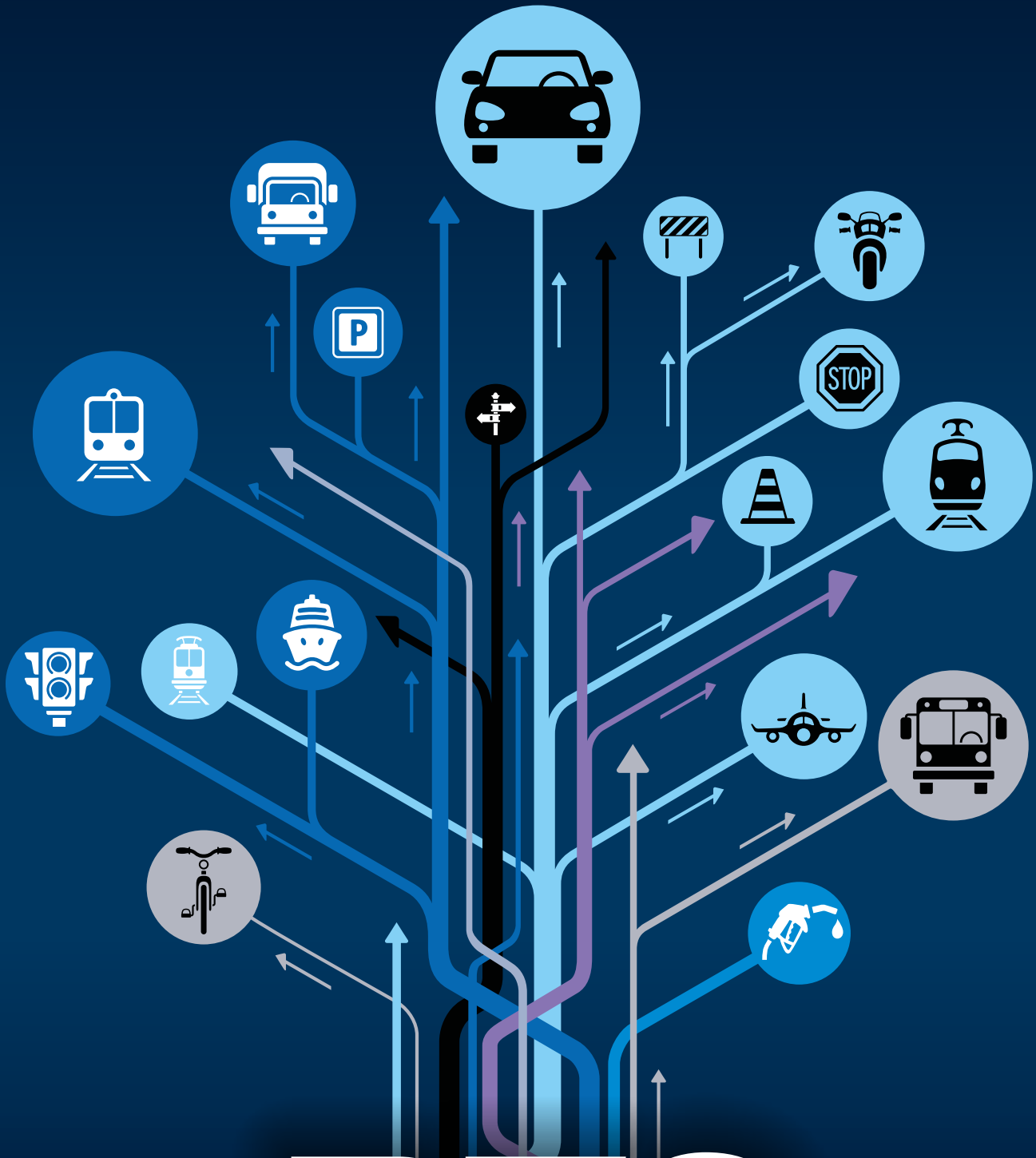




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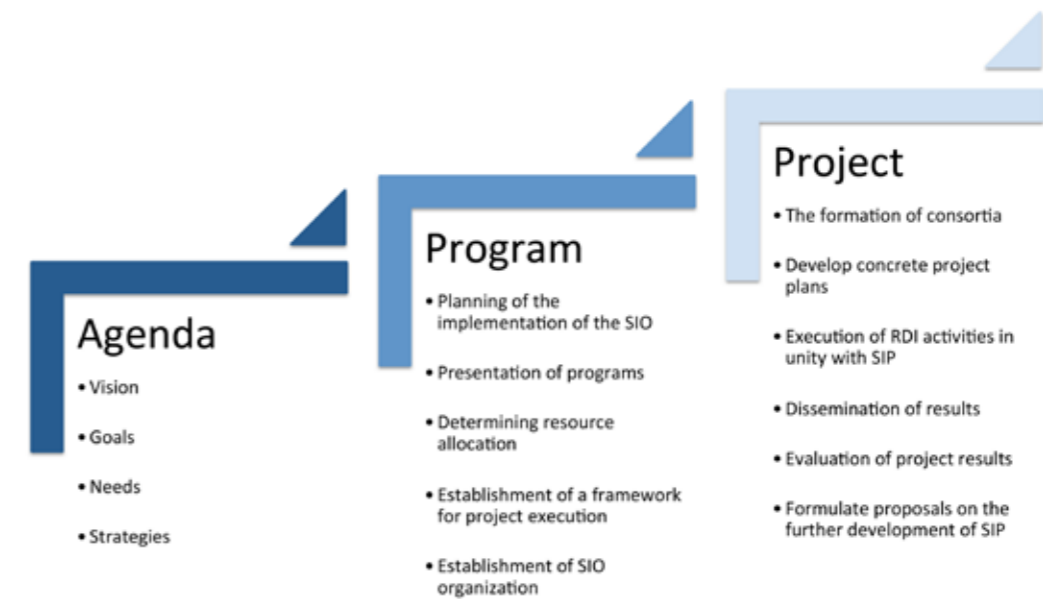
RTS

Robust and Reliable Transport System

ROBUST AND RELIABLE TRANSPORT SYSTEM (RTS)

-a strategic agenda for resource pooling,
collaboration, innovation and research

RTS
Robust and Reliable Transport System



Preface

The effort for creation of this agenda has been funded by a grant from Vinnova to Luleå University of Technology in autumn 2014.

The following organisations contributed to the creation of the agenda are: Acreo Swedish ICT, Appear Networks, Chalmers University of Technology, Damill, Ecoloop, eMaintenance365, Klimator, Royal Institute of Technology, LKAB, Luleå University of Technology, Målarhamnar, MariTerm, MTR Stockholm, NCC, Performance in Cold, ReRail, SAAB Support and Services, SICS Swedish ICT, Stockholms läns landsting - Trafikförvaltningen, Stockholmskonsulterna, Strukton Rail, SWECO, Tunnelbanan Teknik, Terrasolid, Tyréns, Uleåborg university, Victoria Swedish ICT, Volvo Cars, Volvo Group Trucks Technology, Vossloh Nordic Switch Systems, and VTI.

More organisations are expected to endorse the RTS Agenda and to become actively involved in its implementation.

The editorial board consisted of Ramin Karim (Luleå University of Technology), Veronica Jägare (Luleå University of Technology), Rune Lindberg (Luleå University of Technology), and Uday Kumar (Luleå University of Technology).

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Executive Summary

TRANSPORT IS FUNDAMENTAL TO OUR ECONOMY AND SOCIETY. An efficient and sustainable transport system is essential for people and businesses, a truth today, an utmost necessity in the future. But, the Swedish transport system needs to be much more robust, resilient and reliable to make this become an everyday reality.

RTS' **vision** is to enable a robust, resilient, and reliable transport system, which is attractive, safe, sustainable, and efficient.

RTS' overall **goals** are:

1. Improved economic, societal, & environmental efficiency – A yearly potential well above one billion kronor (SEK)
2. Reduction of disruptions – By more than two thirds within five years after implementation of solutions developed within RTS's core activities
3. Enhanced collaboration & cooperation – The transport sector actors are working within an incentive-driven triple helix with holistic system perspective

RTS includes two complementary **research and innovation (R&I) domains**: 1) R&I that create robustness and reliability of the transport system; and 2) R&I that create incentives and tools for the transport industry players within a triple helix to cooperate and collaborate. Furthermore, RTS focuses on the **application domains** rail and road systems including interfaces to ports and airports

The **expected impacts** of RTS are related to:

- Potential for growth in the Swedish, European and global industry & society
- Improved economic, societal, and environmental efficiency
- Reduction of disruptions in transport system
- Enhanced collaboration and cooperation between transport stakeholders
- Increased export of research, technologies and services related to diagnostics and prognostics in connection with the design, construction, operation and maintenance of the transport system
- Dual-use of solutions in other industrial sectors (e.g. mining, energy, aviation, and pulp and paper)

The main **success factors** for RTS are: 1) Resource pooling based on businesses, authorities and academia; 2) A holistic system approach; and 3) Focus on research, innovation, and implementation of solutions.

Based in the vision statement, RTS addresses a set of **focus areas** in order to achieve overall goals and expectations. These are: 1) Transport system governance; 2) Transport system innovation; 3) Freight transport and passenger travel; and 4) Intelligent transport system.

To realise the RTS' vision, the agenda lists a set of **core activities**. These activities are: a) Matches; b) Idea Camp; c) Fundamental and applied research; d) Upscaling projects; e) Network of Infrastructure; g) Wider Society Learning; h) Entrepreneurship Support Services; i) Start-Up Booster; j) SME Growth booster.

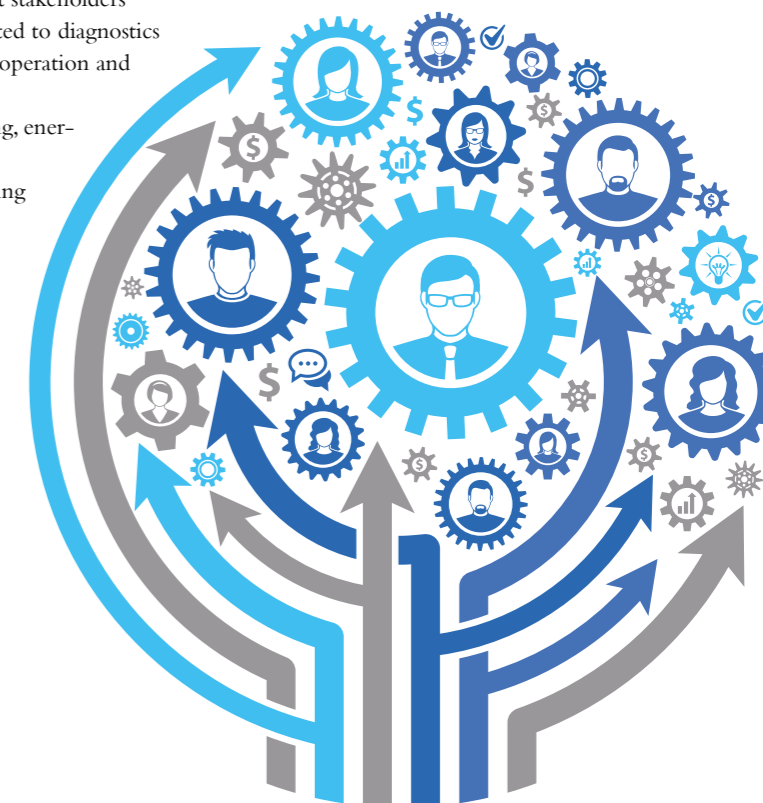
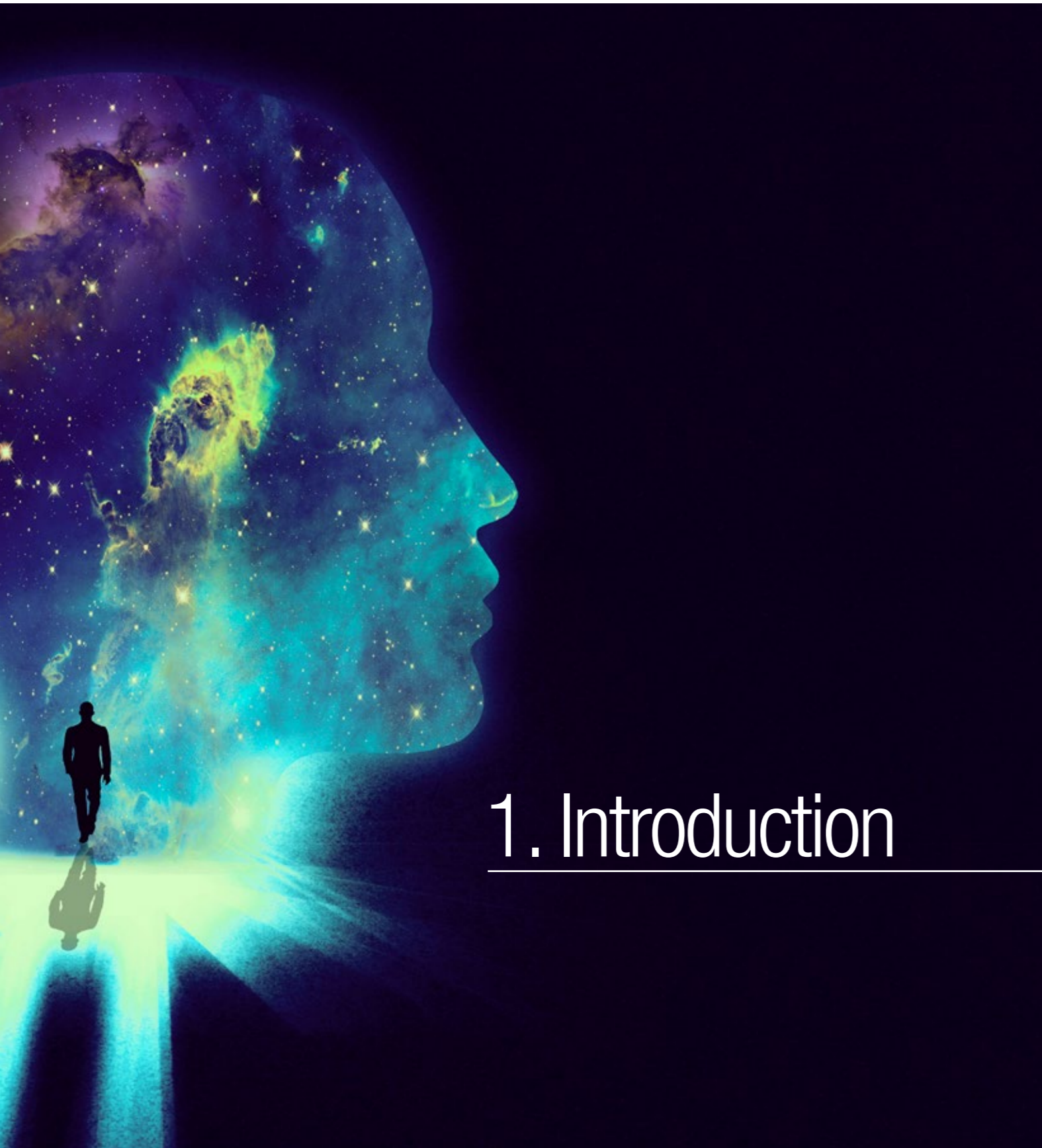


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1. Introduction

1. Introduction

AN EFFICIENT AND SUSTAINABLE TRANSPORT SYSTEM is essential for people and businesses, a truth today, an utmost necessity in the future. But, the Swedish transport system needs to be much more robust, resilient and reliable to make this become an everyday reality.

The RTS agenda is a roadmap that addresses these challenges. The roadmap is built on a holistic view of transport system that allows for the inclusion and consideration of all the relevant systems and actors and their complex interaction.

1.1 Transport system and logistics

Definitions:

- **Transport system** – a transport system is the totality of resources aimed at interacting for optimising and delivery of the requested transport for passengers and goods. A transport system consists of infrastructure, vehicles, transport technologies, logistic solutions, policies, and regulations.
- **Robust** – a robust transport system has the ability to resist changes without adapting its initial configuration
- **Resilient** – a resilient transport system has the ability to restore the functionality
- **Reliable** – a reliable transportation system has the ability to deliver a quality of transport service as agreed with the stakeholders

1.1.1 Scope

RTS INCLUDES two complementary **Research and Innovation (R&I) domains**:

- R&I that create robustness and reliability of transport system. The core is solutions that offer diagnosis, prognosis and resource management as efficient tools in management, operation, and maintenance of transport system.
- R&I that create incentives and tools for the transport industry players within a triple helix to cooperate and collaborate in the improvement of existing and development of new transportation systems.

Furthermore, RTS focuses on with following **application domains**:

- Rail and road systems including interfaces to ports and airports

1.2 Global outlook

THE TRENDS PRESENTED in the Swedish Transport Administration's Intelligence report 2014 (SWETRA, 2014) are:

- Increased demand on transport system capacity
- Enhanced system integration across borders and between modes
- Decreased dependency on cars in cities
- A new era in urban planning
- Improved connectivity of modes of transport
- Extensive requirements for adaptation to the environment and climate

The report suggests on the one hand, society becomes more diverse. Transport demand becomes more varied between and within regions. The transport solutions therefore need to become more differentiated. On the other hand, the supply of transport will become more homogeneous due to continued internationalisation and the EU regulation is coming through. At the same time, we see that the relationships between transport and other policy areas is strengthened. The pervasive digitalisation trend and increased mobility, combined with the continued strong urbanisation and the increasing exchange across borders, are affecting society fundamentally.

1.3 European outlook

TRANSPORT IS FUNDAMENTAL to our economy and society. Mobility is vital for the internal market and for the quality of life of citizens as they enjoy their freedom to travel. Transport enables economic growth and job creation: it must be sustainable in the light of the new challenges we face. Transport is global, so effective action requires strong international co-operation. (EUTRA, 2011)

At the same time, the EU has called for, and the international community agreed on, the need to drastically reduce world greenhouse gas (GHG) emissions, with the goal of limiting climate change below 2 °C. Overall, the EU needs to reduce emissions by 80–95 % below 1990 levels by 2050, in the context of the necessary reductions of the developed countries as a group, in order to reach this goal. Commission analysis shows that while deeper cuts can be achieved in other sectors of the economy, a reduction of at least 60 % of GHGs by 2050 in relation to 1990 is required from the transport sector, which is a significant and still growing source of GHGs. By 2030, the goal for transport will be to reduce GHG emissions to around 20 % below their 2008 level. Given the substantial increase in transport emissions over the past two decades, this would still put them 8 % above the 1990 level. (EUTRA, 2011)



1.4 National outlook

THE SWEDISH TRANSPORT ADMINISTRATION has developed traffic forecasts for passenger and freight transport for the years 2030 and 2050. With the conditions that were predicted, the forecasts show that goods transportation and regional passenger travel will increase in particular. The total passenger transport work is calculated to increase by 63 per cent (passenger kilometre), and more on the railway than on roads. Goods transport work is expected to increase by 61 per cent (tonnage kilometre) between 2006 and 2050. According to the forecasts, imports and exports calculated in tons will double, while domestic transport amounts will only increase marginally. It may be noted that transport to and from the rest of Europe is completely dominant in tonnage, calculated in 2006, and it is estimated to be the same in 2050. The largest increases by far in absolute numbers will occur in transportation to Eastern Europe. (SWETRA, 2012)

The focus of Sweden's national transport plan 2014–2025 is to create conditions for a strong capacity, robust, safe, accessible and sustainable transport system that caters to business and citizens' need of commuting and freight transport in all parts of the country. Capacity utilisation in parts of the transport system is occasionally high. This is particularly evident in urban areas, on busy roads and railroad tracks and along the major transport routes. The importance of transport for the community becomes particularly evident when the transport system is not working as expected. Delayed trains or traffic congestion makes it harder for people to get to work every

day, makes it difficult for companies looking to hire and threatens the industry operating in a globally competitive market with small margins. (SWEGOV-1, 2014)

The national transport plan 2014–2025 involves major investments in infrastructure to create conditions for a robust, efficient and reliable transportation system that meets the needs of the citizens of commuting and business transportation needs. The planning framework for the period 2014–2025 amounts to SEK 522 billion. In addition, there is another SEK 85 billion, made possible by revenues from congestion taxes, fees and contributions. (SWEGOV-1, 2014)

The Swedish Government has issued a vision for Swedish emissions of Green House Gases (GHG) (SWEGOV-2, 2008). The vision is that by 2050, Sweden has no net emissions of greenhouse gases in the atmosphere.

The Government's assessment about the vehicle fleet is: Efforts to reduce the transport sector's impact on the climate evolve and 2030, Sweden should have a vehicle fleet that is independent of fossil fuels.

The transport sector's overall challenge is to meet an expected sharp increase in demand for transport while developing a sustainable transport system. A more rapid renewal of the transport system to meet this challenge requires, in addition to the investments and other measures that have been mentioned above, an increased focus on research and innovation in both the short and long term. The capacity of the transport system must increase, but it takes a long time to accomplish. In the short term, the focus must therefore be

on improving the existing transport system. It must be more robust, reliable, safe and environmentally friendly, and at the same time various transport sub-systems need to be linked together for the benefit of users. The development and introduction of new technologies in the transport system must be stimulated. The potential of new information technologies, electrification and automation must therefore be fully utilised. (SWEGOV-1, 2014)

Several different attempts have been made to assess the financial impact of problems with the rail infrastructure. McKinsey estimated the economic additional costs of freight and passenger traffic winter 2010/11 to SEK 2.6 billion, of which only a small portion related to freight traffic due available calculation methodology (Alexandersson, 2015). Nelldal (2014) has in his study of major traffic disruptions' effects of one single business and concluded that the corresponding additional costs of 28 percent of transportation costs (including the additional costs of the operator). This would roughly be translated to SEK 1.5 billion in additional costs per year for all freight transport in Sweden.

Hence, the vision of a sustainable transport system is also a vision of major savings in the economy. With the current traffic volume of about 80 billion vehicle kilometres and with the assumption that the external marginal cost of carbon dioxide (TRV, 2014) for passenger cars and trucks are on average SEK 0.25 kronor per kilometer, the present marginal external cost of carbon dioxide emissions from the road transport is SEK 20 billion annually.

1.5 Transport system – A fundamental prerequisite

THE TRANSPORT SYSTEM is a fundamental prerequisite for a functioning society. The system should be designed, constructed, operated and maintained so that it is as robust and resilient as possible so that even serious disorders can be managed with reasonable consequences for society.

To maintain good performance and high reliability in the Swedish transport system, operation and maintenance of existing transport infrastructure should be given high priority. The need for freight transport and passenger travel is increasing while there is an emerging need for maintenance especially on the railway. The transport system is aging and in order to avoid the risk that the value of investments already made will be lost, this work is of great importance. To achieve reliable transportation well planned maintenance and reinvestment efforts are required where the primary emphasis should be preventive. Priorities for actions should be made based on the national transport policy, which is to ensure an economically efficient and sustainable transport system for citizens and businesses throughout the country. Moreover, the readiness to deal with disruptions due to unforeseen events should be good.

2. Vision and goals

2. Vision and goals

Vision	Our vision is to enable a robust, resilient, and reliable transport system, which is attractive, safe, sustainable and efficient			
Goals	1. Improved economic, societal, & environmental efficiency - A robust and reliable transport system is contributing considerably to achieving an economical yearly potential well above one billion kronor (SEK).	2. Reduction of disruptions - The number of disruptions hampering transport quality and environment friendliness is gradually reduced by more than two thirds within five years after implementation of solutions.	3. Enhanced collaboration & cooperation - The transport sector actors are working in an incentive-driven triple helix with system perspective aiming at high quality transport from start to goal, from sender to recipient.	
Focus Areas	Transport system governance	Transport system innovations	Freight transport & passenger travel	Intelligent transport system

2.1 Vision statement

OUR VISION is to enable a robust, resilient, and reliable transport system, which is attractive, safe, sustainable, and efficient.

2.2 Goals

FORECASTS ABOUT freight and passenger transport volumes are continuing to show a strong growth rate, especially at existing bottle necks. Transport counts for around 25 % of the emissions of greenhouse gases. The Swedish vision is that by 2050, the net emissions of greenhouse gases in the atmosphere shall be zero. Monitoring of developments over the past five years shows that the improvements in order to cope with those prerequisites are marginal. From now on, considerable and sustainable improvements are needed. The overall goals of the agenda are:

1. *Improved economic, societal, & environmental efficiency* - A robust and reliable transport system contributes considerably to achieving an annual economical potential well above one billion kronor (SEK):

- Improved punctuality (percentage of arrivals at destination within five minutes).
- Increased transport capacity (tonnage km/year, passenger km/year)
- Reduced greenhouse gas emissions (gCO₂/tonnage km, gCO₂/passenger km)
- Improved energy efficiency (kWh/tonnage km, kWh/passenger km)
- Increased efficiency in testing and implementation of innovations (time from idea to implementation)
- Improved cost and resource efficiency in construction, operation and maintenance (cost/tonnage km, cost/passenger km)
- Improved community welfare, efficiency, safety, and development (benefit for community)
- Increased industry profitability and competitiveness (profit for businesses)

2. *Reduction of disruptions* - The number of disruptions hampering transport quality and environmental friendliness is to be gradually reduced by more than two thirds within the next five years after implementation of solutions developed within the RTS' core activities

3. *Enhanced collaboration & cooperation* - The transport sector actors are working within an incentive-driven triple helix (which focuses on inter-collaboration between businesses, governments, and academia) with system perspective aiming at high quality transport from start to goal, from point of departure to destination.



3. Expected impacts



3. Expected impacts

Potential for the Swedish, European and Global industry & society

Transport solutions must be reliable and the functionality of operation must be maintained so that disruptions can be reduced and managed. To enable this, new solutions based on diagnostics and prognostics of the functionality are needed. In addition, the knowledge and resources, which represents the conditions for a robust and reliable transport system, are available from a large number of stakeholders, which are managed based on fundamentally different premises, both socio-economic and business economic. One consequence of this is that strong joint forces are rare for the development and improvement of the transport system at system level. An effort that is correct in one perspective can be directly counter-productive in the second, such as postponing preventive maintenance pending the opportunity for more profitable corrective maintenance. RTS addresses both of these conditions and creates the foundation for two parallel and inter-dependent areas:

- Innovations, which create robustness and reliability of transport system. The essence lies here in solutions that offer diagnosis, prognostics and management of resources in efficient operation of the transportation system
- Innovations, which create incentives and tools for the transportation industry stakeholders to collaborate in the improvement of existing transport systems and the development of new ones

The strategic innovation area RTS has both collectively and from a holistic perspective great potential for growth, sustainability, robustness, higher customer satisfaction and efficiency in the transport system through:

Impacts related to 'Improved economic, societal & environmental efficiency' goal:

- Strengthened growth of well-fare (i.e. regions, jobs, exports, environment) through an efficient transport system
- Increased efficiency in testing, certifying implementing and utilising existing knowledge and new solutions where academia can be a resource for evaluation
- Improved timeliness that will cause a reduced need for inventory for the industry
- Improved risk management through fact-based online real-time decision support and information logistics
- Reduced need for maintenance services and decreased resource losses in infrastructure management, through optimised resource planning
- Reduced emissions due to increased confidence in sustainable transport solutions, fewer interruptions, less stopping and starting in traffic
- Reduced development and production costs, through optimised development, production, and innovation processes

supporting harmonisation of specifications, improvement of the requirement process and the simplification of the authorisation procedures

- Reduced quality deficiency costs and economic losses associated with transport
- Increased industrial competitiveness in the transport sector

Impacts related to 'Reduction of disruptions' goal:

- Increased effectiveness in management, planning and control of design, construction, resource management, operation and maintenance of existing and future transportation systems
- Enhanced condition monitoring through establishment of monitoring techniques, digital infrastructure and interacting systems for monitoring and assessment for transport system
- Improved transport system governance through national coordination and collaboration between authorities, industry, and academia.

Impacts related to 'Enhanced collaboration & cooperation' goal:

- Improved overall innovation, business and engineering conditions related to the transport system, in order to ensure that academia, authorities, and industries collaborate and cooperate
- Reduced risk of sub-optimisation between stakeholders through facilitated interaction between academia, authorities, and industries
- Improved contracting to support incentives related to reliability, availability and maintainability of the transport system
- Improved knowledge and information exchange between transport system stakeholders to enable efficient asset management and continuous improvements through enhanced monitoring and assessment
- Improved methods and systems for planning, managing and disseminating information to increase system reliability to achieve customer satisfaction
- Enhanced decision support tools for the transport industry stakeholders in their various roles to invest in and contribute to the development and improvement at system level

Other expected impacts consists of:

- Increased export of technologies, services, and research skills related to diagnostics and prognostics in connection with the design, construction, operation and maintenance of the transport system
- Technologies, innovations, and solutions in other sectors (e.g. consumer, mining, energy, aviation, and pulp and paper), - with corresponding benefits



4. Opportunities and success factors

4. Opportunities and success factors

AT PRESENT, there is extensive knowledge available based on completed research. In the event of gaps in knowledge complementary research efforts should be performed. Emphases should be put on taking advantage of and cross-fertilising the existing knowledge of business, government and academia through pooling of resources as the basis for innovation, development and utilisation of both existing and new solutions. Platforms for demonstrations need to be available. The performance of the transport system will only be improved if it is understood and managed as a whole system shared between many actors.

The Swedish government published (SWEINV, 2012). As with the European strategy (COM, 2011), the national strategy relates the visions to the 2020 horizon. The purpose of the national strategy is “to contribute to a climate with the best possible conditions for innovation in Sweden with the year 2020 in focus. People and organisations in industry, the public sector and society will be able to develop and more effectively contribute to new or improved solutions meeting needs and demand. The societal challenges faced by Sweden, together with the rest of the world, are both extensive and complex in nature. Therefore, no single player or area of society has sufficient knowledge or resources to meet these challenges on their own. It is important to further develop coordination between different players in order to create the best conditions possible for innovation.”

This strategy constitutes a basis for a long-term approach in order to enhance the Swedish innovation climate and innovation capacity.

A holistic system approach

THE PERFORMANCE OF THE TRANSPORTATION SYSTEM will only be improved if it is understood and managed as a whole system shared between many actors, with particular attention being paid to the interfaces between the parts of the system managed by the different actors. A cross-sector, whole-system approach to design, maintenance, delivery and safe operation should be adopted.

The work within RTS will be based on a holistic view of the transport system that allows for the inclusion and consideration of all relevant systems and actors but also their complex interaction. Cooperation with actors from different modes is important in order to apply innovations to develop high quality and seamless mobility solutions. This holistic system approach will enable the transport industry to adapt more easily to change and to implement innovative new designs and methods that meet the users’ needs, providing customers with much more attractive transport solutions. The approach is the necessary key to increased reliability, availability, maintainability and safety at reduced cost.

Utilization of innovations

A SUSTAINABLE DEVELOPMENT of the transport sector requires a dedicated and balanced approach addressing specific common research and innovation challenges, while integrating and demonstrating cooperation between stakeholders across the whole value chain. However, Technology Readiness Level (TRL) as a classification tool will support RTS to categorise and assign activities to different lifecycle stages of technology development. In order to support technology development phases and collaboration related to transport system, RTS will develop and establish a corresponding Innovation Readiness Level (IRL) to enable side-by-side processes for research, development, and innovation.

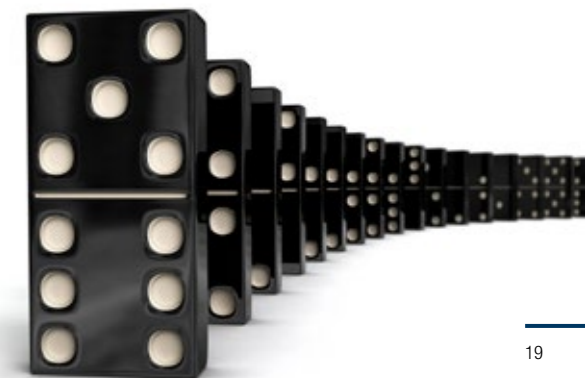
Collaboration

COLLABORATION CREATES A PLATFORM for new types of interaction with the Swedish transport industry and the relevant research and educational institutions. It also creates visibility for common challenges in the national and European innovation systems.

RTS provides a collaborative platform representing stakeholders from industries, authorities, and academia in the transport sector. RTS partners represent infra-structure owner, operators, system integrators, OEM suppliers, maintenance providers, consultants, SMEs, agencies, transport associations, end-users, construction companies, authorities, service providers, service consumers, and academia.

The combination of this wide range of stakeholders is an essential prerequisite to be able to establish a holistic system thinking related to the transport system.

Furthermore, the RTS platform facilitates achievement of e.g.: a) a cross-industrial interaction; b) a higher agility to project initiation; c) an overarching management of needs and requirements between transport modes; d) dissemination of relevant knowledge ; e) a base for recruitment; f) a stronger presence in innovation systems, e.g. H2020, in Sweden and Europe ; g) co-funding of innovation projects; h) a parallel development and implementation of solutions in practice; i) an organisation, standards, and processes for data and information sharing.





5. The Agenda

5. The Agenda

BASED IN THE VISION STATEMENT, RTS addresses a set of focus areas in order to achieve overall goals and expectations. Each focus area highlights a domain where it is fundamental to develop and provide a robust and reliable transport system. RTS focus areas are inter-connected and complementary. In addition, RTS provides a roadmap for conducting core activities. The focus areas and related activities are first explained in tables and then depicted in Figure 1..

RTS focus areas:

The table below provides a description of RTS's focus areas:

Focus area	Description
Transport system governance	Transport system governance addresses domains such as organisation, gender, data ownership, sustainability, equality, process, in-/out-/crowd sourcing, contracting, Risk management, Performance Based Logistics and Contract Based Logistics.
Transport system innovations	This focus area addresses aspects of the process of creation, implementation, deployment, and commercialisation of innovations in order decrease time to bring technology to market.
Freight transport & passenger travel	This focus area addresses aspects of a robust, reliable, and resilient transport system, transport system standards, overall quality, and aggregated system capacity.
Intelligent transport system	Intelligent transport system addresses domains such as condition monitoring techniques and strategies, context-based system modelling for diagnostic and prognostic, road and rail weather information systems, connected vehicles and sensors.





Description of RTS core activities

RTS CORE ACTIVITIES are aimed to support and facilitate the achievement of the RTS' overall goals. The core activities will be conducted within RTS's focus areas.

The table below provides a description of RTS's core activities:

Core activity	Description
Matches	Creating the connections between different people and organisations, so they can develop projects together.
Idea Camp	Generating ideas for innovation projects, then screening and validating these ideas.
Fundamental & applied research	Conducting research activities to enable development and innovation in the transport sector.
Upscaling projects	Developing/testing/demonstrating innovative technologies and products at (pre)-industrial scale (TRL5-9).
Network of Infrastructure	Creating hubs of lab and test infrastructure across several partners (focussing on a specific topic), connecting them into a network and making the infrastructures accessible to others.
Wider Society Learning	Developing and organising activities aiming at raising the awareness and goodwill of society at large towards the transport sector and attracting people to the transport field.
Entrepreneurship Support Services	Strengthening the support capabilities provided by partners at the local level and adapting them to the specific needs of the transport sector.
Start-Up Booster	Providing a support package to customers with excellent start-up ideas, based on a competitive selection.
SME Growth booster	Providing business support to existing SMEs in their expansion beyond their local reach, based on a competitive selection.

Core activities	Focus areas			
	Transport system governance	Transport system innovation	Freight transport & passenger travel	Intelligent transport system
Match-making	✓	✓	✓	✓
Idea Camp	✓	✓	✓	✓
Fundamental & applied research	✓	✓	✓	✓
Upscaling projects	✓	✓	✓	✓
Network of Infrastructure	✓	✓	✓	✓
Wider Society Learning	✓	✓	✓	✓
Entrepreneurship Support Services	✓	✓	✓	✓
Start-Up Booster	✓	✓	✓	✓
SME Growth booster	✓	✓	✓	✓

Figure 1. Relationship between RTS's focus areas and core activities

Transport system according to RTS

The TS is: A system-of-systems, which includes infra-structure, vehicles, and stakeholders related to the system-of-interest.



5.1 Focus area: Transport system governance

GOVERNANCE HAS DEVELOPED IN SOCIETY, from the process of the past where national governments cared rather exclusively for planning and investments, to the present situation where several stakeholders are involved in influencing the processes and have practical or financial responsibilities.

Transport system governance addresses aspects of management, and control related to transport system organised according to the market principles.



Topics to address	Description of the issues & challenges
Sustainable development	<p>In the context of the transport system a sustainable development is essential. Sustainable development refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCOM, 1987). Sustainable development encompasses activities and processes intended to achieve overall sustainability.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> Identify key areas for sustainable development with a large potential to improve robust and reliable transport system. Concurrent inclusion of the financial, environmental and social aspects in sustainable development.
Cooperation and collaboration	<p>A transport system involves an extensive number of stakeholders with heterogeneous interests and needs. In order to fulfil stakeholders' needs effectively and efficiently, the transport system needs to provide flexible and adaptive services and functions. However, need-identification is one of the key success factors in design and development of flexible and adaptive transport services and functions. The need-identification process is highly dependent on input from involved stakeholder. Hence, inter- and intra-organisational collaboration and cooperation are important aspects that need to be considered.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> Create an environment for cooperation and collaboration Identify key areas for joint innovative governance activities Understand the role of various stakeholders Design and test neutral and holistic governance models Identify key processes for cooperation and collaboration Create an attractive environment that encourages collaboration Coordination of heterogeneous needs related to e.g. gender, equality, disability, age etc
Contracting	<p>The transport system is vertically separated, meaning different parties are responsible for: selling infrastructure to operators; selling rights for operating different lines; outsourced maintenance; leasing of cars; and so on, This creates a considerable demand on how to outsource, how to formulate the best tender, how to evaluate the tender, how to cooperate during the contract, how to follow up on the contract and create an positive atmosphere.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> Develop new kinds of contracts that promotes enhanced collaboration and open access Establish criteria and goals for contracts that ensures robustness and sustainability for the transport system Develop procurement and contracting strategies that connect design, construction and maintenance of the infrastructure to enhance a holistic system perspective Design incentives for innovation and sustainable development
Risk management	<p>Risk management in relation to the transport system is the set of processes through which all the stakeholders together identify, analyse, and, where necessary, respond appropriately to risks that might adversely affect realisation of the transport policy goals. The response to risks typically depends on stakeholders perceived importance, and involves controlling, avoiding, accepting or transferring perceived/assessed risk to a third party. Whereas organisations routinely manage a wide range of risks (e.g. technological risks, commercial/financial risks, information security risks etc.), external legal and regulatory compliance risks are arguably the key issue in transport governance. Governance of risk necessarily deals with preventing excessive risk management The aim is to protect an organisation's resources and income opportunities against damage to the organisation, and society so the goals can be achieved at as low a cost as possible.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> Assessing risk management value Defining associated risks Selecting risk assessment method Defining risk assessment metrics Defining risk ownership Developing risk reporting Simulations and stress tests

5.2 Focus area: Transport system innovation

INNOVATION CAN BE VIEWED as the application of better solutions that meet new requirements, unarticulated needs, or existing market needs. This is accomplished through more effective products, processes, services, technologies, or ideas that are readily available to markets, governments and society.

This focus area addresses aspects of the process of creation, implementation, deployment, and commercialisation of innovations in order to decrease the time to bring the technology to the market.

Topics to address	Description of the challenges
Implementation and deployment of transport innovations	<p>The European White Paper on Transport is accompanied by an impact assessment report (EURDM, 2011) that identifies the challenges that the transport system is likely to face in the future. This states that transport research and innovation in Europe today are making progress on supporting the development and deployment of key technologies that are needed to develop the EU transport system into a modern, decarbonised, efficient and user-friendly system. However, bringing the products and services to market to attain this objective is not fast enough. This situation is due to a wide variety of market and regulatory failures that are manifested as:</p> <ul style="list-style-type: none"> ■ Weak innovation process ■ Lack of sufficient coordination related to insufficient data and information and lack of common setting of strategic priorities ■ Excessive time to bring the technology to market ■ The complexity of technology options <p>When (OECD, 2013) evaluates Sweden's politics regarding innovation the conclusions from a SWOT-analysis states that one of nine threats to the Swedish competitiveness is the difficulties in transferring technology from research to industry.</p> <p>A successful implementation of transport innovations depends on whether you have a general understanding of the implementation process. Hence, the establishment of an effective and efficient implementation process requires research which addresses a number of issues and challenges. Some of these are highlighted below:</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ Identify key areas in order to develop the link between research, development and deployment of transport innovations ■ Understand the role of stakeholders to identify drivers and barriers in order to implement transport innovations ■ Design and test models to decrease the time to bring technology to market.
Transport demonstrators	<p>In the Swedish Transport Research Investigation (SOU, 2010) from 2010 the analysis describes how academic competence and long term financing have to be combined with medium and short length projects, where some projects are of a near-market or short-term problem-solving nature. Reinforcements of incubation and demonstration in the existing transport related development environments create good conditions for innovation and growth. In order to balance long and short term projects together with governance and freedom, management and activities in incubators, platforms and projects need to be handled in a good way.</p> <p>Furthermore, demonstrators are described as an efficient instrument in the innovation process that lead to meetings, mostly in pre-commercial phases, between developers, problem owners and innovators but also as a motor for new innovations to be created. Innovations can be tested in realistic operating conditions where risk, costs and accidents can be decreased. Development and the operation of demonstrators can be one of the most important paths to implement and commercialise research results.</p> <p>Hence, issues and challenges related to the establishment and development of effective and efficient transport demonstrators are highlighted below:</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ Identify key areas to establish successful demonstrators for testing and implementing innovations in the transport system ■ Development of organisations and business models for managing effective transport demonstrators ■ Development of models to stimulate collaboration between multiple actors around publicly financed transport pilots and demonstration facilities and describe their role in technological innovation systems.

Topics to address	Description of the challenges
Commercialisation of innovations	<p>Innovation is about change that creates value. Creating the conditions for innovation in the transport industry is therefore not an end in itself, but a means to achieving greater values. For transport stakeholders to be interested in spending time and energy on innovations there should also be incentives for how this can lead to improved competitiveness and profitability.</p> <p>The concept of innovation expands gradually. Companies and organisations are creating value not only by developing and applying new technologies in products and processes, but also by creating new services, markets and business models. Sometimes this means that customers are offered new combinations of products and services, but sometimes the innovation lies in how these products and services are offered through the introduction of new business models.</p> <p>According to the European White Paper on Transport (EUTRA, 2011), technological research needs to be complemented with a systems approach, taking care of infrastructure and regulatory requirements, coordination of multiple actors and large demonstration projects to encourage market take-up. Innovation and deployment need to be supported by regulatory framework conditions. Protection of privacy and personal data will have to develop in parallel with the wider use of information technology tools. Standardisation and interoperability requirements, including those at international level, will avoid technological fragmentation and enable European businesses to fully benefit from the entire European transport market, and to create worldwide market opportunities.</p> <p>Privacy, security and legislation information can be extracted from a combination of several more or less isolated systems that are managed by different stakeholders. Each such system will in general contain information that the owner of that data will not be willing, able and/or legally allowed to distribute or exchange with others. Patterns inferred from user data for instance, may reveal sensitive information, such as the whereabouts of individuals or groups of individuals. In order to ensure data availability it is necessary that privacy issues and concerns are addressed. In order to ensure a functioning data service market and the development of new business models, it is further of vital importance that data storage, transfers, and processing can be made while respecting the basic requirements of information security: integrity, authenticity, confidentiality, availability, and nonrepudiation.</p> <p>Hence, to make sure that innovations are implemented and barriers to commercialisation are avoided, research is required which address a large number of issues and challenges. Some of these are highlighted below:</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ Development of models for data ownership – protection of privacy and personal data ■ Development of business models and strategies related to data and information sharing within transportation systems ■ Requirements of an international standardisation and interoperability
Creation and procurement of innovations	<p>Public creation and procurement accounts for about 19% of GDP in the European Union (EUPROC, 2015) and offers an enormous potential market for innovative products and services. Public procurement practices can help foster market uptake of innovative products and services, whilst improving the quality of public services in markets where the public sector is a significant purchaser. Seeking more innovative creation and procurement solutions can yield benefits for public authorities and the private sector, as well as the wider society. The power of demand (e.g. first buyer or lead customer) can move the market to stimulate the economy and increase competitiveness of firms in future markets, creating new businesses and increasing the level of employment. Scientific and technological breakthroughs can be the result of Pre-commercial procurement (PCP) and Public creation and procurement of innovative solutions (PPI) processes.</p> <p>Hence, the establishment of knowledge regarding procurement of innovations and maintenance contracts requires research and innovation which address a number of issues and challenges. Some of these are highlighted below:</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ Identify key areas for achieving successful stimulation of innovations and smart solutions through contracts and procurement ■ Development of the procurement of innovative forms for transports and services ■ Incentive models for maintenance contracts with regard to stimulating innovation, demonstrators, knowledge transfer, supplier involvement in operations and continuous improvements



5.3 Focus area: Freight transport & passenger travel

THE GLOBAL INCREASE in freight transport and passenger travel call for a more robust, resilient, and reliable transport system. Some of the indicators related to robustness, resilience, and reliability can be expressed in punctuality and capacity. According to the Swedish TTT-project (Tillsammans för tåg i tid/Together for Trains on Time), more than a 50 % reduction of the number of delay minutes is required to reach the project goal, i.e. 95 % of all trains arrive on time within 5 minutes.

This focus area addresses aspects of robust, reliable, and resilient transport system, transport system standards, overall quality, and aggregated system capacity.



Topics to address	Description of the challenges
Robust, reliable and resilient transport system	<p>Today's transport system emphasises enhanced robustness, reliability, and resilience. However, these aspects need to be approached from a holistic perspective and throughout the system's whole lifecycle. These characteristics of the transport system require research and innovation in both the short and long term.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ Development of approaches and methods for work planning and execution (e.g. maintenance work) ■ Implementation and adaptation to relevant standards ■ Development of methods to assess the condition of the transport system using various data sources ■ Development of approaches and tools to assure system and mission readiness ■ Development of tools aimed for safety and security related to the technical system and the users ■ Development of and adaptation to procedures that ensure mission readiness at cross-country passages (requirement compliance)
Quality of commercial transport	<p>Recent developments have included positive elements, such as less load capacity restrictions and a continued reduction in total disruptions in traffic. Actions to monitor and assess the condition of the system are required to improve the punctuality and retain or restore serious failures. Condition monitoring will also facilitate the process of detection and reduction of deviations.</p> <p>Nationally and from an international perspective, freight transport quality is perceived to have deteriorated compared to previous years. A robust, reliable, and resilient transport system supports the quality of commercial transport.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ Development of methodologies and technologies to improve punctuality ■ Development of models and tools to improve cost efficiency during the system's whole lifecycle ■ Development and implementation of approaches and tools to contribute to strengthened business competitiveness
Capacity for freight transport and passengers travel	<p>The transport sector's overall challenge is to meet an expectedly dramatic increase in demand for transport while developing a sustainable transport system. The capacity of the transport system must increase, not only through development and investments in new capacity but also through improving the existing transport system.</p> <p>Robust and reliable transport system support capacity for freight and passenger transport can be achieved through:</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ Development of models and tools to provide appropriate operation and maintenance plans (e.g. timetables and maintenance programme), which contribute to overall system efficiency and customer satisfactory ■ Development of tools and methodologies to facilitate coordination of operations and maintenance plans (e.g. timetables) between different transport stakeholders ■ Development of methods, strategies and decision support systems to improve the recovery process



5.4 Focus area: Intelligent transport system

INTELLIGENT TRANSPORT SYSTEM deals with the development of methodologies, models and tools to ensure system dependability, efficiency, and effectiveness within all system lifecycle processes (e.g. conceptualisation, design, manufacturing, utilisation, and retirement).

Topics to address	Description of the challenges
Condition monitoring techniques and strategies	<p>Condition Monitoring (CM) is about obtaining information about physical state or operational parameters. CM is used to determine when preventive maintenance may be required. CM may be conducted automatically during operation or at planned intervals. Furthermore, CM methods include: vibration analysis, tribology and thermography.</p> <p>The selection and development of adequate CM methods are important parts in operation and maintenance of transport system.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ <i>Measurement strategies</i> – addresses issues and challenges related to management large amount of components and sensors ■ <i>Aggregated measures</i> – addresses issues and challenges related to how to aggregate a large number of measurements and features into a few indicators which can be used for decision support ■ <i>Performance measurement</i> – addresses issues and challenges related to asset monitoring for maintenance, assessment of the operation performance, and the development of key performance indicators
Context based diagnostics and prognostics	<p>One of the key characteristics of a context-aware transport system is the ability to adapt to the current situation through measurement of physical phenomena related to indenture level of the system.</p> <p>Continuous measurement of system condition is essential in diagnostics (which refers to fault detection, identification, and isolation capability of the system) and prognostics (which refers to prediction capability of the system).</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ <i>System modelling</i> – addresses issues and challenges related to modelling of asset behaviour to improve diagnostics and prognostics ■ <i>Remaining technical life estimation</i> – addresses issues and challenges related to models for failure prediction and remaining technical life ■ <i>Remaining useful life</i> – addresses issues and challenges related to models which optimise asset availability and costs
eMaintenance	<p>eMaintenance is about providing decision support to improve effectiveness and efficiency of the decision-making in business, operation and maintenance processes. To achieve excellence in decision-making, eMaintenance solutions utilise enhanced information and communication technologies, including digitalisation.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ <i>Content-related</i> – deals with data and information and considers: I) the syntactic issues; which refers to the format and structure of content, and II) the semantic issues; which refers to the meaning of content ■ <i>Architecture-related</i> – deals with the design principles of eMaintenance solutions. eMaintenance architecture involves the description of systems' inherent components, the interactions between the elements, their composition guided by patterns and the constraints on those patterns ■ <i>Infrastructure-related</i> – deals with development of supporting technologies for eMaintenance solutions. eMaintenance infrastructure aims to develop and provide enabling technologies and tools which enable establishment of eMaintenance services for decision support.



Topics to address	Description of the challenges
Integrated	<p>The transport system lifecycle logistics includes activities such as planning, analysis, testing, production, distribution and support related to a system throughout the system's utilisation period. Hence, Integrated Logistic Support (ILS) is a management function aimed at assuring that the system fulfils the user of a system's (ultimate consumer) requirements and expectation during the system's life cycle.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ <i>Decision support</i> – addresses issues and challenges related to decision models and decision support modelling ■ <i>Process-orientation</i> - addresses issues and challenges related to design and development process-oriented approaches ■ <i>Service-orientation</i> - addresses issues and challenges related to the design and development of service-oriented approached in models, technologies, and tools.
Information logistics	<p>The main aim of information logistics is to provide just-in-time information to targeted users and optimisation of the information supply process, i.e. making the right information available at the right time and at the right point of location. Solutions for information logistics need to deal with: 1) time management, which addresses 'when to deliver'; 2) content management, which refers to 'what to deliver'; 3) communication management, which refers to 'how to deliver'; 4) context management, which addresses 'where and why to deliver'. Some examples of information logistics solutions for transport system are: 'Rail & road weather information system', 'Passenger and freight information systems', and 'Connected vehicles'.</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ <i>Big Data Analytics</i> – addresses issues and challenges related to volume, velocity, and variety in process of data analysis of big data sets. ■ <i>Cloudfication</i> – addresses issues and challenges related to distributed data processing in a heterogeneous architectural environment. ■ <i>Safety & security</i> – addresses issues and challenges related to safety, security, repairability, and survivability. ■ <i>Information governance</i> – issues and challenges related to data and information governance
Sensor technologies	<p>More and more sensors are available and their price has gone down making it possible to deploy sensors in ITS solutions. The challenge with sensors is to understand the information they are gathering and develop a method that makes it possible to evaluate the different properties of the sensors</p> <p>Issues & challenges:</p> <ul style="list-style-type: none"> ■ <i>Methods for evaluation</i> – addresses issues and challenges related to introduction of new sensors and how they should be evaluated ■ <i>Repeatability in different environments</i> – addresses issues and challenges related to environmental changes ■ <i>Energy harvesting</i> – addresses issues and challenges related to measurement applications, where the access to electrical power is limited ■ <i>Reduction of redundant and waste data</i> – addresses issues and challenges related to models which support the reduction the amount of data needed to be transmitted



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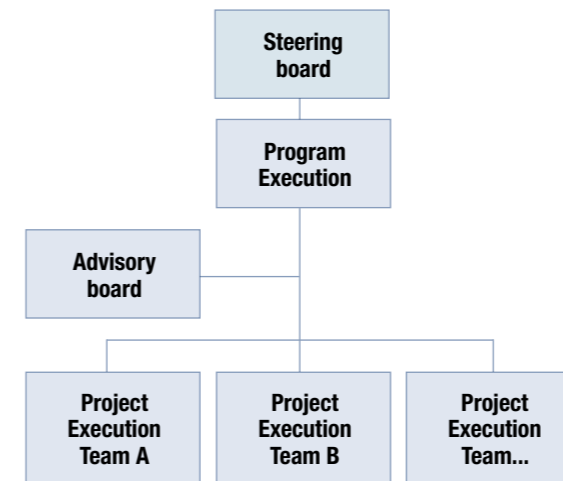


Appendix A: Project organisation

TO CLARIFY THE IMPORTANCE of Robust and Dependable Transport and ensure a long-term legitimacy it is important that the leading stakeholders establish a leadership body for the area. The leadership will have an overall responsibility for the national agenda, to ensure that the innovation-, research- and education policies are focused on the right target.

Focus for the leadership will be on enabling collaboration between the different actors from government, different modes of transport, different infrastructures and academia.

Preferably this could be done by a leadership structure that is showed below:



■ **Steering Board (SB)**, consists of representatives from authorities, industry and academia. It is responsible for overall goal achievement and definition of strategies.

■ **Programme Execution (PE)**, consists of representatives from industry and academia. The chair of the PE is responsible for execution of directives defined by the SB.

■ **Advisory Board (AB)**: consists of a large number representatives from various stakeholders (e.g. from governments, industry, SME, and academia). The main task for AB is to support PE by providing expert knowledge in different topics.

■ **Project Execution Team (PET)**: consists of members from authority, industry, SME, and academia such jointly undertaken execution of a specific task, as defined and approved PE. PET has a manger who is responsible for the execution of the task according to the requirements (e.g. outcome, quality, finance, and schedule).



Appendix B: RDI environments, cluster and initiatives

Automatiserade transporter

As automated transports are a part of a robust and reliable transport system the programme will interface with RTS. At this stage the Automatiserade transporter, which is strategic innovation programme founded by Vinnova, is organising their project organisation, so it is difficult as yet to give any concrete examples of cooperation.

BVFF (Bana Väg För Framtiden)

BVFF is an industry program for research, development and innovations in road and railway construction and maintenance. The aim is to develop and strengthen relevant parts of the road and railway industry and also to help society meet current and future demands for efficient road and rail-

way infrastructure. RTS results will support BVFF to achieve these goals by adding knowledge and solutions that improve robustness, resilience and reliability of road and rail infrastructure.

Capacity in rail traffic - KAJT

KAJT a jointly run Swedish research programme looking at capacity planning and traffic management. RTS creates, among other things, the conditions for better resource management, increased planned prevention maintenance and reduced need for traffic disturbance during urgent corrective maintenance, which for railways means increasing capacity. KAJT are an established industry application that will interface with the RTS.

Effective green freight train

RTS contributes to reliable rail transport within the agenda Effektiva gröna godståg, section Operational reliability through intelligent maintenance, condition monitoring and e-maintenance solutions.

ERRAC (<http://www.errac.org/>)

ERRAC has the ambitious goal of creating a single European body with both the competence and capability to help revitalise the European rail sector and make it more competitive by fostering increased innovation and guiding research efforts at European level.

FFI (Fordonstrategisk Forskning och Innovation)

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI will contribute to the following main goals: 1) Reducing the environmental impact of road transport and 2) Reducing the number killed and injured in road traffic and 3) Strengthening international competitiveness. RTS results will support FFI to achieve these goals by adding knowledge and solutions that improve robustness, resilience and reliability of road transport system.

Horison 2020

Horison 2020 (H2020) is the EU framework programme for research and innovation. By coupling research and innovation, H2020 is helping to achieve this with its emphasis on excellent science, industrial leadership and tackling societal challenges. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. The RTS agenda works in the H2020 spirit by performing research, innovation and collaboration in the Triple Helix and addressing issues to remove barriers from successful implementation of innovations.

ICT-BIM for better processes and products

ICT-BIM for better processes and products of environmental resources is a strategic innovation agenda for 1) Increased residential construction and robust infrastructure, 2) Improved productivity and growth, 3) Increased user benefit and influence, and 4) Improved national and international competitiveness. RTS and ICT-BIM can take advantage of synergies between development in the Transport sector and the Environmental resources sector.

INFRA Sweden 2030

InfraSweden2030 is a strategic innovation programme founded by Vinnova, which has the goal that the Swedish transportation infrastructure system (roads and railroads) will become 100% more sustainable than it is today. A second goal of the program is that Sweden has become world leading in the invention, implementation and nurturing of smart and sustainable transportation infrastructure innovations. The RTS agenda is complementary to InfraSweden2030 by addressing reliability and robustness of the entire road and rail transport system.

Luleå Railway Research Center (JVTC)

Luleå Railway Research Center (JVTC) focus on R&I of operation and maintenance within the railway sector. Research includes the entire maintenance process, with emphasis on RAM4S (Reliability, Availability, Maintainability, Sustainability, Safety, Security and Supportability), LCC, risk, maintenance limits, eMaintenance and the development of maintenance strategies where methods like RAMS and LCC are interwoven applicable to a whole. JVTC supports RTS with new research that contributes to achieving the goals of the agenda.

Shift to Rail (S²R)

Shift to Rail (S²R) is a rail joint undertaking within Horison 2020 that focus on research and innovation (R&I) and market-driven solutions by accelerating the integration of new and advanced technologies into innovative rail product solutions. RTS will be able to give support in the efforts to achieve S²R's initiative aims, to double the capacity of the European rail system, increase its reliability and service quality by 50%, all while halving the lifecycle costs.

Signalling systems in rail traffic

RTS contribute to the conditions for robust and reliable signalling of railway traffic by contributing to the research platform with FOI players within the signal range, as Agenda Signalling systems in rail traffic intend to establish.



Appendix C: List of resources

This agenda is supported by the following stakeholders:

- Acreo Swedish ICT
- Appear Networks
- Chalmers University of Technology
- Damill
- Ecoloop
- eMaintenance365
- Klimator
- Royal Institute of Technology
- LKAB
- Luleå University of Technology
- Mälarhamnar
- MariTerm
- MTR Stockholm
- NCC
- Performance in Cold
- ReRail
- SAAB Support and Services
- SICS Swedish ICT
- Stockholms läns landsting – Trafikförvaltningen
- Stockholmskonsulterna
- Strukton Rail
- SWECO
- Tunnelbanan Teknik
- Terrasolid
- Tyréns
- Uleåborg university
- Victoria Swedish ICT
- Volvo Cars
- Volvo Group Trucks Technology
- Vossloh Nordic Switch Systems
- VTI



Appendix D: Conducted activities

THIS STRATEGIC INNOVATION AGENDA for a Robust and Reliable Transport System (RTS) describes work that has progressed during the period April 2014 to September 2015. The agenda has been developed through broad co-operation between companies, organisations, institutes and universities that are directly or indirectly involved in the transport sector.

The work has consisted in analysing the research and innovation area, in an effort to understand the challenges the transport industry faces and define strategic proposals for the future. The work has been organised by Luleå University of Technology (LTU). The report was developed with Ramin Karim, Veronica Jägare, and Rune Lindberg as the main writers and editors, based on the working group's discussions. The working group was also given opportunities for input and comments on the draft text. The report is to be considered as a product of the entire working group. The work and the outcomes are based on realisation by all the stakeholders that organising and managing innovation in the transport sector is crucial to ensure that the resources the companies have in terms of knowledge, technologies, contacts and capital materialise into actual performance and progress that give organisations competitiveness and thereby secures their long term survival.

From these stakeholders a large number of people have participated in four (4) workshops and several smaller meetings where the starting point was to identify a common vision for a robust and reliable transport system.

The result revealed new areas not previously identified, and also that some already identified areas are particularly important and thus demonstrate the importance of extra effort.

RTS has in addition to the main Swedish and European objectives also taken its starting point in the existing action plans, agendas, projects and collaborations designed to achieve a robust and reliable transport system.

