

Roadmap for innovative operation of the transport system

Satu Innamaa | Elina Aittoniemi | Hanna Askola | Risto Kulmala

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Innovatiivisen liikennejärjestelmän operoinnin tiekartta. **Satu Innamaa, Elina Aittoniemi, Hanna Askola & Risto Kulmala.** Espoo 2012. VTT Technology 8. 30 p.

Abstract

The objective of VTT's Innovation programme for Intelligent Transport Systems and Services (INTRANS) is to promote transport safety, efficiency and environmental friendliness by exploiting new innovative services and technology. The objective of this study was to create a foresight plan and roadmap for innovative operation of the transport system 10–20 years into the future, enabling the most promising services to be selected for development. The services chosen should provide new possibilities for export and domestic business for Finnish companies while providing distinct added value to transport system operators.

The work was based on Ventä's roadmap method and two expert workshops with representatives from the Ministry of Transport and Communications, the Finnish Transport Agency, the Finnish Transport Safety Agency, the Centre for Economic Development, Transport and the Environment of Southeast Finland, the City of Tampere and VTT.

The vision "Proactive operation ensures that the transport system works as a whole in the most efficient, safe and environmentally friendly way and fulfils the user's expectations under all circumstances" was created within the project. In the vision, operation affects the travel mode distribution and prerequisites of mobility and thus the demand for traffic. Within the work the present state was described and future trends were worked out. The challenges and solutions of transport system operation were listed. As a result, lists of action for the different parties in charge were created for the years 2012–2013, 2014–2020 and 2021–2030 in order to reach the vision.

Keywords Traffic management, transport system operation, roadmap, foresight, vision

Innovatiivisen liikennejärjestelmän operoinnin tiekartta

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Tiivistelmä

VTT:n älyliikenteen innovaatio-ohjelman INTRANSin tavoitteena on edistää liikenteen turvallisuutta, sujuvuutta ja ympäristöystävällisyyttä kehittämällä uusia innovatiivisia palveluja ja teknologiaratkaisuja. Tässä työssä oli tarkoituksenaan kehittää ennakkonäkemyksiä ja tiekartta innovatiivisille liikennejärjestelmän operoinnin palveluille 10–20 vuoden päähän, jotta lupaavimmat palvelutyypit voitaisiin tunnistaa ja ottaa kehitettäväksi. Palveluiden tulisi tarjota uusia mahdollisuuksia vientiin ja kotimaan liiketoimintaan suomalaisille yrityksille sekä samalla tuottaa selkeää lisäarvoa liikennejärjestelmän operaattoreille.

Työ perustui Olli Ventän tiekarttamenetelmään ja kahteen asiantuntijatyöpajaan, joissa oli edustajat VTT:n lisäksi liikenne- ja viestintäministeriöstä, Liikennevirastosta, Liikenteen turvallisuusvirastosta (Trafi), Kaakkois-Suomen ELY-keskuksesta ja Tampereen kaupungilta.

Työssä kehitettiin visio: ”Proaktiivinen operointi takaa, että liikennejärjestelmä toimii kokonaisuutena mahdollisimman tehokkaasti ja täyttää käyttäjän odotukset kaikissa olosuhteissa.” Visiossa operoinnilla vaikutetaan kulkutapajakaumaan ja liikkumisen edellytyksiin ja sitä kautta liikenteen kysyntään. Työssä kuvattiin nykytila ja selvitettiin tulevaisuuden trendejä. Liikennejärjestelmän operoinnin haasteet ja keinot selvitä haasteista listattiin. Lopputuloksena annettiin toimenpidelistat alan eri toimijoille vuosille 2012–2013, 2014–2020 ja 2021–2030, jotta visio saavutettaisiin.

Avainsanat Traffic management, transport system operation, roadmap, foresight, vision

Preface

VTT's Innovation programme for Intelligent Transport Systems and Services (INTRANS) decided to create a foresight plan and roadmap for innovative operation of the transport system 10–20 years into the future, enabling the most promising services to be selected for development. Satu Innamaa, Elina Aittoniemi, Hanna Askola and Risto Kulmala were responsible for the work. The work was based on two expert workshops. The authors would like to thank the participants from the Ministry of Transport and Communications, the Finnish Transport Agency, the Finnish Transport Safety Agency, the Centre for Economic Development, Transport and the Environment of Southeast Finland, the City of Tampere and VTT for their contribution.

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1. Introduction

The objective of VTT's Innovation programme for Intelligent Transport Systems and Services (INTRANS) is to promote transport safety, efficiency and environmental friendliness by exploiting new innovative services and technology. Services, service concepts, products and the necessary technology are developed within the programme in cooperation with businesses, the public sector and other stakeholders. The public and commercial services to be developed must be useful and promote welfare for both consumers and businesses, and offer a competitive edge to the latter. The INTRANS programme supports common efforts to bring intelligent transport services into widespread use both in Finland and abroad.

The objective of this study was to create a foresight plan and roadmap for innovative operation of the transport system 10–20 years into the future, enabling the most promising services to be selected for development. The services chosen should provide new possibilities for export and domestic business for Finnish companies while providing distinct added value to transport system operators.

The foresight plan and roadmap cover the technological development, overall economy, politics, organisational trends and challenges to be expected within this and the next few decades, taking into account the strengths of Finnish businesses and VTT. The most important novelty value of the services is probably related to the growing importance of road users, transport companies and other businesses as new interest groups in the actual operation of the transport system. This is a consequence from the changing role of the public sector and from cooperative, social media based applications, which are revolutionising the service content and service organisation concept in the field of transportation. The work covers maritime and road transport.

2. Method

2.1 Ventä roadmap method

The roadmap by Ventä (2004a) is a map of the presumed future and anticipated changes that will affect business operations. The roadmap describes market trends, changes in the operational environment of the examined organisation and technological life spans, which interweave into concrete product line plans. The roadmap considers objectives and know-how of the companies and forms a common vision that is as objective as possible. Roadmaps are also made for different business branches and, usually on a national level, to show concrete directions for publicly funded research and technology programmes. Roadmaps can also be seen as strategic progress schemes of organisations.

Ventä refined the roadmap method after his publication (2004a) and produced a simplified version of the method. Figure 1 illustrates the different phases of the method. Building a roadmap starts with a vision defining an outlook for a time several years in the future. The vision depicts in which kind of (business) activity and in which kind of a world the organisation wishes to be in the target year. This future world should be described without scientific or technical restraints. In other words, it is assumed that all technical and theoretical challenges have been overcome. The vision describes an ideal state (Ventä 2004b).

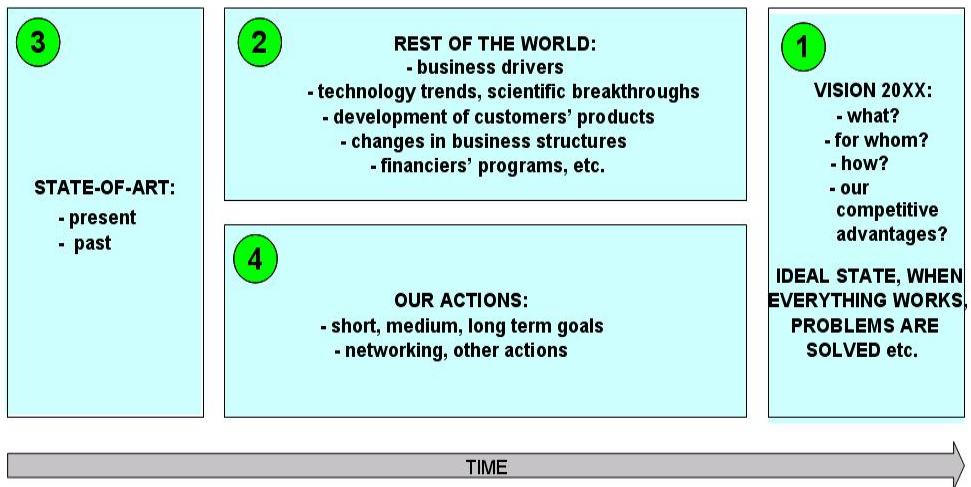


Figure 1. Phases of the roadmap (Ventä 2004b).

The next stage contemplates what is happening in other parts of the world at present and in the future. What happens elsewhere in relation to the defined vision? What do we have to consider? In this phase, all essential aspects should be analysed. Trends, changes in the market, breakthroughs etc. illustrate and complete the vision for their part. It should also be asked whether the vision is still eligible and whether our role relative to the general vision has been clarified.

The third phase assesses the current state of affairs. That is, what the current state is especially in relation to the vision and what is being done right now or what has just been done.

In the fourth phase, the measures of one's own organisation are defined for a short, medium and long-term period. The short-term steps are close to the actions already being taken. The long-term steps should be quite directly related to the vision and should contribute to creating elements of the vision. In this phase, the actual roadmap is created, i.e. the paths and their alternatives from the current state to the future and the vision are being formulated (Figure 2). According to Ventä (2004b), this is the most challenging part of the process, since making decisions is difficult and time has usually run out once this phase is reached and the process is not fully carried out.

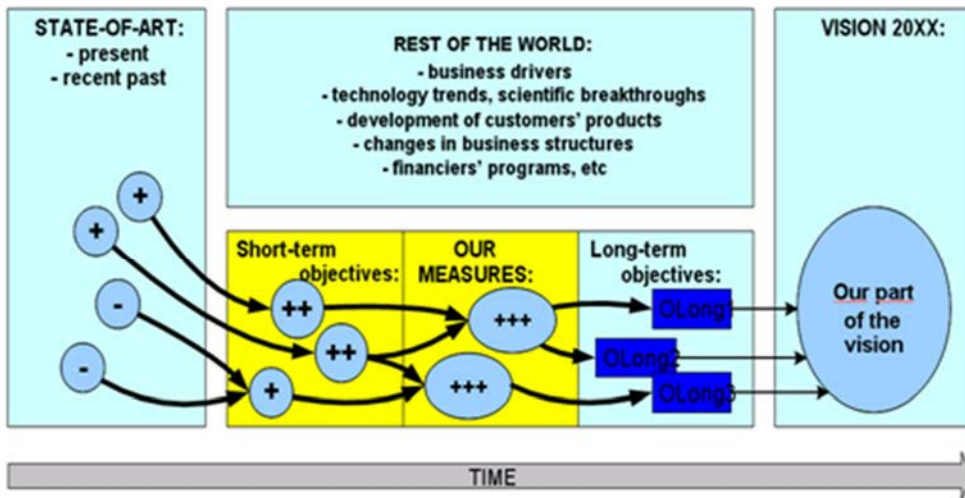


Figure 2. Creating the actual roadmap (Ventä 2004b).

2.2 Workshops

Two workshops were held within the scope of the study. The first took place on June 14th, 2011. In addition to working out the vision, the current state of the transport system, technological development, challenges and potential for improvement were discussed for both road and maritime transport. The participants were Aleksi Uttula from the Finnish Transport Safety Agency, Tommi Arola and Kari Hiltunen from the Finnish Transport Agency, Petteri Portaankorva and Yrjö Pilli-Sihvola from the Centre for Economic Development, Transport and the Environment of Southeast Finland and Hanna Askola, Satu Innamaa, Risto Kulmala, Matti Kutila, Merja Penttinen, Matti Roine and Armi Vilkmán from VTT.

The second workshop was held on September 19th, 2011. This workshop concerned traffic management challenges and solutions as well as prospective short, medium and long-term actions. The participants of this workshop were Marko Forsblom from the Ministry of Transport and Communications, Sami Luoma from the Finnish Transport Agency, Mika Kulmala from the City of Tampere and Satu Innamaa, Risto Kulmala, Hanna Askola, Elina Aittoniemi, Matti Kutila, Merja Penttinen, Pirkko Rämä and Tapio Nyman from VTT.

3. Vision

Proactive operation ensures that the transport system works as a whole in the most efficient, safe and environmentally friendly way and fulfils the user's expectations under all circumstances.

Proactive operation foresees traffic problems and eliminates or at least alleviates the consequences in advance. Operation also affects the modal split and prerequisites of mobility and thus traffic demand. An up-to-date real-time transport network status picture provides the prerequisites for active operation of the transport network, so that incidents and their effects can be minimised beforehand. A short-term forecast can be used in addition to information on the present state. The network status information is located in a cloud¹ for everyone to use.

The transport system operator defines the main principles of traffic control. Daily transport network operation is optimised in every situation because the traffic management centre personnel are educated, competent and motivated for operating the transport system. The operations of traffic management centre personnel have changed from supervising the state of single traffic control systems to supervising the state of and controlling the transport network.

The routine tasks of operation have been automatized so that traffic management centre personnel can focus on operation in emergency situations. In the case of incidents, individual road users transfer information directly to each other. Every actor knows their role and acts without delay according to the previously defined action and guidance patterns.

Single road users, vehicles and their drivers or other travellers act e.g. with the help of their mobile phone, as sensors for current traffic situations and for road, weather and environmental conditions while moving on the transport network.

¹ Cloud data and software are saved on a server and can be accessed from anywhere. Traits related to cloud services are self-service, mass article pricing, transparent scalability, shared infrastructure and assignability (Siljamäki 2010).

3. Vision

Social media play a significant role in controlling mobility. Road users and operators have all needed information and services relating to mobility and its control. They use multiservice platforms, and the services they receive through them support the objectives of operating the transport system, or at least do not work against them. Therefore, individual road users participate in the operation of the whole transport system and, at the same time, improve the functionality of the system for themselves.

Travel and delivery chains can be reliably predicted. The course of single lots can be followed and predicted in real time. The control continues across travel modes and administrative borders.

4. Present state and trends

4.1 Present state

Currently, traffic management centre operators mainly supervise singular traffic management centre systems and react to incident and other messages from various actors. Operation of the traffic system has not been wholly automated and the operation is partly dependent on current traffic management centre personnel. It does not extend across administrative borders or different travel modes, but each operator directs traffic on their own network, and in their own areas and terminals such as ports.

In road transport, traffic situation data is obtained primarily from spot detectors within the infrastructure (automatic traffic measurement points, road weather and traffic cameras) or road sector specific detectors (travel time cameras). Data on the current traffic situation is not passed on across administrative borders. Further, comprehensive data on the current traffic situation is not available for city-administered roads. In maritime transport, traffic situation data from remote controlled systems is gathered by radar images from the coast, the AIS system and position and advance notifications via VHF frequency or e-mail. In maritime transport, international cooperation across administrative borders is carried out for example through the Gulf of Finland reporting system (GOFREP). The traffic situation data for maritime transport is internationally regulated and rather comprehensive, with the exception of small trade vessels, some governmental vessels and leisure boats. In the electronic operational environment for maritime transport, traffic situation data on vessels and transport units is collected through different systems maintained by public authorities, ports and operators.

Weather information in itself, as well as forecasts, is geographically comprehensive across administrative borders. Road weather information is collected by approximately 400 fixed stations. The observations are backed up by over 500 road weather and traffic cameras. In addition, extensive collecting of road weather, road condition and friction data through moving sensors is being developed.

The Finnish Transport Agency provides the real time information it collects and buys on the traffic system situation to service providers through the Digitraffic service.

4. Present state and trends

Not all data collected is available for real time applications and there are different and varying time delays in the data transfer. Data types are assessed separately during active operation of the transport system; there are no intelligent refining or combining methods in use.

The Finnish Transport Agency has been responsible for coordination of incident management improvement since 2010. Formulation of common standards of procedure, incident management schemes and extensive alternative route networks has begun.

4.2 Technology trends

In the future, intelligent, interconnected parts will form networks undergirding a new type of service combining the physical and digital/virtual worlds. A new phase is about to begin in the extensive deployment of Internet services, which brings both opportunities and challenges. Every single object has a unique Internet identifier, also in the transport sector. This enables continuous monitoring of the current state of singular parts and also singular road users (if they allow it) and also helps them by providing various services. Because of increased need for Internet addresses, the IPv6-based address space will be introduced in the transport sector faster than for home networks. Cloud services allow access to services wherever an Internet connection is available. Vehicles of the future will include operating systems and interfaces through which software suppliers can artificially add and modify the vehicles' features and operation environment. A European-wide or sea-area specific service platform will enable operation of the services across national borders.

Common pan-European operation is the goal of road transport system operation. This means that the services for road users and the level of operation do not change at national borders, but the services are similar and easy to use everywhere. In road transport, the EU ITS Action Plan and Directive (Directive 2010/40/EU) aim at European wide services and their large-scale implementation.

In the future, the collection and processing of traffic data will be diversified. Currently, one and the same actor monitors traffic and refines the data. In the future, specialists in data collection will sell their data to data refiners and processors. Even single vehicle users will be able to gather data and sell it through specific purpose-built digital marketplaces.

The requirement for digital services in maritime transport is growing due to future EU directives, and is expanding among businesses as well. Lessons learnt from other travel modes can be exploited in maritime transport in regards to data exchange and operational activity. Digital services for the maritime operational environment are developing alongside conventional services, where their function is to distribute information on vessels and on land and to keep the logistical chain intact. The goals of maritime and multimodal deliveries are economical delivery speeds and fuel consumption, and reducing emissions by increasing effective data exchange between port operators and vessels. Both high quality transmission of

information on regional conditions and automation help with decision making and replace part of the routine operations, but cannot replace vehicle operators.

The digitalization of transport brings new challenges to road transport. The operational range of electric cars, still in its early phase, is short at about 50 km. A whole new service infrastructure will have to be built for electric cars to enable charging or replacing of batteries, as well as intelligent parking spaces that can be reserved in advance.

The automation of transport is proceeding continuously. In the future, vehicles will be more intelligent and will intervene if the driver makes a mistake or is not capable of performing a driving task. Automation increases the efficiency of a transport system and increases safety by removing restraints caused by human performance capacity and errors. However, automation itself can in certain situations also give rise to new problems and instability in the transportation system.

The introduction of technology as well as its risks is increasingly becoming the purview of businesses, while public sector stakeholders are outsourcing their operations and are changing from producing to ordering.

4.3 Challenges

When improving transport system operation it is a challenge to get services or systems from R&D examples to mature, operational business activity. Developing the value chains of service production in such a way that the operation is profitable for different stakeholders is challenging. Individuals, businesses and other stakeholders are used to getting transport services for a very low price or for free. When data is genuinely up to date and brings explicit added value to users, also chargeable demand is created for the services and they start to be profitable. It is important to define where the private sector works independently with no need for support or financial subvention from the public sector. If the public sector buys something from the private sector, for example by outsourcing, it is not purely market-based operation. On the other hand, in a country like Finland the market for transport services can be too small for purely market-driven transport service business activity.

While planning an intelligent transport system, the target for which a better transport system or its details are created has to be specified. The target can be a road user or a transport system operator, carrier, port or city.

The attractiveness of public transport should be improved in terms of prices, accessibility and frequency. The journey chains should work well. However, it is challenging to make public transport profitable. With the help of intelligent transport, public transport can be made an attractive option when choosing the travel mode before making a trip. In order to achieve this goal a dynamic journey planner covering all travel modes is needed. However, compiling and maintaining such a journey planner is challenging, since rail and bus transport have traditionally been competitors.

4. Present state and trends

In the field of intelligent transport, services are often produced that road users have not previously wanted because they did not know of the possibilities these services offer. Part of these services succeed and accumulate sufficient customer potential. It can be enough to find advertisers or equipment manufacturers who are willing to pay; therefore the users do not necessarily have to pay a lot for using the service. The earning chains and networks can be complicated. There have to be stakeholders to whom the service brings additional benefit and who are willing to pay. Private users are not necessarily willing to pay much. It is a challenge to get the services to continue being attractive enough for customers to keep using them. In that case, society does not have to pay for the services.

Information networks exist, but there are still problems with transferring and distributing information. It is a challenge to make the information so reliable and comprehensive that all systems work well. In addition, copyrights bring challenges that require the right choices to be made. The motivation of companies to distribute information on delivery units' routes and volumes in a controlled manner should be increased to optimise the transport and delivery chains. Only then can a strongly competitive market be preserved.

The development of new tailored services and collecting sensor data on single road users and vehicles brings the challenge of protecting privacy. It is possible to follow single users and to hack the related information. Although the great majority of road users are not overly concerned about privacy, there is a difference between controlled information and leaking it to third parties.

It is a challenge to get the choices of individuals, businesses and other stakeholders to support the vision for intelligent transport. Although vehicles develop and receive factory-installed platforms that enable new services, the challenge, especially in Finland, is slow renewal of the vehicle fleet. Renewal of the fleet on Finnish waterways is even slower than the renewal of the car fleet; however, vessels are often modified during their lifetime in line with international legislation and for more efficient operation.

In maritime transport the slowness of passing legislation in line with technological developments is problematic. E-Navigation services are only slowly being taken into use. Maritime transport often passes through different national regions, and variability of national laws can cause problems. Legislation prepared by the International Maritime Organisation (IMO) has to be coherent and comprehensive to ensure operational activity, which is why decision-making is slow. Another challenge to vessel-specific automation is environmental variation in weather and traffic conditions. A vessel can at times be physically out of reach to others. Increasing steering automation can affect operation and recovery in incident situations. Therefore, the education and expertise of the vessel operator has to be verified in case of abnormal situations, and reactivity in danger situations has to be ensured.

Currently the heterogeneity of cities and ports poses a challenge regarding the operation of the transport system. Both the traffic problems and operation potential vary widely. The greatest problems in road transport are in urban areas with a number of stakeholders and interfaces between them. It is difficult to produce

multipliable services if every urban area wants services tailored just for them. The standardization process is progressing faster in the Centres for Economic Development, Transport and the Environment than in the city sector, but not yet according to target. It is a challenge to support the competitiveness of Finnish economic life everywhere in Finland by developing the transport system. The Finnish road network and its capacity should be used as efficiently as possible in all circumstances in different parts of the country.

When developing the road transport system, the public and private sectors should enhance their cooperation. At present, the public sector e.g. creates standards according to which systems can be standardized, but the software is produced by the private sector, which is not always up to date regarding standardization etc. When new stakeholders appear in transport system operation through different driver support systems for individual drivers, also the responsibilities change. It is a challenge to get the systems to work together technically as well as operationally.

Functionality objectives should be defined for the transport system and network on a political level, but it is challenging to get all parties to commit to them. Those objectives are imperative e.g. when outsourcing operations. In addition, the roles of the public and private sectors should be clarified. It is a challenge when a private service provider offers an individual optimum to its clients, while the public provider aims for a society optimum for all road users.

In addition to sea areas, also canals and inland waterways need traffic management in addition to remote control devices. Canals and inland waterways could provide regional possibilities to strengthen the delivery chains, especially by serving as connecting routes from inland waterways abroad, in order to ensure Finland's competitiveness. The Finnish winter poses its own limitations, e.g. because the Saimaa channel is closed for about 5 months of the year due to physical barriers. In the winter season the cargo flow moves to other travel modes especially at Saimaa, but during strong ice winters also in the Bay of Bothnia.

4.4 Measures

Well-considered outsourcing and working PPP models (public private partnership) should be used while developing the innovative operation of the transport system. All essential partners and levels should take part in the standardization. In Finland, work should concentrate especially on areas in which Finland already has world-class expertise, such as wintertime traffic management and mobile services. For example, selling know-how and technology on climate change or on extreme weather events could provide export potential for Finnish companies. Information on the current state of the road surface during winter conditions is one of the most important types of safety information in large parts of Europe. In the Bay of Bothnia, good quality ice-breaking services are provided together with Sweden. These services could be expanded to form compact cooperation with Russia in the Gulf of Finland. Climate change is also likely to increase vessel traffic on the North-

East Passage. Finland has both the experience and technology to help with transport under icy circumstances.

A significant amount of public funding should also in the future be directed towards safe and sustainable transport systems. Sufficient investment should be assured both for basic research and for well-directed applied R&D work. The role of the public sector could be to get the systems to communicate with each other and the role of the private sector to get the software to communicate. The procedures should be favourable to innovation. The various parties in intelligent transport should be brought together in regard to operation of the transport system. Operation of the transport system should be self-learning,² and this ability should be easily exploitable.

It is of additional value when information is processed into services. Also, a service platform has additional value if it ensures that the service is easily attainable. Intelligent and efficient combination and comprehensive exploitation of different data sources help to construct a comprehensive real-time transport network status picture. This is a prerequisite for e.g. operating a transport system. There are different types of data: dynamic or static, self-produced, acquired or coming from social media etc. Part of the information is reviewed; another part is not. The data quality should be associated with the data. It is important for the data to be easily exploitable also by the providers of real-time services.

A basic condition for the operation of an active transport system is a comprehensive, high quality meta-level picture of the system status covering all travel modes. The picture includes both static and dynamic information. This kind of picture would also help private service providers with supporting common objectives of transport system operation. The world's best real-time transport network status picture for road transport, which could be generated by about 10 000–20 000 vehicles connected to a multi-service model in an urban area like the Helsinki metropolitan area, could serve as an example. Floating traffic control data that react to different circumstances could be delivered to participating vehicles. The penetration of intelligent vehicles should be large enough in the test areas.

The capacity of roads is limited and can only seldom be increased according to the growth of demand. The efficiency of the road transport system could be improved by better utilising the load capacity in personal and freight transport and by developing public transport. On the other hand, it is good to keep in mind that in a sparsely populated country such as Finland, the possibilities of public transport are limited and road capacity remains unused in many areas. Privately run public transport could be better suited to Finland's sparsely inhabited areas. Intelligent control of traffic lights evens out the traffic flow in cities. In the countryside, speed control based on travel time could even out the traffic flow efficiently.

² An operation system is self-learning if it learns from its previous mistakes and wrongly chosen actions in such a way that in the future a better action is chosen in congruent situations.

Traffic control could already now be partly implemented within the car. This would alter the character of changes in transport system operation and open up new possibilities. For example, it would be possible to give speed and route suggestions based on a real-time transport network status picture. Ideally, not all vehicles need to get the same information.

An intelligent, large enough road test site such as the stretch between Helsinki and St. Petersburg should be created for developing innovative operation of the transport system. Services could be introduced to consumers and international clients along this stretch. Finland also has good potential in the field of e-Navigation with planning and implementing pilot projects and trials. Especially e-Customs and the AREX system could be developed from the point of view of traffic between the EU and Russia. The possibility for customers to optimise the fastest or cheapest route themselves could be added.

When developing the transport system, sustainable solutions should be accomplished instead of solving problems only for a couple of years at a time. It should be possible to solve traffic political problems on test sites and to expand them later to the whole country. The environmental viewpoint can be significant. For example, a "green motorway" project catalyses surrounding business.

It would be beneficial for the Baltic Sea region to pilot new applications and systems for maritime transport, since there are active stakeholders in the region. In addition, the EU's financing programmes are expected to be favourable to the Baltic Sea region. Also the development of logistical chains is seen as a regional opportunity. Fluent, safe, foreseeable and efficient maritime transport enhances the success of Finnish business life both from the maritime cluster's viewpoint and for the whole export industry. The Finnish maritime cluster has successful technology e.g. among shipyards producing ice breakers and cruise ships, safety device manufacturers and software developers. Companies designing and producing safe maritime systems include Napa, Furuno and Eniram.

Finland also has potential in developing ICT systems related to automatization of transport. In the automatization of road transport, observation of the road service and the environment in general provide possibilities. These observations produce, in addition to services related to automated driving, high quality real time status information e.g. for operation services of the transport system. In addition, Finland is internationally on a high level in developing automatic machinery, and the related know-how should also be applied in transport.

An overview of the challenges and their proposed solutions is presented below in Table 1.

4. Present state and trends

Table 1. Summary of challenges and proposed solutions.

Challenge	Solution	Parties in charge
Systems and services from R&D examples to working business activity (profitableness, attractiveness of services)	<ul style="list-style-type: none"> - PPP models, considered outsourcing - Focusing on domains where Finland has world class expertise - Assuring public funding also in the future <p>Sustainable solutions through test sites:</p> <ul style="list-style-type: none"> - Intelligent, sufficiently large test site (e.g. Helsinki–St. Petersburg) - Futuristic test site (e.g. ITS Factory in Tampere), where cooperative driving in 2020 can be tested today - Pilot projects on e-Navigation 	Ministry of Transport and Communications, Finnish Transport Agency, municipalities, companies
Functionality objectives of the transport system and roles of the private and public sector are blurry	<ul style="list-style-type: none"> - Improving cooperation - Defining functionality objectives for road and maritime transport 	Ministry of Transport and Communications, Finnish Transport Agency, municipalities

Challenge	Solution	Parties in charge
Enhancing efficiency of the transport system, supporting competitiveness of business life everywhere in Finland	<ul style="list-style-type: none"> - Efficient use of loading capacity in personal and freight transport - Intelligent control of traffic lights, speed control based on travel time - Vehicle-specific transport control - Improving reporting systems - High quality meta-level real-time transport network status picture covering all travel modes - Developing automatization of transport 	Finnish Transport Agency, municipalities, Police, Ministry of Transport and Communications, companies
Technical and functional interoperability of systems	<ul style="list-style-type: none"> - Improving cooperation, involving all actors and levels 	Ministry of Transport and Communications, Finnish Transport Agency, emergency centres
Heterogeneity of cities and ports	<ul style="list-style-type: none"> - Cooperation of all parties involved in intelligent transport in the operation of the transport system - Self-learning operation - Financial support of cooperation 	Association of Finnish Local and Regional Authorities, Ministry of the Environment, Centres for Economic Development, Transport and the Environment, Ministry of Transport and Communications, private actors
Environmental variations in weather and traffic conditions	<ul style="list-style-type: none"> - Improving know-how and technology of climate change and extreme weather events - Expanding ice-breaking services on the Gulf of Finland with Russia 	Finnish Meteorological Institute, Foreca, Finnish Transport Agency, Ministry of Transport and Communications, Tekes, Vaisala

4. Present state and trends

Challenge	Solution	Parties in charge
Attractive and cost-efficient public transport (incl. dynamic route planner covering all travel modes)	<ul style="list-style-type: none"> - Improving cooperation, involving all actors and levels - Private public transport in sparsely inhabited areas 	Municipalities, Ministry of Transport and Communications, Finnish Transport Agency
Support from private individuals, companies and other actors in achieving the vision of intelligent transport (slow renewal of vehicle and vessel pool)	<ul style="list-style-type: none"> - Taxation/encouragement - Information provision 	Ministry of Transport and Communications, Ministry of Finance
Reliability and scope of information, copyrights	Efficient combining and comprehensive utilisation of different data types	Ministry of Transport and Communications, Finnish Transport Agency, Finnish Transport Safety Agency
Maritime transport: slow legislation relative to the development of technology	Being part of IMO's activities and the development work it steers	IMO, EU, Ministry of Transport and Communications, Finnish Transport Safety Agency
Protection of Privacy	Instructions and legislation to protect privacy	Finnish Transport Safety Agency, Finnish Transport Agency, Ministry of Transport and Communications /Ministry of Justice

5. Roadmap

5.1 Short-term measures

The objective of this study was to create a foresight plan and roadmap for innovative operation of the transport system 10–20 years into the future, enabling the most promising services to be selected for development. The services chosen should provide new possibilities for export and domestic business for Finnish companies while providing distinct added value to transport system operators.

The objective of VTT's Innovation program for Intelligent Transport Systems and Services, INTRANS, is to promote transport safety, efficiency and environmental friendliness by utilising new innovative services and technology. Only those measures that can be executed or at least started within the scope of the INTRANS programme by the end of 2013 were selected as short-term measures.

VTT's measures:

- Develop working business models, in case operation of the transport system becomes outsourced even more extensively than at present (innovative PPP models, where the functionality or efficiency of a transport system are bought instead of operation).
- Develop a working, coherent test site concept "ITS Test Site Finland", which covers e.g. the ITS Factory in Tampere and the intelligent corridor Helsinki–St. Petersburg (including intelligent border transport services). "ITS Test Site Finland" would be hosted by the Finnish Transport Agency (and concerning border transport services, also partly by the Centre for Economic Development, Transport and the Environment of Southeast Finland).
- Identification of obstacles to cooperation between transport operation in cities and transport systems and developing solutions for removing these obstacles. The aim is to achieve coherent procedures; cities are in charge of implementation.
- Increasing data quality and versatility by developing transport monitoring systems and data fusion.
- Identifying the data needs of information systems related to nodes between travel modes.

5. Roadmap

- Participating in international development work of intelligent maritime transport and its legislation (IMO, IALA). E.g. the AIS+ system (providing real-time wind information graphically to vessels) and the automatic real-time risk identification system for maritime transport.

Measures of other organisations:

- Ministry of Transport and Communications, ITS Finland: Active provision of information in order to distribute the vision of intelligent transport.
- Finnish Transport Agency: Development of an efficient production method for travel time information (e.g. roadside systems, FMD, Bluetooth). VTT participates in developing work and evaluation.
- Finnish Transport Agency, Ministry of Transport and Communications, Helsinki Region Transport, municipalities: Development of a mobile payment system for public transport, VTT participates in development work and evaluation.
- Finnish Transport Agency, Ministry of Transport and Communications, Helsinki Region Transport, municipalities: Development of a truly co-modal journey planner (including personal cars, buses, trains, taxis etc.). VTT participates in development work and evaluation.
- Ministry of Transport and Communications: Defining functionality objectives for the transport system (including roads, railroads, waterways). VTT participates in development work and evaluation.

5.2 Medium-term measures

The medium-term measures of the roadmap comprise actions implemented by the year 2020.

VTT's measures:

- Development of automation in transport (including automated vessel).
- Development of vehicle specific traffic control (cooperative systems).
- Creating operations models for connecting electric cars to the travel chain.
- Development of cooperative systems/services in transport.

Measures of other organisations:

- Transport system operators: Development of a high quality meta-level real-time transport network status picture comprising all travel modes. VTT participates in development work and evaluation.
- Transport system operators: Proactive self-learning operation tools of the transport network. VTT participates in development work and evaluation.
- Finnish Transport Agency, Foreca, Finnish Meteorological Institute, the Centres for Economic Development, Transport and the Environment, Vaisala: Anticipation and identification of effects of extreme weather events on transport. VTT participates.

- Ministry of Transport and Communications, Finnish Transport Agency, Finnish Transport Safety Agency, the Centres for Economic Development, Transport and the Environment, transport system operators: Interoperable payment and real-time information system covering the whole country and all travel modes. VTT participates in development work and evaluation.
- Ministry of Transport and Communications, Finnish Transport Agency: Development and piloting of service system for electric cars. VTT participates in development work and evaluation.

5.3 Long-term measures

The long-term measures of the roadmap comprise actions implemented by the year 2030.

- Implementation of an intelligent and adjustable transport infrastructure on large test sites: Traffic control messages are electronically transmitted to vehicles; these messages and the steering strategy or tactics behind them are changed according to feedback from vehicles, so that the transport system's efficiency can be optimised.
- Completely adjustable, open, modular, cloud-operated, global multi-service platform implemented to the full.
- Implementation of automated transport (including vehicles and operation, where the speed and other activities of the vehicles are regulated automatically e.g. through warnings given by operators) on large test sites.

6. Summary

The objective of VTT's Innovation programme for Intelligent Transport Systems and Services (INTRANS) is to promote transport safety, efficiency and environment friendliness by developing new innovative services and technology solutions. The aim of this study was to create a foresight plan and roadmap for innovative services in transport system operation for a time scale of 10–20 years into the future so that the most promising service types could be selected for development. The services chosen should provide new possibilities for export and domestic business for Finnish companies while providing distinct added value to transport system operators.

The work was based on Ventä's road map method and on two expert workshops with representatives from the Ministry of Transport and Communications, the Finnish Transport Agency, the Finnish Transport Safety Agency, the Centre for Economic Development, Transport and the Environment of Southeast Finland, the City of Tampere and VTT.

The vision "Proactive operation ensures that the transport system works as a whole in the most efficient, safe and environmentally friendly way and fulfils the user's expectations under all circumstances" was created within the project. In the vision, operation affects the travel mode distribution and prerequisites of mobility and thus the demand for traffic. The real-time transport network status picture provides the prerequisites for active operation of the transport system and the transport system operator defines the main principles of traffic control. The activity of traffic management centre personnel has changed from observing the state of separate traffic control systems to observing and controlling the state of the transport network. In incident situations every actor knows their function and acts at once according to the action and guidance patterns agreed on beforehand. Single road users act as sensors for information on the current traffic state, road and weather conditions and environmental state while moving on the transport network. Road users and operators have access to all the information and services necessary in relation to mobility and its control. Travel and delivery chains can be reliably predicted. Control continues across travel modes and administrative borders.

In the description of the current state it was stated that the traffic management centre operators at present supervise mainly single traffic management centre

systems and react to incident and other messages relayed from different stakeholders. In road transport the operation does not extend across administrative borders or travel modes, but each operator controls traffic in their own network area and terminals such as ports. In maritime transport, international cooperation across administrative borders is already widely carried out. The Finnish Transport Agency distributes real-time information on the state of the transport network through the Digitraffic service, but not all gathered information is available for the use of real-time applications. Data types are dealt with one at a time in the active operation work of the transport system, and no intelligent refining or combining methods for traffic information are in use.

When studying future trends it was observed that in the future, intelligent, interconnected parts will form networks as the basis for new services where the physical and digital or virtual worlds merge. A new phase is starting in the extensive introduction of Internet based services. This brings opportunities as well as challenges. In operating the road transport system the goal is common European operation. In maritime and multimodal freight the goals are economical delivery speeds and fuel consumption as well as emission reduction. The digitalization of transport brings new challenges to road transport. E.g. electric vehicles need a whole new infrastructure to be built. The automation of transport is continuously evolving and thus increases the efficiency and safety of the transport system by removing barriers formed by human performance capacity and mistakes. Automation can also cause new problems and instability to the transport system in some situations.

When developing the operation of the transport system it is a challenge to get the systems or services from R&D examples to mature, working business. Value chains for developing commercially sustainable services are needed especially when transport system operation services arguably become widely outsourced in the coming years. In the planning of an intelligent transport network the targets or clients for whom the better transport system or parts of it are being created have to be defined. The attractiveness of public transportation should be improved and travel chains made functional. Producing new tailored services and collecting sensor data from single road users and vehicles emphasises the need for maintaining privacy protection. It is a challenge to get single individuals, companies and other stakeholders to support the accomplishment of the vision for intelligent transport in their choices. In maritime transport the slowness of the legislation related to the advancement of technology is problematic. When developing the road transport system the public and private sectors should improve their cooperation. The services should work well together, both technically and operationally.

When discussing the measures it was noted that considerate outsourcing and working PPP models should be used when developing innovative operation of the transport system. All essential stakeholders and levels should be involved in the work. A significant amount of public funding should also in the future be assigned to safe and sustainable transport systems. The procedures should be favourable for innovations. A prerequisite for the active operation of the transport system is a high quality meta-level picture of the system comprising all travel modes. Both

6. Summary

static and dynamic levels should be included. The efficiency of the road transport system could be increased by better using the loading capacity and by improving public transport. An intelligent, sufficiently large test site should be created for the development of innovative operation of the transport system. On this test site, services could be introduced to consumers and international clients.

The measures chosen as short-term measures were those that are possible to realise or at least to start during the scope of the INTRANS programme by the end of 2013. A summary of the short-term measures of VTT reads as follows:

- Development of working business models for the operation of the transport system
- Development of a working, coherent test site concept "ITS Test Site Finland"
- Identification of barriers to interoperability of urban traffic operation and transport systems and elaboration of solutions to solve them
- Increase of data quality and versatility by improving transport data fusion
- Identification of the data needs of information systems related to nodes between travel modes
- Involvement in the international development work of intelligent maritime transport and its legislation.

Summary of short-term measures of other stakeholders:

- Ministry of Transport and Communications, ITS Finland: Active provision of information in order to distribute the vision of intelligent transport
- Finnish Transport Agency: Development of an efficient method for producing travel time information
- Finnish Transport Agency, Ministry of Transport and Communications, Helsinki Region Transport, municipalities: Development of a mobile payment system for public transport
- Finnish Transport Agency, Ministry of Transport and Communications, Helsinki Region Transport, municipalities: Development of a truly multi-modal journey planner
- Ministry of Transport and Communications: Definition of functionality objectives for the transport system.

The medium-term measures of the roadmap comprise actions to be implemented by 2020. A summary of the medium term measures of VTT reads as follows:

- Developing automation of transport
- Developing vehicle specific traffic control
- Creating operations models for connecting electric cars to the travel chain
- Developing cooperative systems and services in transport.

Summary of medium-term actions of other actors:

- Transport system operators: Development of a high quality-meta level real-time transport network status picture comprising all travel modes.
- Transport system operators: Proactive self-learning tools for the operation of the transport network.
- Finnish Transport Agency, Foreca, Finnish Meteorological Institute, the Centres for Economic Development, Transport and the Environment, Vaisala: Anticipation and identification of effects of extreme weather events on transport.
- Ministry of Transport and Communications, Finnish Transport Agency, Finnish Transport Safety Agency, the Centres for Economic Development, Transport and the Environment, transport system operators: Interoperable payment and real-time information system covering the whole country and all travel modes.
- Ministry of Transport and Communications, Finnish Transport Agency: Development and piloting of service system for electric cars.

The long-term measures of the roadmap comprise actions implemented by 2030. A summary of the long-term measures reads as follows:

- Implementation of an intelligent and adjustable transport infrastructure on large test sites.
- Completely adjustable, open, modular, cloud operated, global multi service platform implemented to the full.
- Implementation of automated transport on large test sites.

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Title	Roadmap for innovative operation of the transport system
Author(s)	Satu Innamaa, Elina Aittoniemi, Hanna Askola & Risto Kulmala
Abstract	<p>The objective of VTT's Innovation programme for Intelligent Transport Systems and Services (INTRANS) is to promote transport safety, efficiency and environmental friendliness by exploiting new innovative services and technology. The objective of this study was to create a foresight plan and roadmap for innovative operation of the transport system 10–20 years into the future, enabling the most promising services to be selected for development. The services chosen should provide new possibilities for export and domestic business for Finnish companies while providing distinct added value to transport system operators.</p> <p>The work was based on Ventä's roadmap method and two expert workshops with representatives from the Ministry of Transport and Communications, the Finnish Transport Agency, the Finnish Transport Safety Agency, the Centre for Economic Development, Transport and the Environment of Southeast Finland, the City of Tampere and VTT.</p> <p>The vision "Proactive operation ensures that the transport system works as a whole in the most efficient, safe and environmentally friendly way and fulfils the user's expectations under all circumstances" was created within the project. In the vision, operation affects the travel mode distribution and prerequisites of mobility and thus the demand for traffic. Within the work the present state was described and future trends were worked out. The challenges and solutions of transport system operation were listed. As a result, lists of action for the different parties in charge were created for the years 2012–2013, 2014–2020 and 2021–2030 in order to reach the vision.</p>
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Nimeke	Innovatiivisen liikennejärjestelmän operoinnin tiekartta
Tekijä(t)	Satu Innamaa, Elina Aittoniemi, Hanna Eskola & Risto Kulmala
Tiivistelmä	<p>VTT:n älyliikenteen innovaatio-ohjelman INTRANSin tavoitteena on edistää liikenteen turvallisuutta, sujuvuutta ja ympäristöystävällisyyttä kehittämällä uusia innovatiivisia palveluja ja teknologiaratkaisuja. Tässä työssä oli tarkoituksena kehittää ennakkonäkemyksensä ja tiekartta innovatiivisille liikennejärjestelmän operoinnin palveluille 10–20 vuoden päähän, jotta lupaavimmat palvelutyypit voitaisiin tunnistaa ja ottaa kehitettäväksi. Palveluiden tulisi tarjota uusia mahdollisuuksia vientiin ja kotimaan liiketoimintaan suomalaisille yrityksille sekä samalla tuottaa selkeää lisäarvoa liikennejärjestelmän operaattoreille.</p> <p>Työ perustui Olli Ventän tiekarttamenetelmään ja kahteen asiantuntijatyöpajaan, joissa oli edustajat VTT:n lisäksi liikenne- ja viestintäministeriöstä, Liikennevirastosta, Liikenteen turvallisuusvirastosta (Trafi), Kaakkois-Suomen ELY-keskuksesta ja Tampereen kaupungilta.</p> <p>Työssä kehitettiin visio: ”Proaktiivinen operointi takaa, että liikennejärjestelmä toimii kokonaisuutena mahdollisimman tehokkaasti ja täyttää käyttäjän odotukset kaikissa olosuhteissa.” Visiossa operoinnilla vaikutetaan kulkutapajakaumaan ja liikkumisen edellytyksiin ja sitä kautta liikenteen kysyntään. Työssä kuvattiin nykytila ja selvitettiin tulevaisuuden trendejä. Liikennejärjestelmän operoinnin haasteet ja keinot selvittää haasteista listattiin. Lopputuloksena annettiin toimenpidedelistat alan eri toimijoille vuosille 2012–2013, 2014–2020 ja 2021–2030, jotta visio saavutettaisiin.</p>
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Roadmap for innovative operation of the transport system

The objective of VTT's Innovation programme for Intelligent Transport Systems and Services (INTRANS) is to promote transport safety, efficiency and environmental friendliness by exploiting new innovative services and technology. The objective of this study was to create a foresight plan and roadmap for innovative operation of the transport system 10–20 years into the future, enabling the most promising services to be selected for development. The services chosen should provide new possibilities for export and domestic business for Finnish companies while providing distinct added value to transport system operators.

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