligent maritime operations. Five industrial and five research partners are involved in it. In this project, both remotely controlled and fully autonomous solutions are being developed, and they are relevant to navigation, machinery and other systems used on a vessel. In addition to mere technical development, the project also examines safety aspects and economic perspectives as well as opportunities and restrictions based on legislation. The project has great potential for the entire Finnish marine industry cluster for creating new business opportunities and being profiled as the world's leading hub of intelligent marine operations.

Action: Entrepreneurs will be encouraged and supported in launching automated vessel experiments, for example in the ferry traffic in the archipelago. Transportation in the archipelago using automated vessels will be tested.

Action: A clear plan will be formulated to encourage the open-minded networking of stakeholders. Projects that are already up and running will be utilised, including the Merit project of the City of Helsinki and the AAWA project of a business and research consortium.

5.4 Rail transport

The Finnish state-owned railway company VR has carried out trials aiming to optimise train energy consumption through intelligent automation.

The current processes for obtaining authorisations for placing into service and approvals for subsystems and rolling stock, which have been harmonised to rather a high degree at the EU level, have been designed to secure the compliance and interoperability of the products offered in the market, and they do not make sufficient allowance for various rail transport trials. In technical specifications for interoperability (TSIs), the realisation of interoperability is to a great extent tied to certain technical solutions and standards, which may slow down the development of new solutions. The modification of the TSIs into a more technology neutral and performance-based direction is likely to be a drawn-out process.

Innovation in rail transport could be promoted by a set of norms that were as technology neutral as possible.

6. Building a business ecosystem for intelligent automation in transport

6.1 About business ecosystems

Typical features of a good business ecosystem capable of sustainable growth include many preconditions of fair competition and cultures (Ventä et al., 2015). A business ecosystem refers to an environment where companies collaborate, compete and create capabilities together around new innovations. These capabilities and resources complement each other, increasing the customer value of the product or the service.

A sector of this type has drivers, technologies, operating methods and even glossaries in common. Many types of useful technical and other infrastructures have been jointly developed for the sector, simultaneously allowing competition between the actors and encouraging many useful applications and requisite interoperability of its components. (Ventä et al., 2015)

Standardisation and legislation are key factors, but not sufficient as such. Competence, operating methods, design tools and platforms for efficiently producing genuine interoperability are needed. When competition, growth and development take place coherently, the sector is accessible for actors both large and small. The process is also facilitated by jointly agreed rules and procedures that support safety, information security and ethical action. (Ventä et al., 2015)

Drivers for healthy development in an ecosystem may include strong suppliers, strong original equipment manufacturers (OEMs), or strong integrators, and in some cases strong buyers or end users (e.g. the car industry) or, depending on the situation, well-informed and knowledgeable authorities or even the central government. In some cases, a single strong actor holds a controlling global market position for years, also effectively dictating the rules of compatibility and the role of third parties in the market. (Ventä et al., 2015)

Finland's strength in ecosystem building lies in our small circles of stakeholders, which enable efficient networking and cooperation. However, this strength has as yet not been capitalised on particular well in promoting digitalisation.

6.2 Common market segments of robotics in Finland

The EU's Strategic Research Agenda (*SRA*) for Robotics divides the market into following sectors (Ventä et al., 2015): consumers, government and public agencies including maintenance of public infrastructure as well as search and rescue services, private sector services, transport and logistics, defence or military applications, manufacturing, agriculture and health care. This division into application areas or market segments also describes the Finnish situation rather well.

Table 2 illustrates the division into market segments and contains the basic information and current situation of companies.

Segment	Sub-segment	Examples	Forms of business	Key actors	Turnover in Finland
Industry	Production lines	Welding and packaging robots	Trade in equipment, systems, contracting, services. Exportation > Importation	Yaskawa, (JPN) KUKA(GER), ABB (SWE), Orfer(FIN), Optofidelity (FIN)	EUR 100 million
	Materials handling	Conveyor, automated warehouse, wire-guided trolley	Trade in equipment, systems, contracting services Exportation > Importation	Cimcorp, Fastems(FIN) Rocla, Solving (FIN)	EUR 10 million
Service robotics	Leisure	Quadcopter, building kits	Retail, online trade		EUR 0.1 million
	Assistance	Autonomous lawnmower, vacuum cleaner	Retail, online trade	Husqvarna(SWE) Samsung (KOR) Bosch(GER)	EUR 1 million
	Care	Remote presence, therapy	Trade in equipment, systems, service		EUR 0.1 million
Hospital technology		Surgery robots, tomography	Trade in equipment, systems, contracting, services	Intuitive Surgical, Medtronic, GE(US), Philips(NED), Planmeca(FIN)	EUR 1.5 million
Field robotics	Mining machinery	Drilling machine, dumper, conveyor	Trade in equipment, systems, contracting, services	Sandvik, Normet(FIN), Metso Minerals(FIN), Caterpillar(US)	EUR 10 million
	Forestry machines	Harvester	Trade in equipment, systems, service	Ponsse(FIN), JDF(US)	
	Agriculture	Tractor-machine combination	Trade in equipment, systems, service	Valtra(FIN)/Acgo(US)	
	Construction	Road scraper, excavator	Trade in equipment, systems, service	Caterpillar(US), Komatsu(JAP), Novatron(FIN)	
	Logistics	Straddle carrier, reach stacker, forklift	Trade in equipment, systems, contracting, services	Konecranes(FIN), Cargotec(FIN), Kone(FIN), Rocla(FIN), Terex(US), Siemens(GER), ABB(SUI etc.)	EUR 10 million
	Surveillance	Quadcopter (professional)	Trade in equipment, systems, contracting, services		
	Safety and security	IR sensor, rescue and fire fighting, border control	Trade in equipment, systems, contracting, services	Bronto Skylift(FIN)	
	Military app.			Patria(FIN)	
Transport	Vehicles	Semi, highly, fully autonomous cars		Daimler, VW, Audi, BMW (DE), Volvo (SE), SWARCO (AU), Elektrobit EB (FIN), Symbio (FIN), Tieto (FIN),	
	Rail transport	Automated metro, people mover		Alstom (F), Ansaldo STS (I), Bombardier (CND), Hyundai Rotem (S.Korea), Siemens (DE)	
	Aviation	Unmanned aerial vehicles (UAVs, autonomous, remotely controlled)		Airbourne Robotics (AT), Aeryon (CND), Indela (BY)	
	Inland waterway and marine transport	Auto pilot => Unmanned bridges		Napa (FIN), Rolls Royce (GBR), Eniram (FIN), Meyer Turku (FIN)	

Table 2. Application areas of robotisation in Finland by market segment (Ventä et al., 2015).

The highly significant machinery sector in Finland is highlighted among the market segments. The Finnish forest harvester is one of the most highly instrumented and automated working machines in the world, a prime example of peak technology. Of the companies, Ponsse is a global leader of its sector with John Deere Forestry, an inheritor of Timberjack, coming close second. Similarly, Konecranes and Cargotec are globally very strong in logistics. All of these companies do the main part of their product development in Finland, with major impacts on education, research and accumulation of experience in these fields in the country. The increasing significance of mining has also created good preconditions for mechanical industry in this sector. Sandvik-Tamrock, Metso Minerals and Normet are thus strong suppliers in Finland and also significant exporters. The closest competitors of all these companies come from Sweden, and going further afield, from Japan, Korea, the USA and Germany. Forestry and the mining industry are examples of sectors that, while small on the global scale, are important for Finland. Agriculture, construction, logistics and hospital technology, on the other hand, are large global sectors with both major global suppliers and a few individual Finnish stars, which have been cited in the table as examples. In a broad sense, the application of robots in these sectors is based on imports. The volume of the field robotics segment (manufacture of products and systems) in Finland totalled approximately EUR 400 million in 2014, and its share in the sector's turnover was some 10%. The markets for these products are global. (Ventä et al., 2015)

When discussing industrial robots, we should mention production automation for the electronics industry. At the turn of the millennium, the sector had its day as a global actor with production lines and robot cells, but with the decline of the electronics industry, the corresponding robotics industry is about to disappear in Finland, and its experts have turned to other sectors. On the other hand, companies delivering robotics for other industries, including Fastems and Cimcorp, have done well. In subsectors with manufacturing in Finland, the total exports of technology clearly exceed the imports. (Ventä et al., 2015)

6.3 The ecosystem for intelligent automation in transport

The ecosystem for intelligent automation in transport, similarly to any other ecosystem, will unavoidably consist of different subsectors and different types of actors. It is by no means certain that the actors will engage in effective cooperation that benefits all parties even within the individual subsectors, to say nothing about having this ability between the different subsectors of the ecosystem. See the Figure below for an illustration of this (Figure 6).

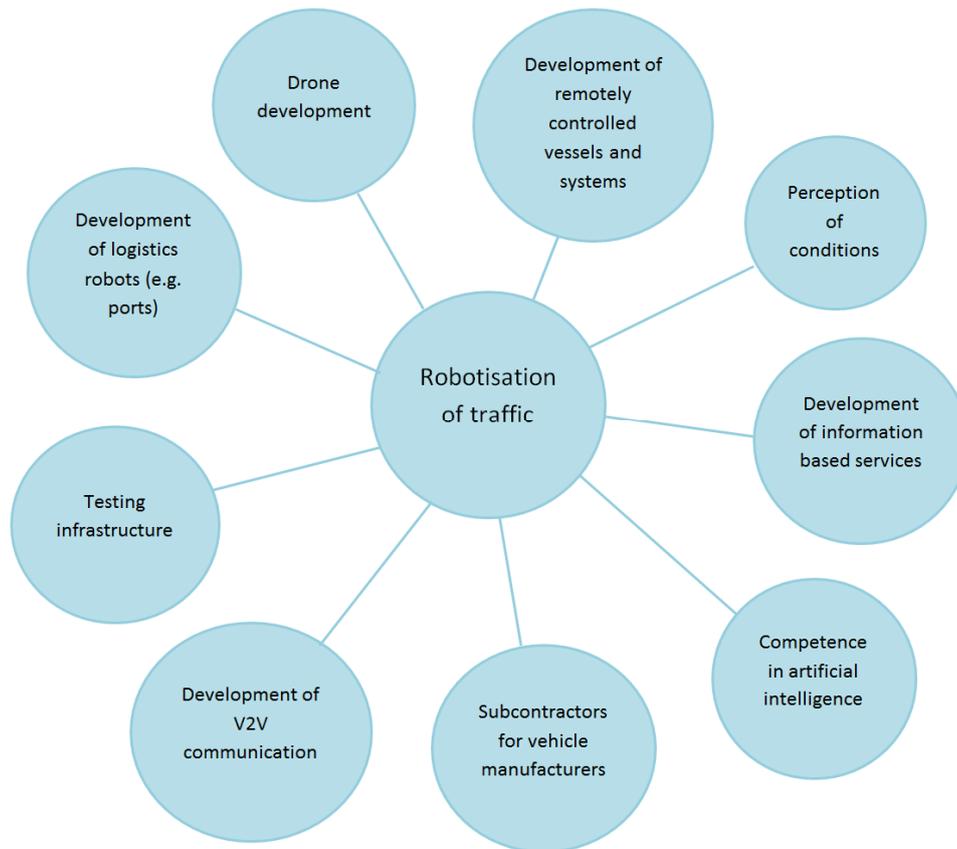


Figure 6. A perception of the Finnish ecosystem for intelligent automation of transport.

A number of companies that are interesting in terms of transport automation are operating in Finland. A list of them, which is not intended to be exclusive, is given below. During the process of drawing up this plan, numerous useful bilateral and multilateral discussions with the actors have already taken place, and these discussions should also be systematically continued in the future.

The objective of ecosystem creation is that companies could benefit from networking, also across conventional boundaries of cooperation. One obvious benefit for all actors could be combining their forces in international marketing efforts. The challenge, however, will lie in finding driver companies or organisations for the ecosystems that would have an interest in developing them.

6.3.1 Road transport automation companies operating in Finland

- Arctic Research Centre - testing services
- Elektrobit - navigation systems, image recognition
- HERE - navigation, maps, personalised automated driving
- Innomikko - testing services
- Linkker - electric buses
- Nokia - communication between cars and infrastructure
- Nokian Renkaat - tires and safe vehicle control
- Roadscanners - measurement and monitoring of transport infrastructure condition
- Teconer - friction measurements, road surface sensors
- TeliaSonera, Elisa, DNA - communication between cars and infrastructure
- Test World - testing for winter conditions
- Vaisala - road surface sensors, weather stations

- Valmet Automotive - vehicle assembly

6.3.2 Aviation automation companies operating in Finland

- AL Safety Design – risk management and reliability technology for technical systems
- SharperShape – property surveying by unmanned aerial vehicles
- DA-Design – electronics, software design and manufacturing
- Insta – industrial automation, lifespan services in aviation, situational awareness and information security solutions and services
- Patria Aviation – assembly, component manufacture, servicing and modifications of helicopters, pilot training
- Robonic - design services
- Space Systems Finland – provision of software and system development services for the mechanical industry, medical equipment industry, nuclear industry and space industry
- Vaisala – measurement solutions for the environment and industry

6.3.3 Shipping automation companies operating in Finland

- Deltamarin - vessel design
- Elomatic - vessel design
- Eniram - optimisation software
- Metso – energy management systems
- NAPA - marine industry software
- Navielektro - VTS systems
- Rauma Marine Constructions - shipbuilding
- Rolls-Royce – Design, support and construction of power and propulsion systems. Integration of technical systems.
- Wärtsilä - shipbuilding

6.3.4 Rail transport automation companies operating in Finland

- Bombardier - global product development of remote control systems in Finland
- Desec - points switching robot
- EKE-Elektroniikka - integrated IP-based intelligent systems for trains
- Mipro - computer-controlled interlocking systems and remote control systems
- Sabik - led light units

Action: Determined efforts will be launched to build a Finnish testing ecosystem, and the open-minded networking of actors in the sector will be encouraged. Workshops and other networking events will be organised.

Action: Team Finland activities will be used and joint efficient marketing measures will be implemented internationally.

7. Conclusion

Anything that can reasonably be automated, will be – in transport as well as more generally in society. What is reasonable automation still remains an open question in this context. To find out, we need experiments of intelligent transport automation in all modes of transport: on land, in water and in the air.

In the years to come, intelligent automation solutions will be as ubiquitous as information technology. The increase of intelligent automation is part of the on-going digital revolution. The combination of mobile devices, cloud services, big data crunching and robotics will change the ways in which we work and spend our free time. Finland has plenty of expertise in all these sectors, and we should now effectively utilise this competence to promote intelligent automation in transport and to realise the ensuing benefits.

This plan has identified a number of actions aiming to achieve these objectives in different areas of society. In the following pages, the actions presented above in this plan document have been collected and grouped by subsector. They have not been prioritised, and no order of priority is intended here.

Data, telecommunications and technology

- Communication systems between cars and between cars and road infrastructure will be developed further, utilising existing radio technology expertise and projects already launched (including NordicWay) in cooperation between different actors.
- The construction of fast and reliable terrestrial and wireless connections necessary for automated driving on roads will be promoted. This process should start with the busiest roads.
- A frame of reference that sets out the information base needed for the automation of each form of transport will be created. In an effort to build a digital information base, the adequacy of national resources of different data types (geographical information services, information administrated by the authorities, service providers' data) for the needs of the digital information base for automated transport will be examined, and the necessary steps will be taken to guarantee its adequacy.
- Investments in replacing obsolete or missing safety devices will be accelerated in order to develop the automatic control of trains.
- Intelligent transport services that enable automated traffic will be promoted, including the Finnish Transport Agency's ENSI project, which will facilitate improved communication, including exchanges of route data between vessels and stations on shore.
- Fairway infrastructure will be developed and equipped with intelligent sensors in order to facilitate safe navigation for automated traffic.
- Finland will take part and join in on the development of the EU's Common Information Sharing Environment for the maritime domain. The reform of information management in shipping will be used as a national example and the requisite architectural changes will be implemented.
- In telecommunications, the priority of real-time traffic information services critical for safety will be ensured in cooperation with the largest telecommunications operators.

Regulation and exertion of influence

- The Government Programme policy indicating a reduction in the car tax will be implemented and its impacts on promoting automation will be established.
- Creation of the best regulatory environment in Europe, or in the world, for testing and introducing automated driving will be ensured. Any corrective action that is

required will be taken without delay. In connection with the overall reform of the Road Traffic Act, it will be ensured that no legislative obstacles remain.

- Finland will actively exert influence in international forums to ensure that international provisions enable the development of automation.
- Availability of accurate information on existing driver assistance systems in registered vehicles will be ensured in the future in order to facilitate a more precise assessment of the impacts of these systems and increasing automation on transport safety and the smooth running of traffic.
- The Finnish Transport Safety Agency and the Finnish Transport Agency will increase their inputs in promoting the creation of open international standards. Merely monitoring the situation is not enough.
- Information will be extensively disseminated, both in Finland and abroad, on the opportunities offered by the current status of regulation.
- Finland will exert influence on the international regulation of rail transport in order to enable development and experimentation, with the EU's Shift2Rail project as an example.
- The extent to which national and international legislation block the development of intelligent automation in shipping will be examined. It will be ensured that national legislation is permissive, and influence will be exerted on the development of international regulation.
- Finland will actively exert influence in the IMO to ensure that e-navigation, which will strongly promote automation, will be introduced internationally as soon as possible, and an effort will be made to create a market for Finnish companies developing the relevant technologies.
- As aviation regulation is drafted at the international level, the transport administration sector will seek to strongly influence the development of international and EU regulation to ensure that a light, risk-based approach to aviation regulation will be adopted.
- Domestic aviation regulation will be continuously compared with regulation in other countries to ensure that it stays on the leading edge of international development.
- The Finnish Transport Safety Agency will encourage the networking of new types of actors operating with unmanned aircraft systems, actively inform them about enabling regulation applicable to them, and provide efficient advisory services.
- The Finnish motor insurance system will be used as an international example of how liability questions related to automated cars can be managed simply.
- The Finnish Transport Safety Agency's single contact point for automated vehicle trials will be marketed actively at international events.

Research, trials and ecosystems

- The actors will work together to develop a snow plough that operates automatically, and under remote control in difficult situations, which can be used for such purposes as developing the winter maintenance of transport routes and advancing Arctic competence in Finland.
- An operating environment called "the Snowbox" that will draw different automation experiments and transport services will be created in Fell Lapland (the Aurora project).
- An effort will be made to improve public transport services using automated vehicles. In the early stages, easy routes will be selected, and the vehicles will travel at low speeds. The ability of public transport vehicles to operate in the winter will be developed. Tuusula, for example, could be used as a test location.
- A clear plan will be formulated to encourage the open-minded networking of stakeholders. Projects that are already up and running will be utilised, including the Merit project of the City of Helsinki and the AAWA project of a business and research consortium.

- Determined efforts will be launched to build a Finnish testing ecosystem, and the open-minded networking of actors in the sector will be encouraged. Workshops and other networking events will be organised.
- Team Finland activities will be used and joint efficient marketing measures will be implemented internationally.
- The study on the most immediate measures required to enable automation, especially at level 3, will be completed and these measures will be implemented on a rapid schedule, proactively if possible.
- An ecosystem of testing areas and competence will be created, and the infrastructure required for experimentation will be developed.
- Entrepreneurs will be encouraged and supported in launching automated vessel experiments, for example in the ferry traffic in the archipelago. Transportation in the archipelago using automated vessels will be tested.
- Using unmanned aircraft systems, experiments will be carried out where limited applications of commercial goods transport activities are permitted. Such applications could include the distribution of medicines in the archipelago and transport of goods in sparsely inhabited areas. Safe distribution warehouses in shared use for goods to be distributed by quadcopters at a walking distance from the end customers will be designed together with the planning authority for quadcopters used for local distribution.
- Innovative solutions will be devised to the challenges of developing unmanned aircraft systems, which may benefit the sector in the international context: the development of anti-collision systems could be cited as an example, and contests could be used as a tool.
- The Finnish Transport Safety Agency will facilitate the arrangement of small-scale trials organised on a short notice more easily and at a lower cost.
- Finland will participate in the European Platooning Challenge, an experiment that will take place during the EU Presidency of the Netherlands in spring 2016.

Appendix: terminology

Road transport

Table 3. Terminology related to automation in road transport (Innamaa et al., 2015)

English term	Finnish term	Explanation
Automated vehicle	Automaattiajoneuvo, automaattinen ajoneuvo	A vehicle that can at least partly perform a driving task without a driver
Autonomous vehicle	Autonominen ajoneuvo, (itsenäinen ajoneuvo, omaehtoinen ajoneuvo)	An automated vehicle that can perform a driving task without a driver and without connections to other vehicles or infrastructure
Connected vehicle	Verkottunut ajoneuvo	A vehicle that has a wireless connection with other vehicles and/or infrastructure
Teleoperated vehicle	Teleoperoitu ajoneuvo	A vehicle that is operated wirelessly from outside. The vehicle need not be automated or autonomous.
Cooperative service	Yhteistoiminnallinen palvelu	A service where the vehicle/traveller and the infrastructure or vehicles/travellers exchange information electronically to implement the service
Collaborative service	Yhteisöllinen palvelu	A service where all road user groups (vehicles, cyclists and pedestrians, and public transport passengers) and the infrastructure are connected (many different parties, crowd sourcing, incl. information production).
Platooning	Letka-ajo, saattueajo	Driving in a queue where the first vehicle of the queue controls the platoon while the others follow automatically. Typically requires a separate lane or lane arrangements.

Aviation

Table 4. Terminology related to automation in aviation (source [ICAO, 2011]).

Drone	an unmanned aircraft system, a term mainly used in the media
UAV	an unmanned aerial vehicle (according to ICAO, an obsolete term)
UAS	an unmanned aircraft system (term preferred by the ICAO); usually translated into Finnish as miehittämätön ilma-alus or miehittämätön ilma-alusjärjestelmä
RPAS	remotely piloted aircraft system, an unmanned aircraft system
Model aircraft	device intended for flying that has no pilot used as a sport or a hobby (Section 2.1(21) of the Aviation Act); only differs from an unmanned aircraft system by its use
Unmanned aircraft system	an aircraft intended for flying without a pilot on board (not a model aircraft; Section 2.1(22) of the Aviation Act)
Remotely controlled aircraft	an unmanned aircraft system piloted from a remote control station (Section 2.1(23) of the Aviation Act)
Quadcopter	a copter that has four rotors, making it steadier and easier to control than a single-rotor copter; typical model used in remote control

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