



Towards a Single and Innovative European Transport System SINTRAS

*Barriers Analysis and Action Plans
Final Report*

April 2017



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Abstract

Europe faces the challenge of meeting growing demand for transport with shrinking public financial resources, while reducing environmental impacts, cutting greenhouse gas emissions, reducing dependency on imported hydrocarbons and lowering accident rates. The European Commission's transport strategy responds to these challenges. It recognises that innovation is vital in achieving these aims but notes that the adoption of innovative solutions is hampered by barriers due, in part, to the fragmented nature of Europe's transport system. This report presents the final results of a study to examine these barriers and to propose actions to overcome them.

The report examines five Focus Areas: connected driving and automation of transport, and the use of automated optimisation of traffic flows; transformation of infrastructure to address connectivity, resilience, new fuels and energy efficiency; smart mobility services (including provision and use of data, and urban mobility), freight and logistics; standardisation and interoperability; and alternative fuels other than electrification.

Although technology development in the five Focus Areas continues, the report finds that the main barriers relate to the implementation and exploitation of existing innovations. The proposed actions address European-level policy; incentive schemes; standardisation; transnational collaboration; the use of data; funding for research, development and innovation; and capacity building.

Acronyms and abbreviations

ACARE – Advisory Council for Aviation Research and Innovation in Europe
AFD – Agence Française de Développement
AI – Artificial Intelligence
ASSTRA – Associazione Trasporti (Italian Association of local public transport companies)
CBA – Cost-benefit Analysis
CEF – Connecting Europe Facility
CEN – European Committee for Standardisation
CENELEC – European Committee for Electrotechnical Standardisation
CEPS – Centre for European Policy Studies
C-ITS – Cooperative Intelligent Transport Systems
CIVITAS – a network of cities dedicated to cleaner, better transport in Europe and beyond, see <http://www.civitas.eu/>
CORSA – Carbon Offset and Reduction Scheme for International Aviation
DMP – Data Management Plan
DTLF – Digital Transport and Logistics Forum
EBRD – European Bank for Reconstruction and Development
ECTP – European Construction Technology Platform
EDI – Electronic Data Interchange
EIB – European Investment Bank
EPIs – Environmental Performance Indicators
ERDF – European Regional Development Fund
ERRAC – European Rail Research Advisory Council
ERTMS – European Rail Traffic Management System
ERTRAC – European Road Transport Research Advisory Council
ESIF – European Structural and Investment Funds
ETPs – European Technology Platforms
ETS – Emission Trading System
ETSI – European Telecommunications Standards Institute
FA – Focus Area
FFV – Flexi-fuel Vehicles
FP7 – Framework Programme 7
f-v-i – fuel-vehicle-infra
GHG – greenhouse gas
ICT – Information and Communications Technologies
IoT – Internet of Things
IPRM – Innovation Policy Roadmapping
ITS – Intelligent Transport Systems
JASPERS – Joint Assistance to Support Projects in European Regions
JRC – Joint Research Centre
KPIs – Key Performance Indicators
LNG – Liquefied Natural Gas
LSP – Logistics Service Provider
MaaS – Mobility as a Service
MMITS – Multi-Modal Information and Ticketing Systems
MS – Member State
OECD – Organisation for Economic Cooperation and Development
OEM – Original Equipment Manufacturer
PCP – Pre-Commercial Procurement
PI – Physical Internet
PPI – Public Procurement of Innovative Solutions
PPP – Public Private Partnership

PT – Public Transport
R&D – Research and Development
RDI – Research, Development and Innovation
REFINET – REthinking Future Infrastructure NETworks
RIS – River Information Services
SC – Supply Chain
SESAR – Single European Sky Air Traffic Management Research
SETRIS – Strengthening European Transport Research and Innovation Strategies
SINTRAS – Towards a Single and Innovative European Transport System
SME – Small and Medium-sized Enterprise
SMS – Smart Mobility Services
STRIA – Strategic Transport Research and Innovation Agenda
SULP – Sustainable Urban Logistics Plans
SUMP – Sustainable Urban Mobility Plan
TEN-T – Trans-European Network - Transport
TIP – Transport Incentive Programme
TMS – Transport Management Systems
VDV – Verband Deutscher Verkehrsunternehmen
WBCSD – World Business Council for Sustainable Development

Executive Summary

Europe faces the challenge of meeting growing demand for transport with shrinking public financial resources. This challenge is made more severe by the simultaneous pressures to reduce environmental impacts, cut greenhouse gas emissions, lessen dependency on imported hydrocarbons and decrease accident rates.

The European Commission's transport strategy responds to these challenges, with the ultimate goal to improve mobility and support growth and jobs in an integrated transport system, a Single European Transport Area. These aims are reinforced by the European Union's Jobs and Growth agenda, in which transport plays a key enabling role; by the Energy Union initiative, in which transport is highlighted as a major consumer of Europe's scarce energy resources; and by the recently adopted European Strategy for Low-emission Mobility.

The intelligent combination of technological, organisational and social innovation is vital in achieving these aims. However, the European Commission's transport strategy recognises that the development and adoption of such innovation is hampered by barriers due, at least in part, to the fragmented nature of Europe's transport system. There is a need to understand in more detail the characteristics and causes of these barriers and thus be able to identify actions to overcome them. The SINTRAS (Towards a Single and Innovative European Transport System) study helps to meet this need.

This report presents the final results of the SINTRAS study. It summarises the conclusions of early work to explore the barriers which inhibit the adoption of innovation and new technology in European transport. It then elaborates this knowledge and evidence base into action plans that suggest means to overcome the barriers and their root causes.

The first finding of the SINTRAS study is that **technology is not the problem**. Substantial technology challenges remain but the barriers to adoption of new technology have more to do with economic, political and societal factors than with the technology itself. Amongst those other factors, the study finds that **investors are reluctant to commit to new technology**, not least due the recent financial crisis. Beyond the crisis, however, two other issues arise. First, building a convincing business case is difficult when the benefits and the costs of the new technology are uncertain or are hard to quantify, such as improvements in safety or quality of life. Second, there is fear of 'first mover disadvantage': no-one wants to be first to invest in a new technology because its performance may turn out to fall short, a rival technology may emerge as a better choice or legislation may become unfavourable. Adoption of new technology often involves collaboration amongst transport actors, for example to share passenger travel pattern data. However, often **commercial interests get in the way of collaboration**, when operators see no commercial benefit in such sharing and, indeed, regard other operators as competitors with whom to share commercially valuable data would be damaging.

For some new technologies, **users do not always directly feel the benefits**. Automated driving and alternative fuels, for example, provide societal benefits such as improved road safety and decarbonisation. While citizens may support these as worthy goals, many are reluctant to adopt such technologies themselves unless and until they see a direct personal advantage in doing so. Behavioural issues, such as conservatism and risk aversion, also mean that **transitions are treacherous**. The transition from old to new technologies or ways of working introduces risks that the new will turn out not to be as good as expected or will have unexpected negative side effects. Conservatism arises when the old is so well established that switching costs are

perceived to be uncomfortably high and when the new will require those involved to work in different ways which are not yet clear.

There are times when **national and local interests work against European solutions**. Member States and regions sometimes face conflicting objectives. Developing an integrated Europe and supporting cross-border transport may be stated aims. Yet, at the same time, protecting national industry may be seen as necessary in order to defend and create jobs. This may lead to setting national standards or adopting support policies which favour domestic solutions at the expense of European harmonisation. Similarly, in different regions with different needs and priorities, **stakeholders have differing aims**. Policies which respond to these local needs in one region may therefore be inconsistent with policies developed for an adjoining region. The resulting inconsistencies in policy across regions create uncertainty and confusion for technology developers and investors.

Underlying many of these barriers, **pricing is a problem**. There is still much to be done to develop ways of charging for new services enabled by new technology, which will attract users and provide adequate returns for investors. A further problem is that **data are missing or not well used**. Effective adoption of new technology often depends on a good understanding of passenger travel patterns and preferences. Not all transport operators gather and use such data, either through a lack of awareness of its potential value or because they prefer to invest limited funds elsewhere. Finally, in some areas **standards are still insufficient**. Despite great efforts and progress to build effective and harmonised standards, in some cases standards are missing, incomplete or allow room for differing interpretations.

Turning to actions, this study leads to recommendations in ten domains. In **policy**, the European Union should provide a stronger long-term unifying vision to guide policy development in Member States. It should then ensure that Member States' strategic policies are appropriately aligned with this overarching vision and themselves provide long-term vision and predictability. Other policy recommendations deal with key performance indicators and capacity building in public authorities. In the **funding** domain, there are opportunities to develop the use of existing European Union funding instruments and budgets, for example by retargeting current programmes and ensuring that funding is only provided where projects clearly support policy objectives. A specific case is the use of **incentives** to encourage the adoption of new technology, by extending or adjusting the focus of existing schemes and making more use of public procurement. Similarly, there is a need for more **harmonisation**: the European Union should do more to set and enforce common frameworks and standards across Europe, to counter the tendency for multiple and incompatible schemes and systems to develop. **Standards**, in particular, can have a powerful effect on innovation and the introduction of new technology, by helping to provide the business opportunities of a single, large market.

Stronger **stakeholder partnerships**, across the public and private sectors, will help the adoption of new technology in many areas. This is partly a matter of the private sector working more closely together and taking collective responsibility for finding ways to deploy new technology effectively. This should be supported by public sector action to raise awareness amongst all stakeholders of new service possibilities and to look at framework conditions, regulatory and cost-benefit issues, the use of neutral brokers and improved data access. This applies especially to stimulating **transnational collaboration**.

Cities make important decisions affecting the adoption of new transport technologies. While some are pioneers, many others need encouragement to engage and to participate early in planning deployment. Improving **data access**, for example by making results from European Union-funded transport projects more widely available

and by stimulating the development of publicly-available transport databases, will help all actors. Finally, to achieve wider adoption of new technology, more action is needed to raise end-user **awareness** of the benefits provided by new technology and thus stimulate demand.

This report examines in detail five Focus Areas, which are similar to the thematic transport areas of the Strategic Transport Research and Innovation Agenda of the Energy Union. The conclusions for each of these Focus Areas support the findings and recommendations described above.

In **Focus Area 1 (Connected driving and automation of transport)**, we look mainly at road transport as it is the most complex subject area that will require the most technological, regulatory and legislative modifications. Much technology already exists. The main barriers to the adoption of this technology include the need for substantial early investments, in capital and in cooperation arrangements between stakeholders, while most benefits will not be seen until later, when sufficient levels of penetration have been reached. This makes it difficult to convince potential users of the benefits and to build attractive business cases for investors. There are also considerable uncertainties about the impacts of the new technology systems on issues such as existing road infrastructure, road safety, liability and insurance, and the roles of the various operational stakeholders. Technology adoption is also hampered by differing policies and approaches to deployment amongst Member States, a symptom of what some stakeholders see as a lack of a strong common vision and approach across the European Union.

Areas for action therefore include stronger measures at European Union level to encourage stakeholders to collaborate and to align Member State approaches through smarter regulation and harmonisation of deployment schemes. At early stages of deployment, it is vital to establish a (reference) system architecture for cooperative intelligent transport systems, to ensure interoperability with future technologies. More attention, at all levels, to building capacity in public authorities, targeting research, development and innovation investments, using public procurement effectively and early deployment of roadside infrastructure will also help.

Focus Area 2 (Infrastructure) suffers from weak investment in new technology, due to risk-averse policies at Member State level coupled with funding limitations following the financial crisis. At the same time, demands to upgrade existing and ageing infrastructure are increasing. Other barriers include the large number of agents involved and differing regulatory frameworks amongst Member States. Inadequate information on the effects of climate change restricts the ability to deal effectively with resilience concerns. Areas for action include promoting a shared long-term vision and using that vision to encourage multiple agents to work more closely together in a spirit of open innovation. Innovations in financing models and better targeting of research and development funding will help to improve investment levels.

Focus Area 3 (Smart mobility services) includes data quality, standards and availability; Mobility as a Service; Multi-Modal Information and Ticketing Systems; Smart City logistics; synchromodality and e-freight. Poor coordination amongst stakeholders is a major factor here, inhibiting technology adoption and the provision of widely available common services. The poor provision of Multi-Modal Information and Ticketing Systems that truly allow the through-ticketing of trips from door to door, though technology is available, is a stark example. A particular problem is the poor exchange of data, due partly to inadequate data quality and standards and partly to commercial considerations. Many stakeholders believe that more policy attention here would be better than continuing what is seen as over-emphasis on hardware and physical infrastructure. Areas for action therefore include exploring the use of neutral third parties for data exchange, incentives for collaboration, better data standards and

more use of open data. Capacity building in public authorities will support these actions.

In **Focus Area 4 (Standardisation and interoperability)**, a major barrier is limited collaboration between stakeholders, partly due to issues of trust and protection of commercially valuable data. This is made worse by a lack of flexible information technology systems for data sharing and of appropriate business models for collaborative working. The absence of a standard for a modular box inhibits improvement of inland freight transport. Areas for action include standards, information technology and data management, and implementing the physical internet.

Focus Area 5 (Alternative fuels other than electrification) is characterised by a lack of enthusiasm by potential users to switch from conventional fuels. Partly this is a matter of cost: the production cost of many alternatives is still relatively high. Inadequate refuelling infrastructure and low supply volumes are also disincentives. It is therefore hard for alternatives to overcome the preference to stay with a well-established and well-understood conventional fuel system. Weak, short-term policy support and differing market conditions across Member States do not help. Areas for action therefore include better alignment of long-term policy support measures, stronger incentives, smart regulation and standards, a common approach to refuelling infrastructure amongst Member States, and targeting of research and innovation funding.

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1 Introduction

1.1 Background

The request by the European Commission's Directorate General for Mobility and Transport for the SINTRAS (Towards a Single and Innovative European Transport System) study drew attention to the challenge of meeting growing European demand for transport with shrinking public financial resources. This challenge is made more severe by the simultaneous pressures to reduce environmental impacts, cut greenhouse gas (GHG) emissions, reduce dependency on imported hydrocarbons and lower accident rates.

In response to this challenge, the European Commission had set out a European transport strategy in its 2011 White Paper¹. This presented ambitious objectives for developing transport provision while also improving the environment, cutting GHG emissions, and so on. The ultimate goal was set to improve mobility and support growth and jobs in a united transport system, a Single European Transport Area. The aims of the 2011 White Paper have been reinforced by the European Union's Jobs and Growth agenda, in which transport plays a vital enabling role, and by the Energy Union initiative, in which transport is highlighted as a major consumer of Europe's scarce energy resources. The environmental dimension has been reinforced by a recently adopted European Strategy for Low-emission Mobility².

The White Paper stressed the role of innovation and new technology in strengthening European transport. It also pointed out that the development and adoption of new technology is hampered by barriers due, at least in part, to the fragmented nature of Europe's transport system. There is a need to understand in more detail the nature and causes of these barriers and thus be able to identify actions to overcome them. The SINTRAS study is intended to help meet this need.

The first SINTRAS deliverable D1.2 "Final Report on state of play and analysis of barriers", presented the results of early work to examine the state of play of technologies and the barriers which stand in the way of a single and innovative European transport system. This second deliverable D1.3 "Final report on barriers analysis and action plans" concludes the SINTRAS study by summarising the barriers, elaborating projected developments and presenting action plans to overcome the barriers. Together, these reports provide a solid evidence base and a comprehensive analysis for the European Commission's transport research and innovation policy as well as for national and regional policies in Member States.

1.2 Objectives

The objective of this report is to present action plans for five thematic Focus Areas, with the aim to address barriers to developing a single and innovative European transport system. Our approach to formulate the action plans builds on Focus Area specific state of play knowledge; we also examine the system-level view across and beyond the Focus Areas.

Three levels of analysis are used. The overarching system-level transition towards a single and innovative European transport system considers wide societal issues

¹ European Commission: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM(2011) 144 final.

² Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A European Strategy for Low-Emission Mobility COM(2016) 501.

relevant in this transformation (level 1). Projected developments within the Focus Areas structure the needs and markets; technology-based and other solutions; and enabling technologies for each Focus Area (level 2). Focus Area action plans in turn identify the actions and responsibilities in terms of decision-making, policy-planning, deployment and maturity (level 3).

The five Focus Areas under study are:

1. Connected driving and automation of transport, and use of automated optimisation of traffic flows;
2. Transformation of infrastructure to address connectivity, resilience, new fuels and energy efficiency;
3. Smart mobility services (including provision and use of data, and urban mobility), freight and logistics;
4. Standardisation and interoperability;
5. Alternative fuels other than electrification.

The projected developments and action plans cover the short, medium and long-term horizons until 2050. Further, we assess the magnitude of the relative costs and benefits of the proposed actions towards transport system integration and propose measurable key performance indicators for monitoring the implementation of the actions and evaluating the achievements over time.

1.3 Working process

The work of completing this report was organised to build on findings from the state of play and barrier analysis (deliverable D1.2). The first step was to draft preliminary summaries of projected developments per Focus Area and at the overarching systemic level. These were further processed into action plans per Focus Area and presented to the stakeholders of the study for feedback and consultation. A cost-benefit analysis on the actions was then carried out, including assessment of wider societal aspects. This was used to prioritise the actions. A set of key performance indicators was formulated for monitoring and assessing how the proposed actions support progress towards transport system integration. Further stakeholder feedback was used to validate and complete the action plans and cost-benefit assessment.

1.4 Methodology

For the methodological framework, we use innovation policy roadmapping (IPRM), a concept developed by Ahlqvist et al.³. IPRM is a systemic instrument that supports forward-looking policy design. It consists of two levels of inspection: (1) '**transformation roadmap**' to capture the systemic level; and (2) '**(technology) roadmaps**' focussing on technology-based solutions and other enablers. Figure 1 shows the template for the visual summary of the overall transformation, where we use numbered lettering (e.g. T1) to itemise each transformative change factor. Figure 2 shows the template for roadmapping Focus Area specific projected developments, with similarly itemised building blocks (e.g. R1). The purpose of the numbered lettering is to ease referencing to specific items within this report.

We apply the IPRM framework in this case by depicting the overall societal landscape; transport and innovation policies; and the European transport system as the study object in the system-level transformation. The five Focus Areas in turn constitute the

³ Ahlqvist Toni, Valovirta Ville, and Loikkanen Torsti, 2012. Innovation policy roadmapping as a systemic instrument for forward-looking policy design. *Science and Public Policy* (2012) 39 (2): 178-190.

key enablers. Each is explored with the aid of a dedicated view of projected developments in that Focus Area. These views summarise possible and desired future developments as reported by the various sources investigated during the state of play and barrier analysis. These five Focus Area summaries of projected developments thus constitute a solution-oriented subset for the overarching hoped for transformation.

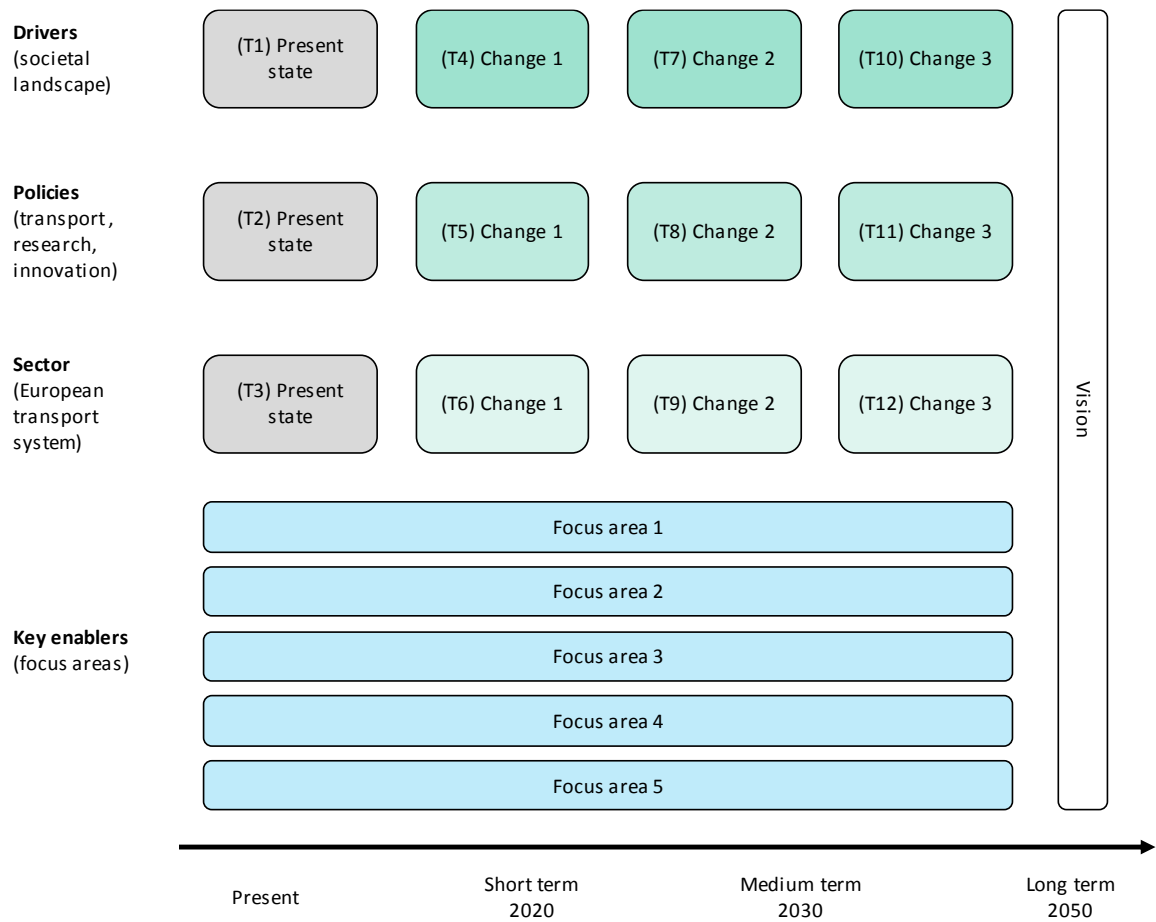


Figure 1. Transformation template.

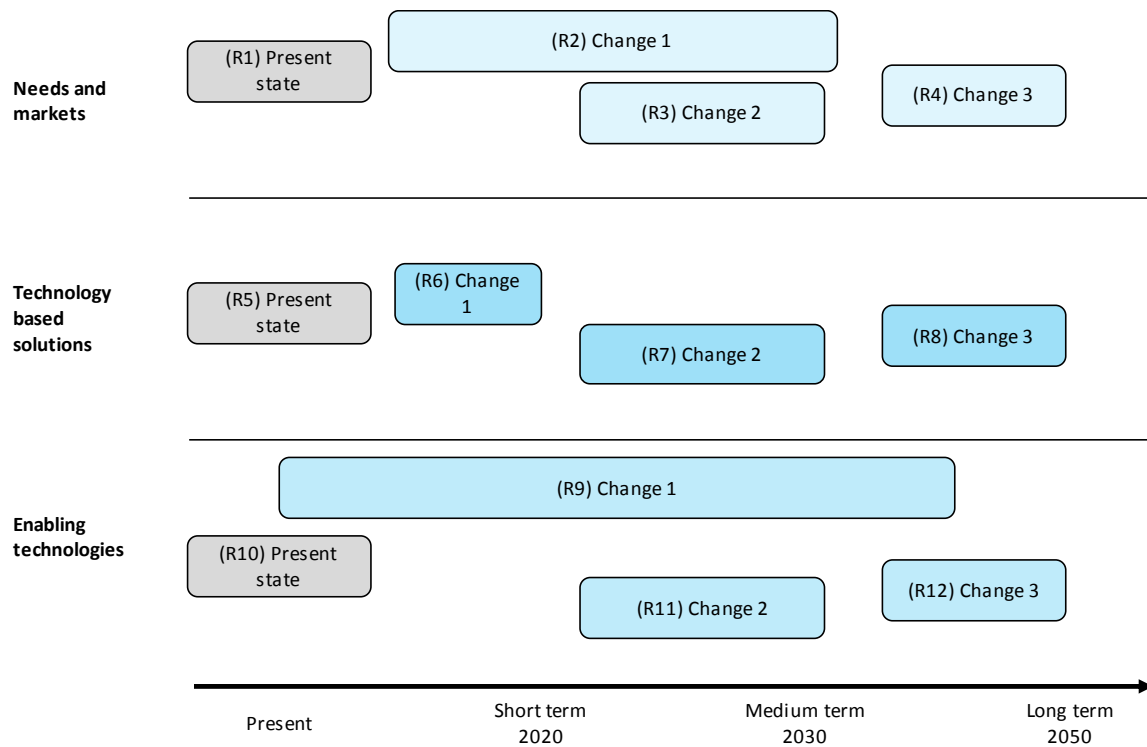


Figure 2. Projected developments template.

The IPRM framework allows us to combine and summarise previous SINTRAS findings so that the state of play and barriers per Focus Area, as well as the overarching system-level aspects, are linked to policy context and action planning. Temporal horizons at 2020, 2030 and 2050 are explored, together with the cycle of progress from research and innovation to standardisation and regulation.

Next, actions are identified and structured in terms of decision making, policy planning and deployment against short, medium and long-term timeframes and maturity (cycle from research and innovation to standardisation, and regulation to deployment), both within Focus Areas. The overview of the state of play and the barrier analysis are thus linked to policy context, technology deployment and action planning. As an outcome, a list of actions is produced with reference to Focus Areas, timing, urgency, maturity, actors, geography, technology, etc. These most importantly focus on actions promoting innovation and the aims of integration regarding the single European transport area. Actions are visually summarised

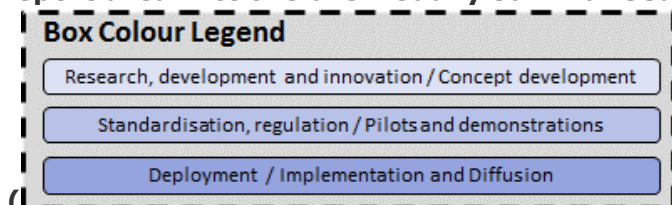


Figure 3) similar to the summaries of the projected developments, and numbered lettering (e.g. A1) is used to itemise each action. Strategic, as well as concrete, actions of different scale by different stakeholders are thus structured against different time scales.

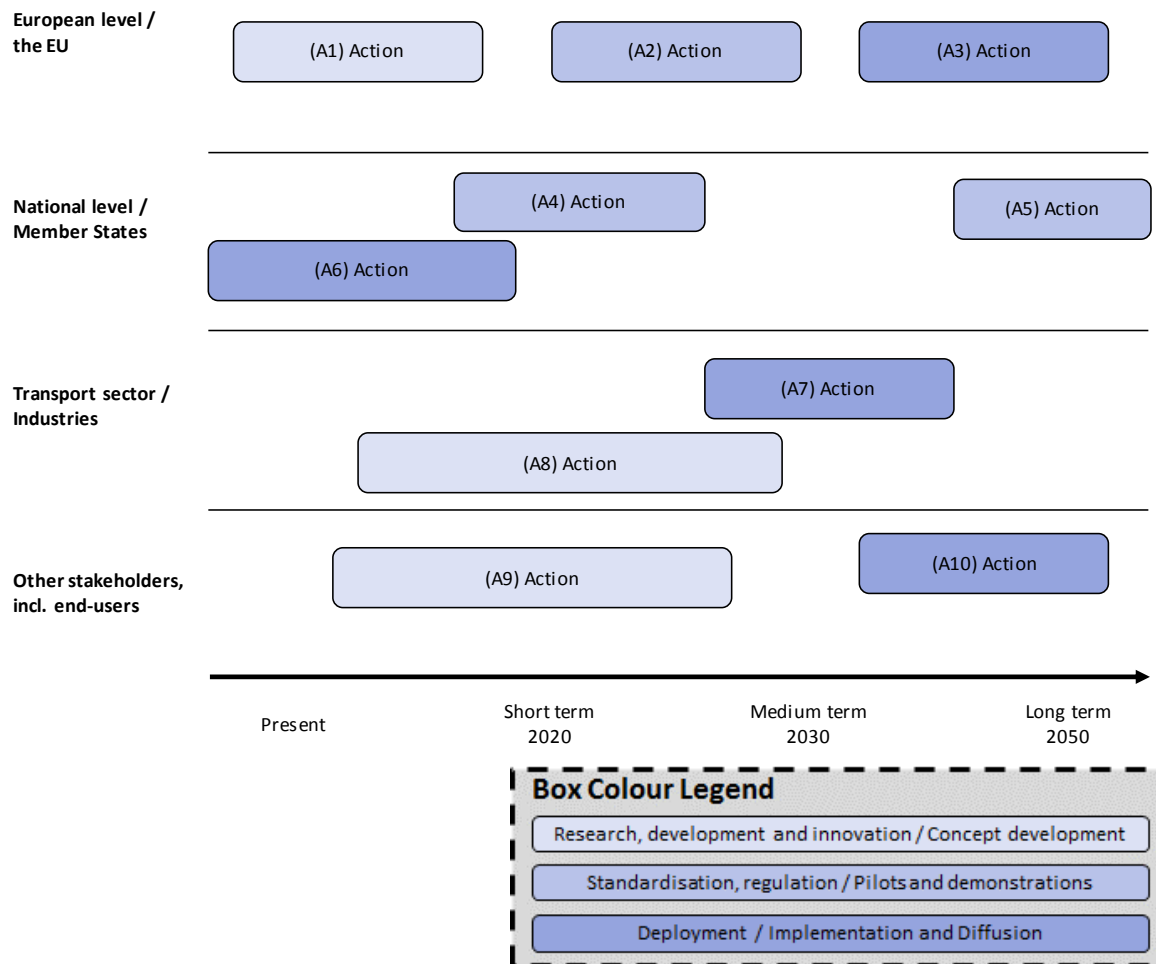


Figure 3. Action plan template.

For the impact assessment of proposed actions, we use a framework that integrates the four steps of an innovation process: (1) research and development (R&D), (2) pilots and demonstrations, (3) implementation, and (4) diffusion (see the second column) with the impact pathway steps of an innovation action (effort, action, outcome and impact). The latter is presented in rows for each of the steps of an innovation process. This matrix framework, including both of these dimensions, is presented in Figure 4. Each of the cells in this matrix describes a step in the process towards wide societal impacts of transport innovations. The two shades of green illustrate the first two steps of an innovation process and the two shades of purple, the last two steps. In our case, we use the impact framework especially for the definition of measurable key performance indicators (KPIs) for each of the specific actions per Focus Area. The KPIs measure the success of implementation of the proposed actions and evaluate the achievements during the whole innovation path from R&D (idea) to diffusion. This process approach results in a larger number of KPIs than would be the case if only outcome or impact KPIs were considered but, in doing so, it provides a more comprehensive view on the inputs and outputs required for innovation.

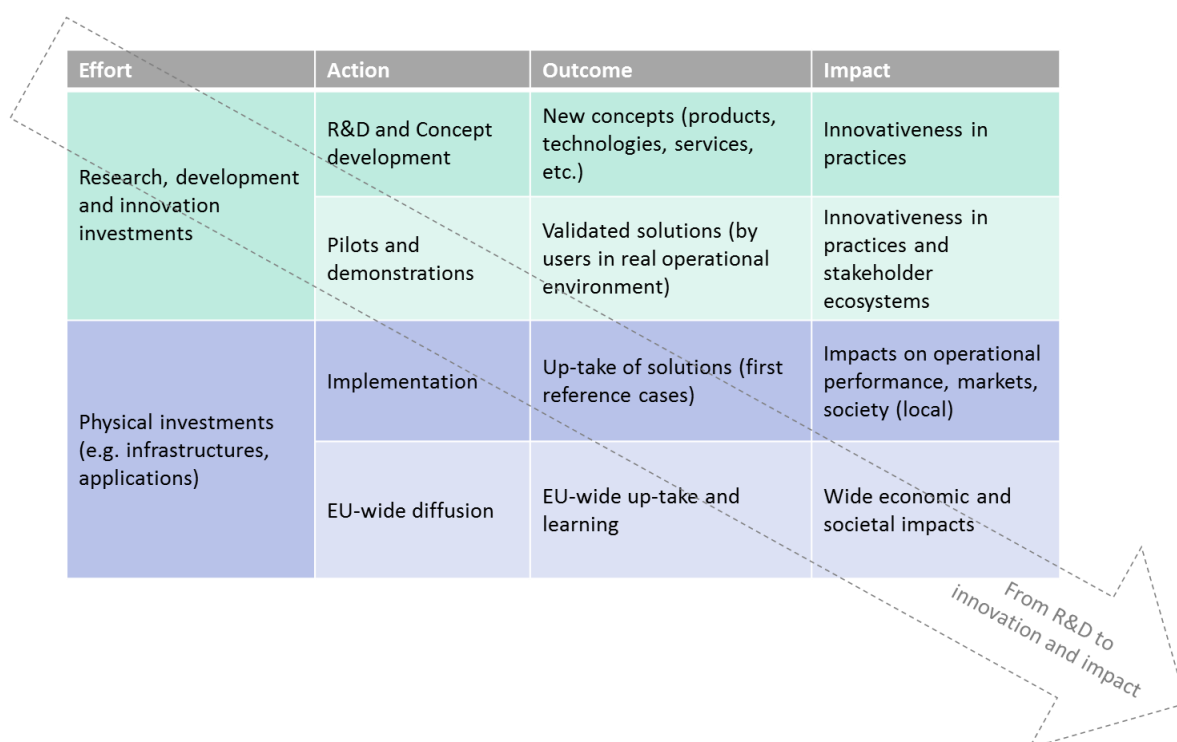


Figure 4. Assessment framework for monitoring and evaluation.

For the cost-benefit analysis (CBA) of the actions proposed in the action plans, we use a semi-qualitative approach in which both the costs and the benefits of each action are estimated as High, Medium or Low. Synergy effects and optimisation within and across Focus Areas is of special interest in order to better understand system-level impacts. The estimates are based on expert assessment by the SINTRAS team and have been validated through stakeholder consultation.

The purpose is to provide a rough idea of the relative costs and benefits of the actions, not to evaluate them in monetary terms. As we focus on strategic policy actions, full quantitative analysis is neither feasible nor necessary for the purposes of illustrating the relative merits of different actions.

Our approach follows, to the extent appropriate, the general principles of the European Commission’s Guide to CBA of large investment projects⁴ to indicate relative cost-benefit position of the proposed actions. The option of not taking action, i.e. the ‘do nothing’ case, is also studied.

Costs considered may be one-time or recurring, including financial (e.g. capital investments or labour costs for development, operation or maintenance) as well as others (e.g. costs involved in changing attitudes or overcoming political resistance). The cost-side assessment also provides some preliminary suggestions of suitable funding mechanisms and financial instruments available in order to link proposed actions to these and to seek for synergies.

For each action within each Focus Area, we identify the main cost components and then summarise their combined magnitude using Table 1 as a guide.

⁴ Guide to cost-benefit analysis of investment projects. European Commission, December 2014. ISBN 978-92-79-34796-2. Available at http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

Table 1. Guideline for assessing costs.

Cost	The action has some or all of the following characteristics
High	<ul style="list-style-type: none"> • Targets a broad cross-section of transport topics or stakeholder communities • Likely to provoke much debate and resistance • What to do is not entirely clear or understood and needs much work to clarify • Needs a long time and sustained persistence to make it work • Initial or recurring financial costs are so large as to require cross-Europe cooperation
Medium	<ul style="list-style-type: none"> • Targets a fairly well defined and coherent set of topics or stakeholders • Likely to be generally accepted though some stakeholder groups may protest • What to do is broadly known though some details remain to be worked out • Can be completed in the medium term provided all concerned continue to support it • Initial or recurring financial costs can be met by stakeholders but support is needed
Low	<ul style="list-style-type: none"> • Targets a well-defined and narrow topic or stakeholder community • Likely to be non-contentious • What to do is clear and well understood • Can be completed quite quickly • Initial or recurring financial costs likely to fit within existing stakeholder budgets

Regarding benefits of actions, we acknowledge direct consequences in the relatively short term (outcomes) as well as longer-term effects (impacts). Some actions may be quite small but have large impacts. Such actions can have modest outcomes but then serve as triggers or enablers for substantial longer-term impacts, including through economic multiplier effects.

Some benefits will be essentially financial (e.g. savings in travel time or increased utilisation or efficiency of a transport mode) while others cover environmental and societal aspects (e.g. improvements in safety, reductions in greenhouse gas emissions or improved quality of life).

We identify the main benefit components and then summarise them using Table 2 as a guide.

Table 2. Guideline for assessing benefits.

Benefit	The action has some or all of the following characteristics
High	<ul style="list-style-type: none"> • Leads to substantial and long lasting impact across the entire transport system • Unlocks or creates very substantial economic value for many stakeholders • Immediate outcomes are highly visible and widely appreciated • Leverage and multiplier effects are substantial • Likely in time to be recognised as a major game-changer for European transport
Medium	<ul style="list-style-type: none"> • Leads to substantial impact in a specific transport mode or sector • Unlocks or creates substantial economic value for a group of stakeholders • Immediate outcomes are clearly recognised and valued by the stakeholder group • Some leverage or multiplier effects • Seen as a big step forward in the mode or sector concerned
Low	<ul style="list-style-type: none"> • Leads to a significant impact in a narrow aspect of a transport mode or sector • Creates significant economic value for a narrow set of stakeholders • Immediate outcomes are recognised and appreciated by those concerned • Limited leverage or multiplier effects • Seen as a helpful contribution by those affected

Summaries of the costs and benefits of the actions proposed for each Focus Area are presented using the template shown in Table 3.

Table 3. Summary table for CBA.

Benefit	High			
	Medium			
	Low			
		Low	Medium	High
		Cost		

A dedicated consultation with 154 stakeholders underpins the results of the Cost Benefit Analysis.

2 Focus Area 1. Connected driving and automation of transport, and use of automated optimisation of traffic flows

2.1 Overview

This chapter describes Focus Area 1 and presents the needs and markets, possible technological solutions, and recommended policies that are to address the challenges foreseen in the future of transport where systems and networks develop towards connected driving and automation of transport. The focus of this chapter is on the automation of road transport as this is currently the most complex subject area that will require the most technological, regulatory and legislative changes. Comprehensive coverage of all modes would clearly exceed the scope of this chapter.

In the SINTRAS study, Focus Area 1 “Connected driving and automation of transport, and use of automated optimisation of traffic flows” has been defined as follows:

Connected Driving or Cooperative ITS (C-ITS) is a sub-set of Intelligent Transport Systems (ITS) and is here understood to describe technology which allows vehicles to become connected to each other (V2V), to the infrastructure (V2I) and to other devices (V2X). This systemic connectedness facilitates the provision of advice to drivers and is expected to help avoiding collisions, improving safety more generally, reducing congestion, increasing sustainability, efficiency and comfort beyond the scope of stand-alone systems. To be able to successfully deploy C-ITS, a C-ITS system architecture or a reference architecture (e.g. the Dutch C-ITS Reference architecture) needs to be established as a framework showing the interconnectivity and interfaces among the various measures. Ideally, a suitable architecture also needs also consider the involved stakeholders at the European Union level and their respective roles.

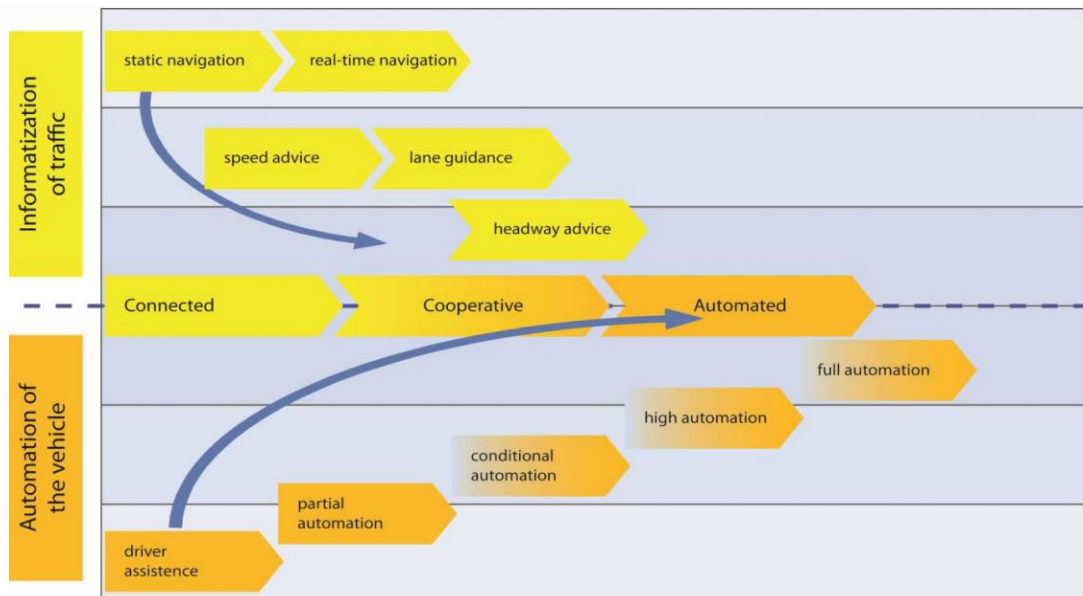


Figure 5. Connected, cooperative and automated driving developments should come together to harvest societal benefits (Source: Declaration of Amsterdam, 2016)

The Figure above explains the differences between the terminologies used in this chapter.

Automation of Transport: Automated vehicles rely on on-board equipment to collect information, take decisions and inform tasks. The level of automation is defined by the SAE standard definition (e.g. Level 0: No Automation; Level 5: Full Automation). Assisted driving (level 1) is almost ubiquitous nowadays with cruise control and similar features. Partially automated vehicles (level 2) are expected to be available from 2016 for low-complexity situations like stop-and-go at speeds below 30km/h. From 2020, highly automated driving (SAE 4) is likely to be possible and full automation (SAE 5) from 2025⁵.

Automated Optimisation of Traffic Flows: The growing number of connected and automated vehicles will result in the use of applications and services that can improve traffic management through the automated cooperative optimisation of traffic flow. In Focus Area 1 the "Automated Optimisation of Traffic Flows" is understood as a result from services and application that emerge from "connected driving" and "automation of transport". Other methods to automate the optimisation of traffic flow (e.g. variable speed signs based on input from loops) are not in the scope of Focus Area 1. Automated strategic rerouting is also beyond the scope of this chapter as it will only be available in the long-run.

Progress in these areas calls for joint decisions and actions by multiple stakeholders at European and national levels. The thematic actions need to be complemented by strategic actions across the themes contributing at least to the following issues:

- In the context of connected driving, as identified in the SINTRAS consultation days, there is still a missing overall vision that stakeholders can connect to, despite the establishment and continuation of the C-ITS platform, which serves as a platform to tackle and share a common goal in dealing with the development of C-ITS. Without a common vision that is relevant to Member States and private stakeholders, there is a risk that the market will become further fragmented and interoperability will be at risk. In particular, the unclear role of the public sector in the deployment of connected driving is a major issue that was also identified during the SINTRAS consultation days held with stakeholders in various locations across Europe. Nonetheless, on the top of the C-ITS platform, the launch of the C-Roads platform⁶, which was initiated by eight Member States, aims to solve the issues regarding interoperability, coordination, and cooperation, with the goal of the harmonising C-ITS related deployments and end-user services across Europe. In addition, another important step in the right direction was achieved by the very recent European Commission Communication⁷ which presents an EU strategy for the coordinated deployment of C-ITS in order to avoid a fragmented internal market in the field of C-ITS and to create synergies between the different initiatives. The strategy sets out specific actions to reach large-scale commercial deployment in 2019. This SINTRAS report builds upon the specific actions and recommends actions that go beyond 2019. Furthermore, as part of the deliverables of the CIMEC⁸

⁵ Jadranka, D., Müller, B., & Meyer, G. (2015). European Roadmap Smart Systems for Automated Driving. European Technology Platform on Smart Systems Integration - EPoSS. Retrieved from <http://www.webcitation.org/6c3NefXbr>

⁶ The C-Roads platform: harmonisation of C-ITS related deployments throughout Europe <https://www.c-roads.eu/platform/about/about.html>

⁷ A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility. European Commission COM(2016) 766 final, Brussels, November 30, 2016

⁸ <http://cimec-project.eu/>

project, a draft C-ITS roadmap⁹ for European cities has been published which addresses the deployment of C-ITS considering the multivariate aspects.

- Currently, there is a first mover (dis-)advantage problem: should one invest in C-ITS first and wait for the benefits or wait for economies of scale before investing? Robust business cases are so far lacking. Sufficient penetration rates (approximately 1-30% depending on the services) of connected vehicles and scalability will have to be achieved to be able to experience the benefits of connected driving.
- In the context of automation¹⁰, there are still some general framework conditions (e.g. legal and regulatory issues) that need to be resolved, even with automation level 1-3 vehicles, before vehicles with level 4-5 capability can operate on the public road network. Aspects of multi-modal cooperation (e.g. public transport vehicles and private vehicles) are also not yet systematically looked at – modal silos still exist. Nonetheless, automation of transport is also deployed in all transport modes, not just private vehicular road transport. There is a long history of automation in public transport (e.g. metro lines) and it is deployed more widely in aviation, rail and waterborne. Hence, the focus in this Focus Area is on road transport as it currently is the most complex subject area that will require the most technological, regulatory and legislative modifications. Comprehensive coverage of all modes would clearly exceed the scope of this SINTRAS chapter.
- The automated optimisation of traffic flows has been proven, but a sufficient penetration rate (approximately 10-45%¹¹) of connected vehicles is required for any significant effect on traffic flow to kick in, particularly in damping shockwaves. It is suggested that further action to stimulate the uptake of connected vehicles through public procurement and to promote end-user uptake of the technology through additional connected services, e.g. infotainment.

For Focus Area 1 (FA1), twelve barriers were identified early during the SINTRAS project. The elaboration for each barrier can be found in the annex. These barriers are, in the approximate decreasing order of decisiveness as expressed by SINTRAS consultation workshop participants:

- Barrier FA1-01: Low acceptance of the technology that exists for C-ITS and hesitation to invest from diverse stakeholder groups (1) (R1, R2, R3) (A1, A12)¹²
 - The technology is ready for the market, but a major obstacle for C-ITS deployment is that significant upfront investments are required both on the vehicle and the infrastructure level and that enhanced co-operation needs to be established among the many stakeholders involved before any benefits will occur. Additionally, since benefits can only be realised beyond only a sufficient penetration rate (percentage depends on services: even at 1% there are some benefits for estimations of traffic conditions in local zones; 10-45% for shockwave damping; the higher

⁹ http://cimec-project.eu/wp-content/uploads/2016/12/CIMEC_D3.2-Draft-Roadmap.pdf

¹⁰ Please refer to the definition of the SAE levels of automation in the definition of Focus Area 1 at the beginning of this chapter.

¹¹ This penetration rate is based on the scenario of damping shockwaves as discussed in: Netten, B.D., Van den Broek, Th.H.A., Passchier, I., & Lieveerse, P. (2011). Low penetration shockwave damping with cooperative systems; and the study of: Monteil, J. (2014). Investigating the effects of cooperative vehicles on highway traffic flow homogenization: analytical and simulation studies.

¹² Codes R and A provide cross-references to project developments (R) and proposed actions (A), defined in sections 2.2 and 2.3 respectively

rate, the more benefits), wide-spread acceptance across the diverse stakeholders, including the users, to adopt the technology is crucial.

- Barrier FA1-02: Insufficient knowledge about type and scale of changes required to physical road infrastructure (2) (R20) (A6, A16)
 - The impact of connected and automated driving on the physical infrastructure includes new requirements imposed on road construction to help unlock maximum benefits from this new technology but also that old practices may no longer be necessary (e.g. removal of physical road signs and their maintenance) or that current practices (e.g. shared space) might raise safety concerns. For instance, should there be a more physical separation to slow modes? Currently, there is a lack of use cases to influence adaptation of roadway/highway codes.
- Barrier FA1-03: Unclear business case and “sensitivity case” for C-ITS deployment in urban areas (3) (R1, R2, R3) (A9, A16)
 - There is a poor understanding of the urban C-ITS policy framework and factors driving procurement decisions: cities are comparatively more complex than corridors, strongly policy-driven and risk-averse when it comes to new technologies. The benefits for cities are uncertain at the moment. There is still the discussion of whether it would make sense to invest in C-ITS and automation, when the business case for it remains unclear and knowing the fact that cities have shifted their focus on public transport and non-motorised transport. Furthermore, there is often inappropriate communication of C-ITS: excessively focussed on car driver benefits, while cities are not especially interested in this issue but on solutions for their transport problems, addressing sustainability, modal shift, quality of life, and others.
- Barrier FA1-04: Unclear user acceptance, willingness to pay and business case for C-ITS day 1 and 1.5 services (4) (R4, R5, R7) (A2, A7, A13, A17)
 - What are the resulting applications? How can the benefits be sold to the large number of stakeholders? There is an unclear division between personal and societal benefits of services and applications. No business models (i.e. willingness to pay) for services and applications; additionally, these services and applications have not yet been deployed. For instance, for the day 1 services, buyers of non-equipped cars might be unwilling to participate in the financial burden sharing; potential opposition. Nonetheless, this barrier could be something to tackle in due time, rather than being a blocking factor today.
- Barrier FA1-05: Long waiting period and sufficient penetration rates (approximately 1-30% depending on the services) are required until benefits such as optimisation of traffic flow materialises (5) (R6, R7, R8) (A2, A17)
 - Significant benefits will only start to accumulate 5 to 10 years after initial investments, depending on deployment scenario and uptake rates. At what penetration level do traffic flow benefits emerge? At penetration rates of approximately 30%¹¹ of connected vehicles, which was also mainly identified based on simulations based on assumptions, only partial benefits are expected. There is a need for higher penetration rates (more than 45%, which is the upper threshold for benefits on shockwave damping) for the realisation of the full benefits brought by services such as automated optimisation of traffic flow.

Nonetheless, researchers have identified that there would be benefits even at 1%¹³ penetration rate for traffic surveillance (traffic volume estimation) in given zones. Hence, the selling argument should not be fully automated traffic. Rather, benefits from early applications should also be acknowledged.

- Barrier FA1-06: Unclear role for operational stakeholders for enhanced traffic management (6) (R1, R2, R3) (A1)
 - Facing a transition period, from conventional driving to fully automated systems, will be challenging. This includes setting up the right strategies and understanding, at operational level, the impact of automation and the changes to come on roles and borders of the road authorities, traffic managers, service providers, vehicle manufacturers and physical infrastructure stakeholder groups.
- Barrier FA1-07: Road Safety concerns about C-ITS and Automation can inhibit its deployment (7) (R12, R13) (A4)
 - All road users involved in traffic will be affected, including fully or partially automated motor vehicles, non-automated motor vehicles, motorcyclists (not yet automated), cyclists and pedestrians. Safety improvements are a powerful argument for the deployment of C-ITS and automation but new types of road safety issue might arise, especially during the transition phase. Safety concerns can restrict C-ITS and Automation deployment to restricted areas only.
- Barrier FA1-08: Uneven deployment of C-ITS across EU-28 (8) (R6, R7, R8) (A1)
 - Currently C-ITS are high on the policy agenda in a few European Union Member States in north-western Europe. How can other Member States, where there is no industrial agenda (e.g. Slovakia, Romania) and more important aspects are on the agenda than digitisation, become more involved? The industry's plan is to make all C-ITS equipped vehicles "EU-ready". But when passing a border, the vehicle will have to adjust its "behaviour" to the specific national regulations (e.g. speed limit in inner cities 30 km/h versus 20 m/h; left-hand versus right-hand driving; etc.)
- Barrier FA1-09: Unclear lending criteria by financial institutions to finance C-ITS measures (9) (R1, R2, R3) (A11, A15)
 - Funding institutions, International, European or national development banks (e.g. EBRD, EIB, KfW, AFD) do not have lending criteria to assess the bankability (feasibility to be bankable) of C-ITS measures. Development banks lack examples of financed C-ITS measures. Moreover, technological debates have not included the banking/financial sector as much as needed.
- Barrier FA1-10: The "Hybrid" Issue: How to make 802.11 p / mobile internet / 5G choices and still be able to create a workable system? (10) (R14, R15, R16) (A3)
 - Road infrastructure operators have uncertainties about the technology in which they should invest for C-ITS. For instance, technology progress

¹³ The objectives and findings of the Colombo projects can be found in this website <http://www.colombo-fp7.eu/>

in the medium-long-term (10, 20 or 30 years) is uncertain. It is not fully clear where to focus the investments: regions, locations, hot spots with a high level of accidents or traffic jams, end customer visibility; where is the break-even for these services? Who is the driver of a technology? Moreover, there are still safety and technical issues that need to be resolved regarding access-layer agnostic (meaning C-ITS messages can be transmitted independent to the underlying communication technology used) communication, which is one of the main aims of hybrid communication to speed-up the uptake of C-ITS.

- Barrier FA1-11: Liability, legislation and insurance related aspects (11) (R17, R18) (A3)
 - There is a lack of business models for insurance companies, and of corresponding legislation, in relation to liability aspects. The current degree of uncertainty around liability in the field of connected driving and the automation of transport is not surprising given the wide and rapidly developing range of (complex) applications and services and the highly varied liability regimes across the European Union. Although an important (potential) barrier, it is likely to be tackled in time as more business models from insurance companies emerge.
- Barrier FA1-12: Unclear risks between interaction with non-equipped and equipped vehicles (12) (R9, R10, R11) (A4)
 - New cars are gradually being equipped with driver assistance technologies which may assist the driver in some tasks or even take control of the vehicle in an emergency situation. The deployment of C-ITS will result in more advanced assistance systems made possible on the basis of communication between vehicles (V2V) or between vehicles and infrastructure (V2I). The deployment of such systems will be gradual, which means that cars with very different levels of equipment will inevitably circulate at the same time. The situation is likely to be prolonged for a very long time. The fact that vehicles equipped with these technologies and other vehicles or users not equipped will share the road may give rise to some new risks, mainly related to user behaviour.

2.2 Projected developments

Figure 6 presents projected developments (technology and framework conditions) for Focus Area 1. In the following subsections we explain this graph in detail, layer by layer, using the numbers in parentheses when referring to specific boxes within. In the graph we also use the codes for identified barriers to link present-state items to specific Focus Area 1 barriers identified during the SINTRAS project.

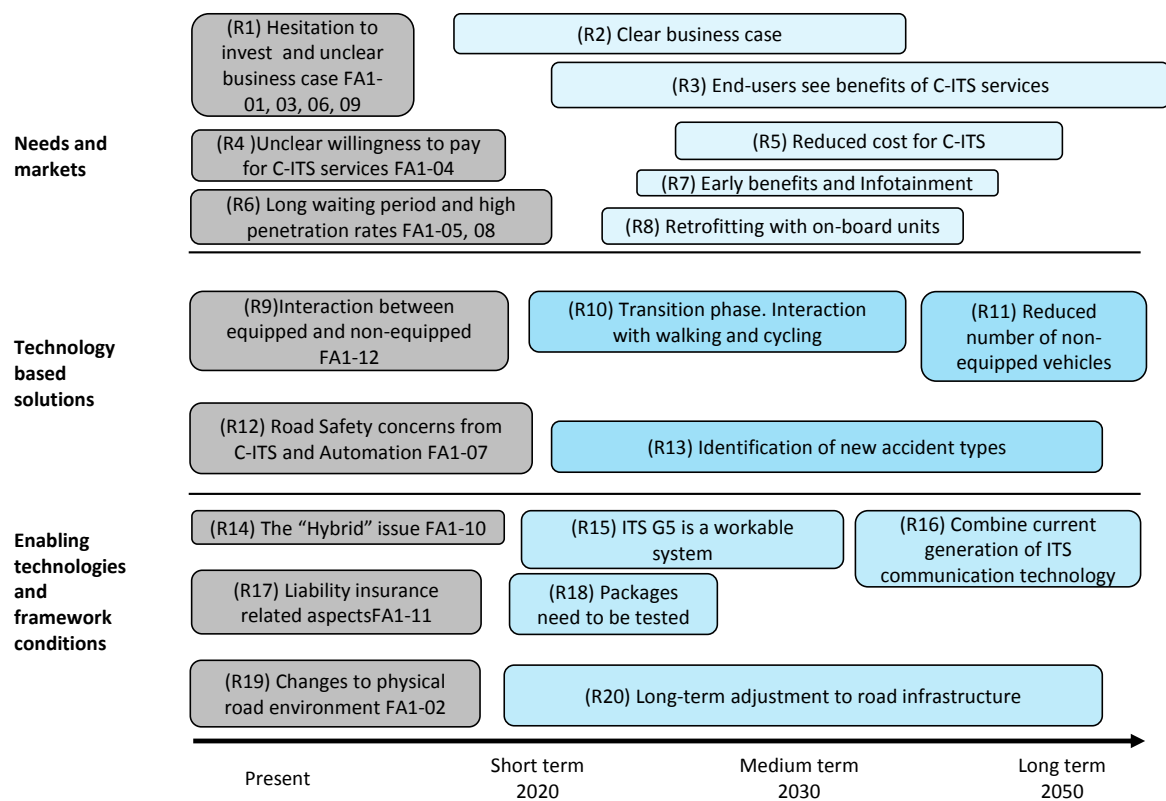


Figure 6. Projected developments in Focus Area 1.

2.2.1 Needs and markets

For Focus Area 1, the layer for **needs and markets** looks into matters of supply and demand for connected driving, connected applications and automation of transport.

Currently, there is (R1) hesitation and an unclear business case for many stakeholders involved in the deployment of connected driving. One of the reasons behind the hesitance is that there is currently a misalignment between the stakeholders who benefit from investment into connected driving infrastructure (e.g. private car users and freight operators) and those who have to carry the costs of the investment (e.g. road authorities and local authorities) within the transition period within the short-term. In the short-term (ca. 2020), a clear business model with a resulting (R2) business case needs to be developed for all stakeholders. The participants of the SINTRAS consultation days agreed that the focus, especially for automation, should be on freight and public transport because the business case (i.e. reduced driver costs) is clearer as for private vehicles.

End-users of connected driving (R3) who benefit most from connected driving services need to contribute to the necessary investments from the beginning, as they are going to benefit the most in the short-, medium- and long-term, as seen in Figure 6. Overall, the role of public authorities needs to be defined clearly and from our stakeholder consultation workshops it became clear that public authorities need to take an important role in the deployment of connected driving and automation, just as they do for other transport services.

Currently, it is unclear how much end-users and other stakeholders are willing to pay (R4) for *day 1* and *day 1.5* services and at which point they should start contributing or should they contribute at all; which has to be identified in the short-term. Currently, nobody is offering the day 1 and 1.5 services and subsequently, and simultaneously, the costs for providing the connected driving infrastructure are still high (e.g. beacons on gantries or poles, widespread deployment of smart traffic lights, sensors, etc.), but with the wider deployment expected to occur between the short to medium-term (i.e. 2020 to 2025), the costs (R5) for connected vehicles and infrastructure are bound to fall.

Freight and public transport operators have a higher willingness to pay due to the potential reduction in driver costs. Willingness to pay by end-users (i.e. owners of private vehicles) is likely to increase when non-transport related applications (R7) (e.g. additional infotainment services or mobile working) become more widely available. These could reduce the long waiting periods (R6) until sufficient penetration rates (approximately 30%) of connected vehicles are reached, which will result in overall benefits for traffic performance through the automated optimisation of traffic flow under the day 1 service, shockwave damping and so on. Retrofitting existing vehicles with on-board units will facilitate an accelerated uptake of connected driving within the transition phase, despite not being able to use all services which are fully available for connected vehicles (R8).

Access to data from the connected and automated car is determining for market players to design and offer services. Users need to know which data their vehicle shares and they must be given a real choice with whom they wish to share data. The legislation should therefore ensure competition in the aftermarket with a variety of service providers, so that drivers have the right to choose between several offers. Together, all of these are vital in facilitating the progress of the developments (R2, R3, R5, R7, R8) for the needs and markets section of Focus Area 1.

2.2.2 Technology-based solutions

For Focus Area 1, the layer for **technology-based solutions** for connected driving and automation of transport covers aspects concerning the transition period from conventional vehicles to connected and automated vehicles.

The stakeholders during the SINTRAS consultation days agreed that the technology for fully automated vehicles is still a barrier to deployment, whereas the technology required for day 1 services of connected driving no longer poses a barrier. However, the wider deployment of connected vehicles and automated transport are expected to result in challenges that cannot yet be anticipated. In particular, the long transition phase will be challenging. Conventional vehicles will interact (R9) with connected and more automated vehicles with varying penetration rates on the same network. Interactions in urban areas between connected and automated vehicles and pedestrians and cyclists will stretch the technological limits (R10). The key question is, how public safety is ensured without discouraging technical innovations? In the long term, the reduced number of conventional vehicles (R11) will resolve the risks that result from the transition phase.

It is anticipated that connected driving and automation of transport will result in improved safety across the transport network as the human error factor is eliminated. However, there is also the possibility that new accident types (R12 and R13) will emerge, thus resulting in a novel risk for the deployment of connected and automated

vehicles. Issues such as approval of connected and automated vehicles need to be resolved and driver training needs to be updated to reduce the risk of accidents.

2.2.3 Enabling technologies

For Focus Area 1, the layer for **enabling technologies and framework conditions** covers communication technology, liability issues and changes to the physical road infrastructure.

Currently, the main enabling technology is the communication technology (R14) available for the provision of connected driving and the automation of transport. These services and applications require an open Hybrid Communication approach supporting the adoption of new communication technologies¹⁴. Moreover, there are still safety and technical issues that need to be resolved regarding the deployment of access-layer agnostic communication (meaning C-ITS messages can be transmitted independent to the underlying communication technology used), which is one of the main aims of hybrid communication to speed-up the uptake of C-ITS.

For applications and services (e.g. safety and automated optimisation of traffic flow) that are needed for connected driving and the automation of transport, a demand for data exchange is expected. Furthermore, mobile working and infotainment-related services and applications will require even higher data exchange volumes. This overall high demand for data exchange requires a fast-increasing amount of spectrum. The C-ITS Platform working group on 'Hybrid Communications and Spectrum Allocation' concluded that currently neither ETSI ITS-G5 nor cellular systems (R15) can provide the full range of necessary services for connected driving and automation of transport. Consequently, as a hybrid ITS communication solution, the current generation of technology (R16) need to be combined (i.e. ITS-G5 combined with existing cellular networks, like 3G/4G) in order to take advantage of complementary technologies; the C-Roads platform has shown full commitment in the deployment of to this form of hybrid communication for C-ITS across Europe¹⁵.

An enabling framework condition for the deployment of connected driving and automation of transport is a liability framework (R17) for the new technologies. For connected driving, the driver always remains in control of the vehicle. Therefore, there are no changes concerning liability compared to the current situation. However, with the growth in "trusting technology" it needs to be ensured that end-users are aware that information provided inside the vehicle is for guidance purposes only, and that they should not solely rely on technology to decide for them, as they would still be liable for their decisions. For the automation of transport, the issue is different because with higher levels of automation, more decisions are taken by the control logic of the vehicles. Law and policy makers need to ensure that the current liability of drivers is changed: vehicle manufactures and providers of digital road infrastructure need to be included in the liability. Current discussions addresses this issue. Insurance companies (R18) will have to develop new products that account for the technological changes. Additionally, as already adopted by some manufacturers, data protection and cyber security must be incorporated in the technical design of future vehicles and the infrastructure. Manufacturers and ITS infrastructure providers would need to meet and

¹⁴ Such as 3G/4G, LTE, LTE-D, 5G, WAS / RLAN versions of IEEE802.11, IEEE802.11p/ETSI ITS G-5, Bluetooth, ZigBee, UWB CEN DSRC, DAB.

¹⁵ The C-Roads fact sheet is accessible at https://www.c-roads.eu/fileadmin/user_upload/media/Dokumente/c-roads-flyer_2.pdf

regularly update protection profiles to secure the vehicles and the ITS against cyber-attacks.

It needs to be identified whether every road is suited for automated driving and whether lane markings (e.g. for areas with regular snowfall), junction design and other physical road features need to be improved to ensure safety with higher levels of automated driving. Changes to the physical road infrastructure (e.g. junction design and road layout) (R20) will be required in some cases to unlock maximum benefits from connected driving and the automation of transport. For instance, there could be capacity and safety benefits at junctions where there is a mix of different modes (including slow modes); since automated vehicles are very sensitive to the surroundings, there might be a need to adjust designs which better demarcate the segregations between modes¹⁶. Findings from European Union research projects, such as FP7 CityMobil2, show that public transport vehicles are likely to be early adoptors of automated driving, which will require insignificant changes to the physical road infrastructure to ensure safe operations. Due to the long life-cycles of physical road infrastructure, these adjustments (R20) will have to be made over a long time period.

2.3 Action plan

Figure 7 **Error! Reference source not found.** presents the actions for Focus Area 1. In the following subsections, the action plan is explained in detail, layer by layer, using the numbers in parentheses when referring to specific boxes within the action plan.

¹⁶ As stated in ERTRAC's (2015) Automated Driving Roadmap: "... providing a simplified and logical environment that can support the vehicle to avoid situations of many stops (cross sections, pedestrians/bicycle crossings, etc...". Accessible under http://www.ertrac.org/uploads/documentsearch/id38/ERTRAC_Automated-Driving-2015.pdf

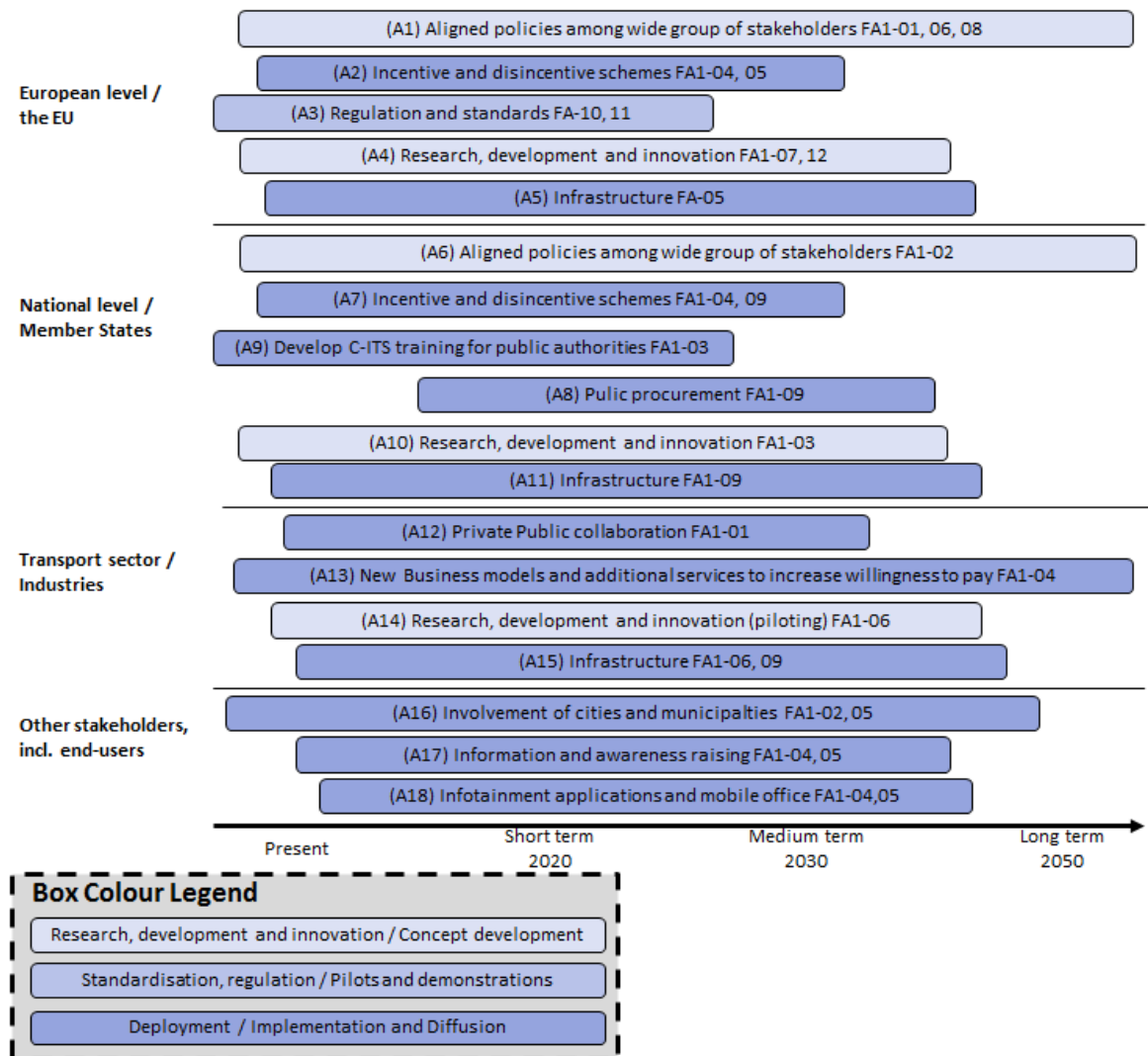


Figure 7. Focus Area 1 action plan.

List of actions:

European Union Level

- (A1) Aligned policies among wide group of stakeholders
- (A2) Incentive and disincentive schemes
- (A3) Regulation and standards
- (A4) Research, development and innovation at European Union level
- (A5) Infrastructure at European Union level (TEN-T and urban nodes)

National Level / Member States

- (A6) Aligned policies among wide group of stakeholders
- (A7) Incentive and disincentive schemes
- (A8) Public procurement
- (A9) Develop C-ITS training for public authorities
- (A10) Research, development and innovation at national level

- (A11) Infrastructure at Member State level (national infrastructure)

Transport Sector / Industries

- (A12) Private-Public collaboration
- (A13) New Business models and additional services to increase willingness to pay
- (A14) Research, development and innovation (piloting)
- (A15) Infrastructure (new business models)

Other Stakeholders, including End-users

- (A16) Involvement of cities and municipalities
- (A17) Information and awareness raising
- (A18) Infotainment applications and mobile office

2.3.1 European level

Stakeholders during the SINTRAS consultation days appreciated the coordination that has been achieved by the C-ITS and C-Roads Platforms, but still stated that there is currently limited **coordination between the different stakeholders (FA1 Action A1) in the value chain** for connected driving in the urban context. If this is not dealt with at these early stages, there is a danger that stakeholders develop proprietary technological solutions as mentioned in the C-ITS Roadmap of the European Commission¹⁷: *"some stakeholders have already developed proprietary technological solutions and established market positions, but these are often developed in a silo-like way, leading to fragmented and potentially incompatible solutions, which can hamper continuity and integration of services, in particular between technological ecosystems and across geographical borders. Introducing interoperability afterwards in already operational systems often proves to be very difficult and costly (for instance in the tolling sector)"*. The deployment mistakes occurred in the lorry tolling scenario (e.g. national silos between Germany's Toll Collect and Austria's ASFINAG toll operator; integrated only at a later stage as TOLL2GO) needs to be avoided by ensuring better cooperation in the value chain on EU level. Pilot projects such as the Rotterdam, Frankfurt/M. and Vienna C-ITS corridor have been able to foster cooperation between numerous Member States and the value chain across the European Union. More recently, the establishment of the C-Roads platform in order to harmonise C-ITS related deployments and interoperability across Europe has been a major step towards a better cooperation. Furthermore, stakeholders at the SINTRAS consultation days agreed that the C-ITS Platform activities should be continued and extended to a larger group of stakeholders.

Incentives (A2) for investing into connected vehicles and into digital road infrastructure need to be ensured. This can be fostered through the Connecting Europe Facility on the TEN-T network (e.g. the NordicWay corridor) and the C-Roads platform, and potentially by making C-ITS road side infrastructure a requirement for road infrastructure funded by structural and cohesion funds. These requirements would act as a disincentive against investments into conventional road infrastructure.

Until recently, the main connected driving activities have been focussed on research and innovation in an attempt to support technical development. Based on these pilots,

¹⁷ European Commission (2016, p.3). A Master Plan for the deployment of Interoperable Cooperative Intelligent Transport Systems in the EU. Retrieved from: http://ec.europa.eu/smart-regulation/roadmaps/docs/2016_move_040_cooperative_intelligent_transport_en.pdf

some Member States are currently further developing their own national solutions, which risks leading to inconsistency in the applicable **regulatory frameworks (A3)**, (in particular around issues such as liability, security, privacy, data protection and frequencies) if not properly coordinated as mentioned by the stakeholders at the SINTRAS consultations. This uncertainty is hampering large-scale investment from the private and public sectors to reach large-scale deployment of connected driving to achieve the full benefits. Regulations need to be general enough to handle many unique automated vehicle deployments simultaneously, spanning the multiple levels of automation and operating scenarios that may be introduced by various manufacturers. The C-ITS platform has identified the key issues that affect the harmonisation of regulatory frameworks for the deployment of C-ITS and the automation of transport. There was a general acceptance from the SINTRAS consultation day stakeholders that the C-ITS platform should be continued and extended, especially to include countries that have so far not been active in the platform.

Continued **research, development and innovation (A4)** need to be facilitated at EU-level to foster the development in the field of connected driving and automation of transport. This could be achieved through the continuation of the Horizon 2020 (H2020) Automated Road Transport (ART) and Mobility for Growth (MG) calls. Stakeholders from the SINTRAS consultation days highlighted that the operational role of public authorities (especially local authorities) and the transition phase need to be researched. This could be fostered through the CIVITAS action, which fosters the uptake of innovative transport measures in European cities.

C-ITS infrastructure (A5) including roadside units and off-road measures (back office central ITS centre) at the European level needs to be deployed as early as possible to reduce the hesitation end-users might have in purchasing connected and automated vehicles.

Off-road measures mainly compose of back office central ITS centres, which ideally should develop a C-ITS Reference¹⁸ and system architecture as a framework for future deployments. Particularly the reference architecture is established to guide future system architects and designers to develop technical C-ITS solutions that are sufficiently flexible and have the capability to support the permanently-evolving business and market models, while simultaneously being able to provide guidance in the creation of interoperable systems in different projects across the transport corridors in Europe. A system architecture the application of the C-ITS Reference architecture to a particular context. A suitable architecture needs to also consider the involved stakeholders at the European Union level and their respective roles.

Roadside units/infrastructure among many include beacons on gantries, such as Wireless Local Area Network (WLAN)-based radio devices¹⁹ which can receive data (from as smart traffic lights, vehicles, environmental condition detectors, traffic controls, and traffic centres) and transmit data to vehicles (V2X communication). These can be installed along transnational motorways, to enable services such as traffic ahead warning, road works warning, weather conditions, and in-vehicle data regarding speed limits and optimal speeds and others. The focus should be on the TEN-T core network and funding for cross-border corridor projects such as NordicWay

¹⁸ C-ITS system architectures can be developed based on the guidelines such as that developed by the Dutch C-ITS Reference architecture as cited in Passchier, I., van Sambeek, M., van den Broek, J., & Potters, P. (2016). The Dutch C-ITS Reference architecture. *Proceedings of the 11th ITS European Congress, Glasgow, Scotland*

¹⁹ An example of a cooperative road-side unit is the technology of Siemens which is being used for the Rotterdam, Frankfurt/M., and Vienna C-ITS corridor project <https://www.mobility.siemens.com/mobility/global/en/urban-mobility/road-solutions/trends-in-urban-traffic-technology/vehicle2x/pages/vehicle2x.aspx>

should be continued. During the consultation day, stakeholders mentioned that future corridor projects should also include the related urban nodes.

2.3.2 National level

Member States stakeholders (A6) need to have an active role and continue their discussion for the harmonisation of C-ITS across Europe through the C-Roads Platform in ensuring interoperability between their regulatory and policy frameworks for systems that are developed for connected driving. Among several issues, the different regulations and policy frameworks for the use of in-vehicle data in different Member States poses a threat to interoperability. On the other hand, it is important to ensure that Member States, especially those without an automobile industry or ITS sector, are not left behind in the deployment of connected driving infrastructure. Hence, continual active participation of all Member States in the C-ITS Platform and C-Roads Platform is highly encouraged.

Member States should approach the topic of connected driving and automation of transport as a horizontal topic that affects many different government activities and layers, such as the coordination between different highway authorities. Targeted **incentive systems (A7)** need to be developed in order to foster the deployment of connected driving and automation of transport. Particularly, vehicle taxation schemes and rebates could be adapted to foster the uptake of connected vehicles or retrofits for both purchasers and dealers of automated/connected vehicles. Other incentives could also include prioritised or free parking or access to bus or tram lanes.

The H2020 CIMEC project²⁰ provides an overview (based on results from an online survey with 57 responses from European local authorities) of the main barriers towards the take-up of connected driving in urban areas. 57% of the respondents state “not sufficient personnel with ITS /C-ITS competence” as a reason for not working on a connected driving strategy. This lack of understanding echoes throughout many public entities in many Member States. **Capacity building should therefore be organised for public authorities (A9)** to mainstream the topic across many organisations. As the H2020 CIMEC project identified, capacity building is particularly required for European local authorities. This could be fostered through continued research and innovation projects in the European Union research framework programme. Furthermore, it was mentioned by SINTRAS consultation day stakeholders that cooperation between different layers (i.e. local authorities and highways authorities) should be fostered and their staff should be enabled to do so through appropriate training. Another important leverage factor can be **public procurement (A8)** contracts that foster the update of connected driving and automation of transport, e.g. through the procurement of local authority fleets. This is particularly relevant in the context public transport (e.g. automated buses) where C-ITS and automation can result in significant cost savings.

With continued **research and innovation projects (A10)**, Member States can stimulate the wider deployment of connected driving and automation of transport. There are especially many operational issues that need to be resolved. For example, national strategies need to be developed for operational stakeholders responsible for the enhanced traffic management that will be required for connected driving. Roles and responsibilities between road authorities, service providers, vehicle manufactures and physical infrastructure stakeholder groups need to be agreed at an operational level through multi-level stakeholder lighthouse projects. This interaction between the different stakeholders will facilitate the **deployment of C-ITS roadside infrastructure** along national corridors and urban nodes and the establishment of a

²⁰ <http://cimec-project.eu/>

C-ITS system architecture (A11) as a framework for the deployment and implementation of C-ITS. On a national level, the development of a C-ITS system architecture depends on (1) the ITS applications that are intended to be implemented, (2) the existing legacy system of transport infrastructure, and (3) constraints with regards to money, time and business models. At the same time, a suitable architecture has to take into account the involved stakeholders and their respective roles and to which particular function with which they would be connected. In addition to the beacons on gantries, the installation of smart traffic lights, environmental condition detectors, traffic controls, and traffic centres able to communicate with connected vehicles falls within the Member State/national level scope. The services that would be enabled include: mostly day 1 services (traffic ahead warning, road works warning, weather conditions, and in-vehicle data regarding speed limits and optimal speeds and others, signal violation, traffic signal information, green light speed advisory, shockwave damping – depending on the number of connected vehicles present) and some of the day 1.5 services (traffic information and smart routing, and coordinated traffic lights depending on the road traffic conditions). Investment decisions need to be adjusted to the lifecycle of the road infrastructure to ensure the deployment of C-ITS-ready road infrastructure.

2.3.3 Transport sector

Private and public sector collaboration (A12) is key to addressing most of the issues related to the deployment of connected driving and automation of transport. The launching of C-Roads platform has been able to tackle this by providing a platform where Member States, road operators, and the industry have jointly agreed upon a shared vision to start full-scale deployment of C-ITS in 2019. To do this, the C-Roads platform has identified a set of objectives²¹ to harmonise the deployment of C-ITS across Europe, as well as conduct pilot implementation, demonstrations of C-ITS deployment and advance to large-scale deployments. Moreover, concerted action and synchronisation of investments is therefore required. Stakeholders during the SINTRAS consultations days strongly advised that the public sector needs to take ownership of some key issues like data security and sharing among numerous stakeholders in the deployment of C-ITS.

New business models and additional services and applications (A13) need to be developed that foster the uptake of connected driving. Stakeholders from the SINTRAS consultation days identified the freight sector as early adopter of the technology. Business models (e.g. higher willingness to pay for C-ITS applications) that are developed for the freight sector could then be transferred to the passenger vehicle market in the future. These can be tested through national **innovation pilots (A14)** that also pilot new approaches/business models for **C-ITS infrastructure (A15)**, both roadside units as well as off-road/off-site measures such as a C-ITS system architecture.

2.3.4 Other stakeholders

Deployment of connected driving and automation of transport in cities is comparatively more complex than along inter-city corridors. Cities also tend to be strongly policy-driven and risk-averse when it comes to new technologies. Besides, a growing number of cities want to reduce the absolute number of cars – not simply make them smarter. **Cities (A16)** need to be involved early on to ensure that problems they face (e.g. shortage of capacity and expertise) are addressed in good time. Several European Union projects (e.g. CARTRE, CAPITAL, L3Pilot, AUTOPILOT,

²¹ <https://www.c-roads.eu/platform/objectives.html>

etc.) are currently addressing the topic of automation in order to facilitate pilot projects and encourage deployment and uptake of C-ITS across Europe.

Many benefits from connected driving will only materialise once penetration rates of connected vehicles have reached a level of approximately 30%. This is a long time to justify investment in connected vehicle functionalities for first movers. It is likely that many end-users will purchase connected vehicles only after a specific penetration has been reached. **Information campaigns, awareness raising (A17), infotainment applications (A18)** and mobile office functionalities could facilitate the earlier adoption by end-users. The C-ITS Platform could be extended with a work package that focuses on the end-user requirements and extends the involvement and increases the participation of a number of non-industry stakeholders (e.g. car associations and associations representing other modes such as cyclists or pedestrians).

2.4 Cost-benefit analysis

The cost-benefit analysis (CBA) conducted in this section is mainly based on the interview results of the SINTRAS stakeholder consultation days, stakeholder surveys and the findings from the C-ITS Platform phases 1 and 2, which were developed on the basis of a more comprehensive stakeholder engagement process²². The results of the analysis have been validated through a further extensive stakeholder survey.

The cost-benefit analysis illustrated in the Table below **Error! Reference source not found.** shows that, overall, no Focus Area 1-related actions have been identified with a low benefit. Most actions have a moderate to high benefit to cost ratio. This is in line with the findings of the C-ITS Platform's cost-benefit analysis²³ regarding the deployment of C-ITS. The proposed actions would build upon the strong interest in enabling a fast move at the European scale to support and enhance market production and early deployment.

All actions that facilitate the development of a common vision for the deployment of C-ITS are classified as 'high benefit' and 'low cost' because they mainly focus on the involvement of stakeholders and their encouragement to actively support the deployment of C-ITS. This reflects very well the general perception of the interviewed stakeholders as well as the discussions during the stakeholder consultation days. Generally speaking, stakeholders were of the opinion that the necessary technologies are already there but the public sector needs to take a stronger responsibility to develop a common vision in conjunction with the private sector. The role of local authorities especially needs to be fostered through capacity building as most European local authorities do not have the technical knowledge to deploy C-ITS roadside infrastructure (e.g. beacons on gantries, environmental conditions detectors, smart traffic lights, smart traffic controls, etc.) on their network and to manage the overall C-ITS system architecture. 'Low cost' actions that support cities such as CIVITAS could foster 'high benefits'.

Thus, most costs have to do either with time components (actions can be completed in the medium term or need sustained persistence to make them work) or the objective (what to do is not always entirely clear and needs work to clarify). This is, for instance, the case with those actions that deal with regulations and standards (A3) or

²² Refer to Table 1 and Table 2 in Chapter 1 for the elaboration of the guidelines on assessing the costs and benefits for each action

²³ As mentioned in the C-ITS Platform: "With alerts generated from the increased information available, these systems have a strong potential to improve road safety and the efficiency of the road transport. Because of these expected benefits and considering the overall relatively moderated costs linked to deployment, there is a strong interest in enabling fast moves at the European scale that will translate into market production and early deployment."

new business models (A13). There is a high time-related cost in identifying the most suitable approaches.

Table 4. Summary table on costs and benefits of Focus Area 1 actions.

Benefit	High	A9 Capacity Building, A8 Public Procurement, A7 Incentives at MS level,	A1 Stakeholder coordination at EU level, A3 Regulations and standards A4 Research, Development, & Innovation (RDI) at EU level, A10 RDI at MS level A12 Private-Public collaboration, A16 Involvement of Cities and Municipalities	A18 Infotainment applications, A14 Innovation pilots
	Medium	A2 Incentives at EU level, A17 Info & awareness campaigns, A6 Member State stakeholders have an active role, A5 C-ITS infrastructure deployment at EU level, A11 C-ITS infrastructure deployment at MS level	A13 New business models A15 New approaches for C-ITS infrastructure deployment	
	Low			
		Low	Medium	High
Cost				

The categorisation into the various cost and benefit groups is primarily based upon the feedback received during the five SINTRAS stakeholder consultation days, the stakeholder interviews and the stakeholder surveys. In addition, strong signals from the literature – especially if it contained stakeholder-validated conclusions – was consulted for this purpose. Special mention is deserved by some selected types of actions as follows:

Actions A1, A9, A12, and A17 fall into a group of actions which were mentioned repeatedly by the attendees of the SINTRAS stakeholder consultation days as (very) desirable due to their assumed high or good effectiveness. They were therefore classified in the high or medium benefit categories. These actions have less to do with technological innovations per se or with direct subsidies but rather with “softer” aspects like human knowledge, skills and awareness and with an improved coordination of goals and actions among various actors. Related signals about usefulness of such actions by the stakeholders consulted during the SINTRAS study were near unanimous.

For A2 and A7, categorised as the role of incentives, both at the MS level and the EU level, were discussed intensively during the SINTRAS stakeholder consultation days. The near-consensus position that the former are even more effective than the latter is reflected in the corresponding benefit categorisation.

The action A3, A6, A8, and A16 (governance, regulations and standards) were put into the high-benefit category in response to clear statements of the stakeholders that were consulted during the SINTRAS study regarding the importance of actions the public stakeholders have to take to facilitate the deployment of C-ITS across the EU, national, and local levels.

The last categorisation is the actions requiring research, innovation, and technology. Included in this category are actions A4, A5, A10, A11, A13, A14, A15, and A18. As these actions are mostly intertwined, none of them can alone be categorised as having low costs but high benefits. As research is time costly, it falls within the medium cost but high benefits. Innovation pilots on the other hand require high investments both in time and monetary values, but with subsequent high benefits. As mentioned in the C-ITS Platform, the costs for the deployment of infrastructure to support C-ITS is relatively low in comparison with the total cost, thus is placed at low cost; however, infrastructure on its own cannot provide much benefit and hence is placed as medium benefits.

2.5 Prioritisation

Amongst the actions described above, the highest priority should be given to those which offer an attractive benefit-to-cost ratio (in particular, those which impact the entire European transport system) and which are urgent or will yield results in the relatively short term. Urgent actions are especially important if they will unlock a series of positive changes. Short term results are important as they will quickly demonstrate that the efforts to transform the European transport system are paying off. This will help to build momentum and continued support for change.

Second priority should go to actions which still offer an attractive benefit-to cost ratio but which will yield results in the medium to long term. These actions are important because they yield valuable results; but, as they need to persist for some time before the results become visible, they will be less effective in building momentum and support.

The third priority actions are those which yield less attractive benefit-to-cost ratios. For example, the benefit of such actions, while still substantial, may be limited to an individual issue or a narrow group of stakeholders. The results of such actions,

whether short- or long-term, will have less impact on the functioning of the European transport system as a whole.

Based on the discussions of timing and cost-benefit in the previous sections and the views of stakeholders expressed in an online survey, we propose the following prioritisation of actions. Within each group, we list actions in decreasing order of priority:

Table 5. Action prioritisation

Priority 1: Attractive benefit-to cost ratio and urgent or short term results	
A9	Capacity Building
A8	Public Procurement
A1	Stakeholder coordination at the European Union level
A16	Involvement of Cities and Municipalities
A7	Incentives at Member State level
A18	Infotainment applications
A17	Information and awareness campaigns
A12	Private-Public collaboration
Priority 2: Attractive benefit-to-cost ratio and medium- to long-term results	
A3	Regulations and standards
A4	Research, Development, & Innovation (RDI) at the European Union level
A10	RDI at Member State level
A14	Innovation pilots
A2	Incentives at the European Union level
A6	Member State stakeholders have an active role
A5	C-ITS infrastructure deployment at the European Union level
A11	C-ITS infrastructure deployment at the Member State level
Priority 3: Less attractive benefit-to-cost ratio	
A13	New business models
A15	New approaches for C-ITS infrastructure deployment

2.6 Key performance indicators

To measure impacts of the Focus Area 1 actions, key performance indicators (KPIs) along the four impact pathway steps are shown in Table 6 ²⁴.

²⁴ See elaboration of assessment framework for monitoring and evaluation in Chapter 1, Figure 4

Table 6. Focus Area 1 key performance indicators.

Effort-KPIs	Action-KPIs	Outcome-KPIs	Impact-KPIs
(A1) Resources allocated for the second phase of the C-ITS platform and C-Roads platform [person months/year, €/year]	(A1) Comprehensiveness of concept development [number of stakeholders supporting the concept]	(A1) Number of newly added Member States in the C-Roads platform [number]	(A1) Strength of common vision among EU stakeholders [number of stakeholder]
(A2) Resources allocated for CEF [€/year]	(A2) Number of C-ITS CEF projects [number]	(A2) Resulting leverage investment in C-ITS [€/year]	(A2) Number of connected vehicles and C-ITS roadside infrastructure [modal share of connected vehicles and kms of C-ITS supported roads]
(A3) Resources allocated for the second phase of the C-ITS platform and C-Roads platform [person months/year, €/year]	(A3) Comprehensiveness of concept development [number of stakeholders supporting the concept]	(A3) Number of new or revised regulations and standards supporting C-ITS deployment [number]	(A3) Strengths of common vision among EU stakeholders [number of stakeholders supporting]
(A4) Resources allocated for H2020 research and innovation projects [person months/year, €/year]	(A4) Calls for H2020 actions [number of calls]	(A4) Successful projects [number of successful projects]	(A4) Uptake of H2020 findings [number of patents]
(A5) Resources allocated for CEF [€/year]	(A5) Number C-ITS CEF projects [number of CEF projects]	(A5) Resulting leverage investment in C-ITS [€/year investment]	(A5) Number of connected vehicles and C-ITS roadside infrastructure [modal share of connected vehicles and kms of C-ITS supported roads]
(A6) Resources allocated for the second phase of the C-ITS platform and C-Roads platform [person months/year, €/year]	(A6) Wider representation of MS in C-Roads platform [number of MS in C-Roads platform]	(A6) Number of MS actively participating in C-ITS platform [number of MS in C-ITS platform]	(A6) EU-wide deployment of C-ITS and automation of transport [number of MS actively deploying C-ITS]
(A7) Adapt national regulation to foster investment in C-ITS [number of national regulations]	(A7) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A7) Penetration rate of connected vehicles [modal share of connected vehicles and kms of C-ITS supported roads]	(A7) Efficiency parameters of the transport network [safety performance; level of congestion]
(A8) Number of connected vehicles through public procurement [number of vehicles procured]	(A8) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A8) Penetration rate of connected vehicles [modal share of connected vehicles]	(A8) Distance from critical mass / tipping point of minimum penetration rate for C-ITS [modal share of connected vehicles]

(A9) Resources allocated for capacity building of local authorities [person months/year, €/year]	(A9) Competence level of local public officers [number of local public officers trained]	(A9) Penetration rate of connected vehicles [modal share of connected vehicles]	(A9) Improved urban transport network [kms of C-ITS supported roads]
(A10) Resources allocated for multi-stakeholder lighthouse projects [person months/year, €/year]	(A10) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A10) Penetration rate of connected vehicles [modal share of connected vehicles]	(A10) Size and quality of pool of best practice examples for other C-ITS projects [number of best practice examples]
(A11) Resources allocated for C-ITS roadside infrastructure [person months/year, €/year]	(A11) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A11) Kilometres of C-ITS ready road infrastructure [kms of C-ITS supported roads]	(A11) Willingness to purchase connected vehicles [number of vehicles purchased]
(A12) Funds allocated to support private / public collaborations [person months/year, €/year]	(A12) Number and intensity of private / public collaborations [number of collaborations]	(A12) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A12) More active role of private sector [number of private companies involved]
(A13) Raise interest of end-user to pay for C-ITS services [number of end-users paying for C-ITS services]	(A13) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A13) Penetration rate of connected vehicles [modal share of connected vehicles]	(A13) Increased willingness to purchase connected vehicles [number of vehicles purchased]
(A14) Resources allocated to innovation pilots [person months/year, €/year]	(A14) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A14) Penetration rate of connected vehicles [modal share of connected vehicles]	(A14) Size and quality of pool of best practice examples for other C-ITS projects [number of best practice examples]
(A15) Resources allocated to support industry investments [person months/year, €/year]	(A15) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A15) Kilometres of C-ITS ready road infrastructure [kms of C-ITS supported roads]	(A15) Increased willingness to purchase connected vehicles [number of purchased vehicles]
(A16) Resources allocated for capacity building of local authorities [person months/year, €/year]	(A16) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A16) Penetration rate of connected vehicles [modal share of connected vehicles]	(A16) Improved urban transport network [kms of C-ITS supported roads]

(A17) Resources allocated to inform end-users [person months/year, €/year]	(A17) Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]	(A17) Penetration rate of connected vehicles [modal share of connected vehicles]	(A17) Increased willingness to purchase connected vehicles [number of purchased vehicles]
(A18) Resources allocated for C-ITS working group on end-users [person months/year, €/year]	(A18) Deployment rate of C-ITS in urban areas [modal share of connected vehicles and kms of C-ITS supported roads in urban areas]	(A18) Penetration rate of connected vehicles [modal share of connected vehicles]	(A18) Increased willingness to purchase connected vehicles [number of purchased vehicles]

In the following we list all KPIs per action:

European Union Level

- (A1) Aligned policies among wide group of stakeholders
 - Resources allocated for the second phase of the C-ITS platform and the C-Roads platform [person months/year, €/year]
 - Comprehensiveness of concept development [number of stakeholder supporting the concept]
 - Number of newly-added Member States in the C-Roads platform [number]
 - Strength of common vision among European Union stakeholders [number of stakeholders]
- (A2) Incentive and disincentive schemes
 - Resources allocated for CEF [€/year]
 - Number C-ITS CEF projects [number]
 - Resulting leverage investment in C-ITS [€/year]
 - Number of connected vehicles and C-ITS roadside infrastructure [modal share of connected vehicles and kms of C-ITS supported roads]
- (A3) Regulation and standards
 - Resources allocated for the second phase of the C-ITS platform and the C-Roads platform [person months/year, €/year]
 - Comprehensiveness of concept development [number of stakeholders supporting the concept]
 - Number of new or revised regulations and standards supporting C-ITS deployment [number]
 - Strengths of common vision among European Union stakeholders [number of stakeholders supporting]
- (A4) Research, development and innovation at the EU level
 - Resources allocated for H2020 research and innovation projects [person months/year, €/year]
 - Calls for H2020 actions [number of stakeholders supporting [number of calls]

- Successful projects [number of successful projects]
- Uptake of H2020 findings [number of patents]
- (A5) Infrastructure at the European Union level (TEN-T and urban nodes)
 - Resources allocated for CEF [€/year]
 - Number C-ITS CEF projects [number CEF projects]
 - Resulting leverage investment in C-ITS [€/year investment]
 - Number of connected vehicles and C-ITS roadside infrastructure [modal share of connected vehicles and kms of C-ITS supported roads]

National Level / Member States

- (A6) Aligned policies among a wide group of stakeholders
 - Resources allocated for the second phase of the C-ITS platform and C-Roads platform [person months/year, €/year]
 - Wider representation of Member States in C-Roads platform [number of MS in C-Roads platform]
 - Number of Member States actively participating in C-ITS platform [number of Member States in C-ITS platform]
 - European Union-wide deployment of C-ITS and automation of transport [number of Member States actively deploying C-ITS]
- (A7) Incentive and disincentive schemes
 - Adapt national regulation to foster investment in C-ITS [number of national regulations]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - Penetration rate of connected vehicles [modal share of connected vehicles and kms of C-ITS supported roads]
 - Efficiency parameters of the transport network [safety performance; level of congestion]
- (A8) Public procurement
 - Number of connected vehicles through public procurement [number of vehicles procured]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - Penetration rate of connected vehicles [modal share of connected vehicles]
 - Distance from critical mass / tipping point of minimum penetration rate for C-ITS [modal share of connected vehicles]
- (A9) Develop C-ITS training for public authorities
 - Resources allocated for for capacity building of local authorities [person months/year, €/year]
 - Competence level of local public officers [number of local public officers trained]

- Penetration rate of connected vehicles [modal share of connected vehicles]
- Improved urban transport network [kms of C-ITS supported roads]
- (A10) Research, development and innovation at national level
 - Resources allocated for multi-stakeholder lighthouse projects [person months/year, €/year]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - Penetration rate of connected vehicles [modal share of connected vehicles]
 - Size and quality of pool of best practice examples for other C-ITS projects [number of best practice examples]
- (A11) Infrastructure at the Member State level (national infrastructure)
 - Resources allocated for C-ITS roadside infrastructure [person months/year, €/year]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - Kilometres of C-ITS ready road infrastructure [kms of C-ITS supported roads]
 - Willingness to purchase connected vehicles [number of vehicles purchased]

Transport Sector / Industries

- (A12) Private Public collaboration
 - Funds allocated to support private / public collaborations [person months/year, €/year]
 - Number and intensity of private / public collaborations [number of collaborations]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - More active role of private sector [number of private companies involved]
- (A13) New Business models and additional services to increase willingness to pay
 - Raise interest of end-user to pay for C-ITS services [number of end-users paying for C-ITS services]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - Penetration rate of connected vehicles [modal share of connected vehicles]
 - Increased willingness to purchase connected vehicles [number of vehicles purchased]
- (A14) Research, development and innovation (piloting)
 - Resources allocated to innovation pilots [person months/year, €/year]

- Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
- Penetration rate of connected vehicles [modal share of connected vehicles]
- Size and quality of pool of best practice examples for other C-ITS projects [number of best practice examples]
- (A15) Infrastructure (new business models)
 - Resources allocated to support industry investments [person months/year, €/year]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - Kilometres of C-ITS ready road infrastructure [kms of C-ITS supported roads]
 - Increased willingness to purchase connected vehicles [number of purchased vehicles]

Other Stakeholders, incl. End-users

- (A16) Involvement of cities and municipalities
 - Resources allocated for capacity building of local authorities [person months/year, €/year]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - Penetration rate of connected vehicle [modal share of connected vehicles]
 - Improved urban transport network [kms of C-ITS supported roads]
- (A17) Information and awareness raising
 - Resources allocated to inform end-users [PM,€]
 - Deployment rate of C-ITS [modal share of connected vehicles and kms of C-ITS supported roads]
 - Penetration rate of connected vehicles [modal share of connected vehicles]
 - Increased willingness to purchase connected vehicles [number of purchased vehicles]
- (A18) Infotainment applications and mobile office
 - Resources allocated for C-ITS working group on end-users [person months/year, €/year]
 - Deployment rate of C-ITS in urban areas [modal share of connected vehicles and kms of C-ITS supported roads in urban areas]
 - Penetration rate of connected vehicles [modal share of connected vehicles]
 - Increased willingness to purchase connected vehicles [number of purchased vehicles]

3 Focus Area 2. Transformation of infrastructure to address connectivity, resilience, new fuels and energy efficiency

3.1 Overview

In the SINTRAS study, Focus Area 2 “Transformation of infrastructure” has been defined as follows:

The transport infrastructure is fundamental for the mobility of people and goods, which in turn facilitates economic growth, competitiveness and territorial cohesion of Europe. However, transport infrastructure is faced with challenges including ageing, growing mobility needs, enhancing resilience against climate change and extreme weather events, reducing the impact on the environment or increasing energy efficiency among others.

Thus, transport infrastructure should be transformed introducing innovation and new technologies in terms of construction procedures and materials, upgrading and maintenance techniques or integration of intelligent transport systems in order to better address the following goals: a) connectivity (considered from the perspective of intermodality, interoperability and accessibility), b) resilience to the impact of climate change, c) new fuels and the provision of alternative fuel infrastructure, and d) energy efficiency.

The barriers identified for Focus Area 2 (FA2) early in the SINTRAS project are:

- Barrier FA2-01-Funding gap in the development or improvement of transport infrastructure: The scarcity of and decreasing public resources at the national level means that European Union transport infrastructure funding is subject to higher competition. Moreover, the difficulties to attract complementary sources of resources require further development of innovative funding instruments. Private sector funding is still difficult as long as the business and risk sharing models are still considered ill-defined and unattractive. Root causes have been identified as slow economic growth in the European Union during recent years leading to austerity of public investments in transport infrastructure, insufficient private funding sources, a shortage of innovative financing instruments for transport infrastructure, and a lack of a business model for services and infrastructures.
- Barrier FA2-02-Risk-averse policies: In Member States, transport infrastructure policies do not provide sufficient support to the development and deployment of innovation and new technologies. Policy support on this issue is rather risk averse so far, as long as infrastructure assets have a very relevant impact on safety and security aspects for users, economic activities, etc. As innovation in transport infrastructure is highly capital intensive, it is a risky activity in many cases. The decision-making situation to adopt new technologies or innovation into transport infrastructures is complex as far as it involves high levels of investment and uncertainty.
- Barrier FA2-03-Challenges to incorporate new technologies and innovation into already existing infrastructure networks: To cope with the increasing mobility demand and current requirements, these infrastructures have to face continuous upgrading, refurbishing, strengthening and transformation

processes along the time. However, the integration process of new technologies or innovation is more complex if they have to be embedded in an already existing and well-established infrastructure network, designed according to other past parameters. The root causes are twofold: long trajectory of infrastructure investment in Europe and legacy of existing ageing infrastructure.

- Barrier FA2-04-Timing of the standardisation process: Right timing of standardisation is an important issue; standards should not come too early, but neither too late. Early adopters may find themselves in a situation where the system has to be updated completely after the publication of the standards. Standards are typically applied on voluntary basis. Distinguishing between standards and political enforcing of standards is considered important.
- Barrier FA2-05-Large number of agents implied with different priorities and visions (Fragmentation): Although Member States are still in charge of the infrastructure design and deployment, other authorities connected to different links of the value chain and different modes of transport are also relevant actors when working towards an interoperable, multi-modal and accessible transport system. The large number of agents are characterised by a general low level of collaboration across administrative levels (different roles) and transport modes, and of incentives, and weaknesses in real coordination and joint decision-making. They do not give the same relevance to the adoption of innovation or new technologies into the process or even have the same priorities.
- Barrier FA2-06-Policies at national level have insufficient transnational and network vision and specialisation of transport modes in terms of regulatory frameworks and management systems: Different regulatory frameworks, management systems and standards for each transport mode and each country are normally strongly embedded in the national system and context, becoming a barrier for the integration of European transport system, in general, and for interoperability and multimodality, in particular. National regulations and standards can be mutually incompatible or too well established to be changed. There is no binding framework implemented by the EC regarding the trans-European transport network regulation, so the EC can only give recommendations and ask MS make their best efforts to achieve the goals set at a European level.
- Barrier FA2-07-Slow and patchy ERTMS deployment across Europe: ERTMS is a unique European train control system designed to gradually replace the existing incompatible systems Europe-wide, aiming at making rail transport interoperable cross-countries, safer and more competitive. Despite ERTMS being embraced by all the Member States and the Fourth Railway Package, implementation has not progressed as planned in all countries.
- Barrier FA2-08-Information gap and uncertainties on climate behaviour: There is a need for climate change information specifically tailored to the transport infrastructure sector. The available information does not always provide the level of detail needed by each stakeholder involved in infrastructure management, operation or construction to understand their own risks and to adopt appropriate responses. Additionally, uncertainty about the way the climate system behaves makes it increasingly difficult to model climate change

at the regional level, assess impact on infrastructure and make accountable cost-benefit analysis that demonstrate the advantages (at social and economic level) of acting ahead of time.

- Barrier FA2-09-Limited demand of new fuels and lack of innovative business models: Attending to demand-supply criteria, the deployment of distribution infrastructure for new fuels could not be justified from the economic perspective due to the limited number of vehicles using them. The deployment of vehicles is also hampered by the poor alternative fuels infrastructure. The development of innovative business models (private-public partnerships, etc.) could support the development.

3.2 Projected developments

The following graph presents the projected developments in Focus Area 2, distinguishing the present state, short, medium and long term (Figure 8 **Error! Reference source not found.**). This graph will be further explained in the sections which follow.

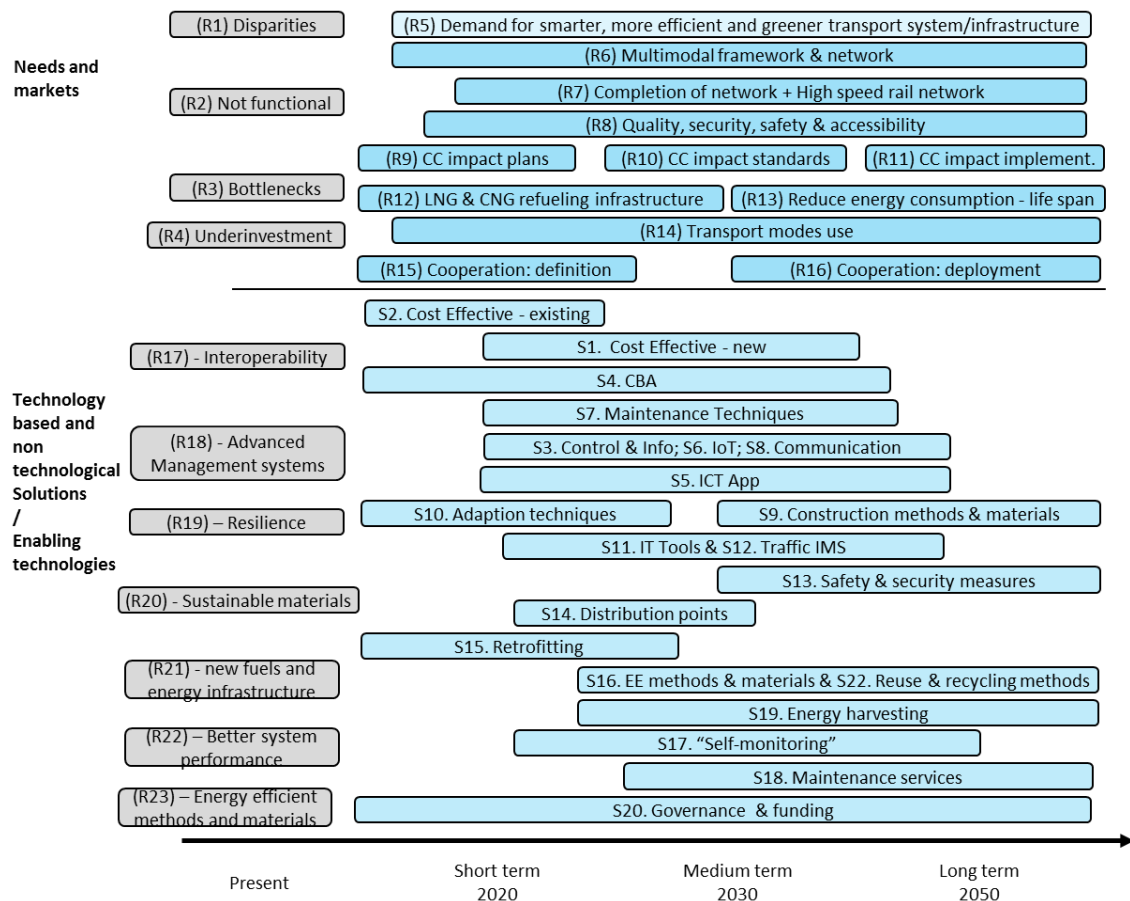


Figure 8. Projected developments in Focus Area 2.

3.2.1 Needs and markets

The European transport infrastructure network is one of the densest and most developed in the world. Most of the European transport infrastructure was constructed

in the 1960s and 1970s with a designed working life of 50 years. It is now reaching the end of the service time and is often used far beyond intended capacity in terms of traffic flows and loads. Existing infrastructures no longer fulfil current functional requirements or today's safety and quality standards (R2)²⁵.

Economic growth and international trade are the major drivers for increased freight and passenger flows that will determine future transport infrastructure needs. The current transport infrastructure does not cope well with the expected conditions related to the growth of mobility demand, new challenges related to climate change mitigation, cross-modal requirements and needs for sustainability and energy efficiency. All these trends lead to a growing demand for smarter, more efficient and greener transport infrastructure (R5). At the same time, investments in transport infrastructure are at an exceptionally low level in Europe²⁶ (R4).

There are also noticeable disparities between EU28 countries in terms of infrastructure provision and quality in all transport modes (R1). The European transport network still has bottlenecks and missing links in cross-border sections (R3) despite the notable progress made with TEN-T. Multi-modal platforms also need important further development (R7). Physical infrastructure alone is however not enough to achieve interconnected network that can support highly efficient traffic flows. To optimise traffic flows, the use of a safe and efficient combination of transport modes (or multimodality) is needed. By 2020, the objective is to establish the framework for a European multi-modal transport information, management and payment system, both for passengers and freight (R6, R8).

Adapting transport infrastructure to climate change (R9, R10, R11) needs to be considered in two respects. First, when constructing new infrastructure, climate resilience can be ensured by locating, designing and operating an asset with the current and future climate in mind. This is particularly important in the case of transport infrastructure. This usually has a lifespan of at least 20 years and investment decisions therefore influence future generations' wellbeing. Secondly, existing infrastructure can be made more climate-resilient by retrofitting and/or ensuring that maintenance regimes incorporate resilience to the impacts of climate change over an asset's lifetime²⁷. The impact of measures towards adapting transport infrastructure to climate change will take place in the medium and long-term. The different transport modes of rail, road, water and air, are subject to climatic pressures and to corresponding adaptation policies. The adaptation not only involves the infrastructure but also the distribution of transportation and traffic flows between different geographic areas and between transport modes, digitisation of transport between others. Moreover, different transport modes also have their own timings and delays.

The market introduction of new fuels (R12)²⁸ requires modified or new recharging and refuelling points, network infrastructure and common technical specifications. The lack of alternative fuel infrastructure and common technical specifications for the vehicle-infrastructure interface are considered as major obstacles to the market introduction of alternative fuels. The Directive on the deployment of alternative fuels infrastructure

²⁵ Codes such as R and A provide cross-references to project developments (R) and proposed actions (A), defined in sections 3.2 and 3.3 respectively

²⁶ International Transport Forum at the OECD (2015) Statistics in brief: Infrastructure investments.

²⁷ Adapting infrastructure to climate change, Commission Staff Working Document, accompanying document for "An EU Strategy on Adaptation to Climate Change"

²⁸ Infrastructure for Alternative Fuels, report on European Expert Group on Alternative Fuels (2011) http://ec.europa.eu/transport/themes/urban/cts/doc/ftf_eg_report_201112.pdf

established in 2014²⁹ mandates the planning of alternative refuelling points across Europe with common standards for their design and use³⁰.

Energy efficiency in transport is directly or indirectly affected by several interconnected factors. These domains, and others, correspond to energy efficiency: improvement of vehicles, the market transformation rate, i.e. the replacement speed of old vehicles with new more efficient ones, the way the vehicles are used, the shift of persons and goods from individual vehicles to collective ones, etc. According with the scope of FA2, the most important aspects to be highlighted are: 1) shift in demand trends and shares of different transport modes (R14), and 2) reduction of energy consumption of infrastructures throughout their lifespan (R13).

All these mentioned needs involve technological challenges, near-market innovation related challenges and coordination and support action aiming towards improved governance of the infrastructure (R15, R16)³¹. The following sections will show how these challenges are turned into actions.

3.2.2 Technology-based solutions, non-technological solutions and enabling technologies

The SINTRAS work has clearly shown that the main barriers preventing advancement towards single and innovative transport system are not necessarily technological by nature. Technology and solutions exist but they are not necessarily deployed as shown by the barrier analysis. An overview of technological challenges and solutions is briefly given below in the (partially overlapping) fields of connectivity, resilience, new fuels and energy efficiency.

Connectivity in the European transport infrastructure (R17) still shows large margins of improvement before achieving a fully integrated transport system. The main barrier hampering the future development is the lack of interoperable solutions implemented across Member States affecting the continuity of long-distance or cross-border flows. The technology challenges, in which technology can provide a solution, include missing cross-border connections, development of multi-modal passenger and freight hubs, optimising the infrastructure capacity and minimising congestion, and improving safety, security and environmental performance of the infrastructure. Connectivity also relies on intelligent transport systems (ITS) as an enabling technology to achieve the deployment of smart infrastructures (R18). ITS solutions will let the network implement advanced and integrated information management systems and travel process management systems. Some of the key technological solutions expected to be developed in the following decades to face the connectivity challenge are:

- From the perspective of intermodality, interoperability and accessibility:
 - S1. Cost-effective and environmentally-friendly design, planning, and construction methods of new infrastructure
 - S2. Cost-effective and environmentally-friendly upgrading and maintenance techniques of existing infrastructure
 - S3. Control and information systems that support infrastructure in its proper and integrated operation

²⁹ COM(2013) 18 final: directive of the European Parliament and of the Council on the deployment of alternative fuels infrastructure.

³⁰ Electricity supply for transport: ensure recharging points accessible to the public at least on the TEN-T Core Network in urban/suburban agglomerations and other densely populated areas by 31 December 2025.

³¹ Most relevant transport infrastructure related topics were collected from Horizon 2020, Work Programme 2014-2015, 2016-2017 in the fields of Smart, Green and Integrated Transport; Secure, Clean and Efficient Energy.

- S4. Enhanced cost-benefit approaches/analysis methods providing more accurate estimates along the infrastructure life-cycle
- From the perspective of SMART Infrastructure:
 - S5. ICT applications (e.g. ITS embedded in and incorporated to infrastructure, infrastructure sensors)
 - S6. Internet of Things (IoT) technologies (e.g. vehicle to infrastructure connectivity)
 - S7. Optimised maintenance plans and conservation actions based on accurate data. New techniques for maintenance and upgrading, such as predictive techniques, early damage detection, advanced system for survey, satellite system for infrastructure health monitoring, autonomous inspection and testing, amongst others
 - S8. Communication measures from infrastructure operators and maintenance contractors and users
 - S21. Intelligent, automated and flexible rail traffic dispatching systems

From the resilience point of view (R19), the challenges are related to incorporation of climate needs to design, operation and maintenance technologies of infrastructure. Climate-resilient infrastructure technologies need to be adaptable and able to react to extreme events. Here innovations in new, more durable and sustainable materials, and new construction and maintenance methods can help to provide the infrastructure the needed resilience (R20). However, the SINTRAS stakeholder workshop reported that the information and data on climate change behaviour specified to infrastructure needs are not sufficiently available, challenging the identification of specific needs. In the field of resilience and sustainability, some of the key solutions expected to be developed are the following:

- S9. Innovative design and construction methods and materials adapted to the needs of resilience
- S10. New techniques for adapting the infrastructure to extreme events ensuring safety and service
- S11. IT Tools (Effective and real-time communication with infrastructure operators and users)
- S12. Intelligent traffic management system ensuring the services in case of extreme events
- S13. Advanced safety and security forecasting and prevention measures enabled, for example, by sensors, digital systems and self-healing materials

Regarding the deployment of new fuels, there is a need to develop innovative concepts and methods for new fuels and energy infrastructure, related to distribution and harvesting fields (R21). In this sense, it is expected to implement new energy distribution points using new materials and installation techniques (S14).

The energy efficiency challenge is tackled in two ways. On one hand, there are the considered support measures related to better performance on vehicles or better traffic management systems (R22). This perspective includes the following general solutions: the digitisation of transport, new infrastructure methods, alternative fuels enhancement, and shift in demand trends and share of transport mode. On the other hand, related to the transport infrastructure itself, it is the scope of the integration of more energy-efficient methods and materials when constructing and retrofitting transport infrastructure (R23), e.g. new less energy-consuming materials, composites,

and surface coatings; recycled materials and self-healing materials. Both perspectives result in the following technological solutions, amongst others:

- S15. Retrofitting techniques for existing infrastructures
- S16. New more energy-efficient construction methods and materials
- S17. ICT Tools of energy consumption monitoring “self-monitoring”
- S18. New maintenance services
- S19. Energy harvesting infrastructure
- S20. New governance and funding processes
- S22. Reuse and recycling methods

3.3 Action plan

Figure 9 **Error! Reference source not found.** lists the actions selected to overcome the barriers to the transformation of transport infrastructure to address connectivity, resilience, new fuels and energy efficiency.

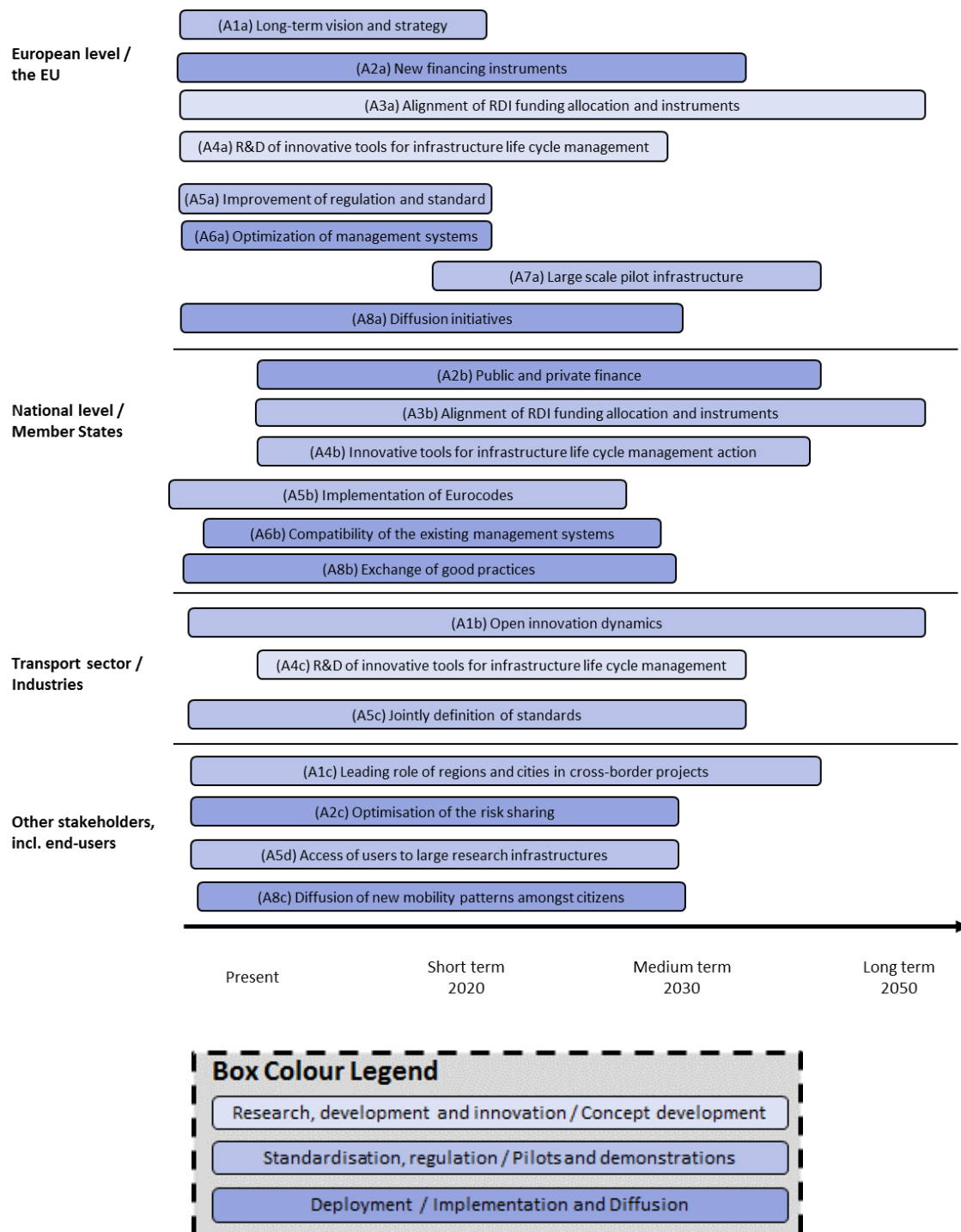


Figure 9. Focus Area 2 action plan.

List of actions (grouped by topic):

- (A1) Building a shared long-term strategy based on the stakeholders' agreement and commitment
 - (A1a) Development of a shared long-term vision and strategy
 - (A1b) Promotion of open innovation dynamics across the transport infrastructure value chain agents

- (A1c) Encouragement the leading role of regions and cities in cross-border projects
- (A2) Innovation in financing instruments
 - (A2a) Design the new innovative financial instruments
 - (A2bc) Attracting public and private financing
- (A3) Alignment of RDI funding allocation and instruments (at European and national level) with transport infrastructure public policy priorities and with the sector's stakeholder needs, including users
 - (A3a) Integration of innovation policy and stakeholder needs in general transport infrastructure strategy
 - (A3b) Adoption of specific funding measures / instruments to integrate innovative solutions or new technologies within the TEN-T projects: specific support devoted to applied research featuring high maturity level, adoption of Public Procurement of Innovative Solutions, funding boosting transnational cooperation projects, funding prioritising RDI projects involving several links of the transport value chain
- (A4) R&D of innovative tools for infrastructure life cycle management
 - (A4a) Resources for regulation/standards implementation in MS
 - (A4b) Transfer of knowledge and results (From European Union to MS and sector stakeholders)
 - (A4c) Adaptation, adoption and promotion of innovative tools for infrastructure life cycle management (basically at the national level)
- (A5) Improvement and continued adaptation of the regulation and standard frameworks to the new transport infrastructure demand to boost innovation and technology in the sector
 - (A5a) Enhanced regulation and standardisation process (appraisal of innovation, timing, performance-based, utilising web-based platforms, coordination with international processes)
 - (A5bcd) Implementation of regulations and standards by MS and involvement of industry in the processes
- (A6) Optimisation and compatibility of the existing management systems
 - (A6a) Design compatible and optimised management systems
 - (A6b) Implementation of compatible and optimised improvements to the existing management
- (A7) Piloting research, development and innovation
 - (A7a) Large-scale pilot RDI infrastructure
- (A8) Development of diffusion initiatives to increase the awareness of the key role of transport infrastructure for the economic growth and quality of life amongst all stakeholders
 - (A8a) Development of broader diffusion initiatives targeted at MS, industry and final users
 - (A8b) Promotion of the exchange of good practice amongst MS
 - (A8c) Development of diffusion actions of new mobility patterns amongst citizens

3.3.1 European level

One of the key actions carried out at the European level is **the definition of a long-term vision and strategy (A1a)** for the transport infrastructure and its transformation. This is crucial in order to address the challenges of connectivity, resilience, new fuels, and energy efficiency in a holistic manner.

A European-level strategy is expected to streamline the infrastructure development; the implementation of such a strategy could help to overcome many current infrastructure development bottlenecks and yield important economic, environmental and social benefits³².

In this sense, the European Commission's Transport White Paper (2011)³³ is a good framework, since it envisages a European integrated and sustainable transport system. Moreover, the European Union already has a relevant starting point for infrastructure development, the TEN-T policy³⁴. This policy shows an important trajectory and progress towards a connected transport infrastructure across the Member States. It forms an appropriate basis for achieving the vision of an integrated European transport infrastructure during the coming decades.

Moreover, there are other initiatives that show the European commitment in the field. These include projects such as SETRIS (Strengthening European Transport Research and Innovation Strategies)³⁵, that aims to produce a cohesive approach to innovation and research strategies for all transport modes at the European level.

The Strategic Transport Research and Innovation Agenda (STRIA) initiative is the most relevant action to define a strategic agenda for transport RDI. In coordination with Member States and transport stakeholders, STRIA aims to set out common priorities and deploy innovative solutions to address the Energy Union and other policy goals. STRIA will outline the steps needed to support and speed-up the research, innovation and deployment process leading to radical technology changes in transport³⁶.

This strategic process should include the participation of all stakeholders related to transport infrastructure, to design a governance structure including Member States, infrastructure managers, concerned regional and local authorities, as well as the users. This multi-governance approach would contribute towards overcoming the fragmentation of the large number of agents involved in the transport infrastructure field. Those agents are characterised by having different incentives and conflicting objectives when incorporating new technologies to infrastructure development. The value/supply chain related to transport infrastructure involves a great number of agents responsible for management and operation, project design, construction, upgrading or maintenance, together with end-users, amongst others. Each has their own interests, in many cases not duly integrated and working towards a common goal.

This transversal action is orientated to deal with the need to integrate all stakeholders in the decision-making process in order to reach a consensus on the vision and pathways to achieve it. The incorporation of a variety of actors in the long-term strategic process would help to integrate not only the vision, but also the long-term aims, based on a common and agreed pathway. This would increase the commitment

³² The participants of the workshops during the project supported the need to adopt a holistic and long-term perspective in the future at the European level.

³³ Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system (COM(2011) 144 final)

³⁴ https://ec.europa.eu/transport/themes/infrastructure_en

³⁵ The SETRIS project brings together, for the first time, all major transport-related European Technology Platforms (ETPs) into a single collaborative initiative. <http://www.uitp.org/setris-%E2%80%93-strengthening-european-transport-research-and-innovation-strategies>

³⁶ <http://ec.europa.eu/programmes/horizon2020/en/news/towards-strategic-transport-research-innovation-agenda-stria>

of stakeholders, thus optimising the innovation and deployment processes around European transport infrastructure. This optimisation would ultimately lead to better results for the resources invested.

The REFINET platform and REFINET project³⁷ are good examples of the steps taken at the European Union level to involve all the stakeholders in the decision-making process. The objective is to create a sustainable network integrating relevant agents of all the transport modes and transport infrastructure sectors in order to develop a shared European vision in the field. Further support and consolidation of this network would be a good tool to define the long-term vision and strategy for transport infrastructure proposed by this action.

The implementation of action A1a (*to define a long-term vision and strategy*) should be tackled in the short term, since it is a key facilitating activity. The development of a common vision and strategy would ultimately support the deployment of other relevant actions defined to overcome the barriers of infrastructure development.

Investment needs for transport infrastructure in European Union Member States are substantial. Government funds are far from sufficient to cover these. The European Union needs to strengthen **the use of new financing instruments (A2a)** that are already developed.

The use of innovative financial instruments facilitating and attracting new sources of public funding and especially private financing to projects of EU interest should be reinforced by working together with the European Investment Bank (EIB). Plans to engage private actors, such as pension funds or insurance companies, to invest projects with commercial viability (i.e. projects with stable and predictable cash flow generation potential) should be further explored and exploited. In this respect, Australian and Canadian pension funds have been pioneers in infrastructure investing since the early 1990s. These countries also have the highest asset allocation to infrastructure around the globe. Important lessons can be learnt not only by investors but also by policy makers as political and regulatory stability are paramount for long-term investment strategies³⁸.

The Connecting Europe Facility (CEF) grants support projects that implement TEN-T priorities, with a specific focus on pre-identified projects and horizontal priorities on the core network, listed in the CEF Regulation. The final selection for the allocation of CEF Transport support takes into account synergies between the European Structural and Investment Funds, financing by the European Investment Bank, national promotion banks and private sources, such as institutional investors and the banking system more generally. In this respect, Member States should also reinforce support dedicated to generating a better understanding of the Public-Private Partnership (PPP) schemes and to mastering risk-sharing techniques to boost the use of new financial instruments. The complexity of PPP models is determined not just by the difficulty of choosing the optimal mix of public funding and private financing, but also by the need to manage a broad range of unconventional financial instruments. This action of enhanced use of new financing instruments should be reinforced immediately and maintained on a long-term basis.

In order to optimise the results achieved in terms of new technology and innovation adoption to transform transport infrastructure, it is necessary to **improve the alignment of RDI funding allocation and instruments used (A3a)** with the related framework public policy priorities, and also with the interests and needs of the sector's stakeholders, including users. In this respect:

³⁷ <http://refinet.eu/about-us/introduction/>

³⁸ Pension Fund Investment in Infrastructure. A comparison between Australia and Canada

- The innovation policy regarding transport infrastructure could be further developed and embedded at the European level with general strategies of transport infrastructure. While RDI funding allocation in H2020 seems to be quite focused on prioritised challenges within the framework transport infrastructure policies, the latter (e.g. TEN-T policy, CEF) should better reflect the need of deploying innovation or new technologies for the more effective achievement of its goals. The adoption of innovation and new technologies is considered in several articles of the European Union guidelines for the development of the trans-European transport network³⁹ and the CEF regulations⁴⁰ as a measure to achieve better performance of the transport system. However, in our view, this important issue should be tackled in a more comprehensive and integrated manner. With this aim, the European Commission is leading the development of the Strategic Transport Research and Innovation Agenda (STRIA) in which infrastructure is one of the seven areas examined⁴¹. CEF Innovation and new technology actions considered in the Multi Annual Programme of the Cohesion Call are also an example of an embedded initiative to boost innovation and new technology deployment within the transport system.
- The adoption of specific measures to integrate innovative solutions or new technologies within the TEN-T projects would contribute to boost the approach of keeping TEN-T as the European flagship on innovative transport infrastructure development initiative. Incentive measures within TEN-T funding instruments could comprise higher co-financing rates for projects incorporating innovation or new technologies. Another option would be better integration of new technology aspects to the award criteria of TEN-T funding. As an example of existing schemes, concerning climate change resilience in transport infrastructure, TEN-T projects, co-financed under the CEF, that are expected to contribute towards transition to a climate- and disaster-resilient infrastructure are receiving an increased financing rate⁴². A similar approach could be implemented to incentivise technology and innovation deployment as that in TEN-T development.
- The transport infrastructure technology development already show, in general, very high technology readiness levels (TRLs) as stated by RDI stakeholders interviewed by the SINTRAS project. The main reasons that these technologies have not yet reached the market are related to perceived uncertainties and risks. The uncertainties and risks are associated at least to 1) long-term performance of new technologies during the service life of infrastructure, 2) the impact of new technologies on safety and security aspects, and 3) long-term economic benefits or cost savings related to the trade-off between adapting the most innovative solution and the most economical alternative⁴³. Thus, it is

³⁹ REGULATION (EU) No 1315/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on European Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU. http://publications.europa.eu/resource/cellar/f277232a-699e-11e3-8e4e-01aa75ed71a1.0006.01/DOC_1

⁴⁰ REGULATION (EU) No 1316/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 establishing the Connecting Europe Facility, amending Regulation (EU) No 913/2010 and repealing Regulations (EC) No 680/2007 and (EC) No 67/2010. <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R1316&from=en>

⁴¹ <http://ec.europa.eu/programmes/horizon2020/en/news/towards-strategic-transport-research-innovation-agenda-stria>

⁴² European Commission (2011) COM(2011) 665 final REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing the Connecting Europe Facility available, page 30 available at <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011PC0665&from=EN>

⁴³ REFINET (2016) Deliverable D3.1 REFINET multi-modal transport infrastructure (RMMTI) model, Page 12, available at http://ectp.org/fileadmin/user_upload/documents/REFINET/CE_REFINET_D3.1_RMMTI_v06.pdf

recommended to draw special attention and enhanced support to applied research projects dealing with market uptake of the technologies. In this respect, the TEN-T projects could act as pilot demonstrators in order to boost the deployment of innovative solutions to transport infrastructures⁴⁴ (see also a specific action on large-scale pilot network A7a).

- The adoption of Public Procurement of Innovative Solutions (PPI) schemes could be a way to enhance the delivery of innovative transport infrastructure⁴⁵. Horizon 2020 already provides grants that co-finance the costs for consortia of public procurers to undertake PPI together or pre-commercial procurement (PCP). Moreover, it officially introduces PCP as a new funding instrument to be used across all areas of research and innovation supported by the European Commission⁴⁶. Even though some PPI projects in the construction and transport sector are already being supported, this measure could be further enhanced.

Moreover, to better overcome some of the identified barriers (such as Barrier FA2-05 – Large number of agents implied with different priorities and visions), the funding instruments should (as H2020 at least to some extent already does) apply a set of specific requirements, prioritisation criteria or incentive measures, such as:

- Public funding could boost RDI projects in which different countries come to an agreement to search for solutions to common challenges. Transnational collaboration is especially relevant in the framework of cross-border infrastructure projects.
- The prioritisation of RDI projects that involve several links of the transport value chain could maximise the likelihood of future adoption of innovations or new technologies developed.
- Additionally, promotion of instruments aiming at building long-term cooperation between stakeholders from policy, industry and research, could enable the deployment of infrastructure research results.

Even if public funding must protect and preserve common societal goals, transport infrastructure stakeholders' interests should also be supported in a prominent manner in order to enhance technology and innovation adoption. In this respect:

- The funding allocation should be more focused on prioritised interests and solutions identified by transport sector stakeholders, also taking into account users' interests.
- The RDI funding allocation focus on maintenance and retrofitting technologies should be retained and reinforced. Given the vast and ageing legacy of existing transport infrastructure in Europe, the main objectives are to minimise disruptive events and improve the efficiency and asset management. Thus, RDI funding should focus on areas such as material technologies, methods, processes and supporting systems related to infrastructure maintenance and retrofitting.

⁴⁴ EC (2016) TEN-T Corridors: Forerunners of a forward-looking European Transport System. Issue Papers by the TEN-T European Coordinators. Available at: <http://ec.europa.eu/transport/sites/transport/files/themes/infrastructure/news/doc/2016-06-20-ten-t-days-2016/issues-papers.pdf>

⁴⁵ REFINET (2016) Deliverable D3.1 REFINET multi-modal transport infrastructure (RMMTI) model, Page 10, available at http://ectp.org/fileadmin/user_upload/documents/REFINET/CE_REFINET_D3.1_RMMTI_v06.pdf

⁴⁶ <http://www.innovation-procurement.org/about-ppi/policy-support/>

Within this context, the INFRAVATION ERA-NET Plus⁴⁷ could be considered a pilot example for future disbursement of public RDI funds on the transport infrastructure sector. The design of the programme has the following characteristics:

- Transnational cooperation in research funding.
- Application of a real common pot approach nourished by individual national funding contributions and related EC top-up funding.
- Coordinated, common governance structure of the transnational RDI projects to be funded, independent from individual national funding rules.
- Research results accessible jointly for the funding organisations, what contributes to reduce overlaps in research and innovation activities.
- Clear thematic scope of the call, prioritised by road transport sector stakeholders.
- Prioritised challenges identified by stakeholders (in this case by road authorities).
- The scope of the call embraces cost-effective advanced systems, materials and techniques in road infrastructure construction and maintenance, including repair, retrofitting and revamping.
- “Near market-ready research” projects.
- At least two different countries in the consortia.

The action A3a (Improve the alignment of RDI funding allocation and instruments used) should be undertaken immediately and regularly revised in order to meet the changing needs of the sector.

According to expert interviews and the information gathered in the stakeholder consultation workshops, there is a need for **design of innovative tools for infrastructure life cycle management (A4a)**. These tools would improve the information that transport sector stakeholders have when faced with investment decisions. A set of life-cycle management tools would help to enhance the adoption of innovative solutions and to overcome the barriers related to the uncertainty that characterises these initiatives.

The infrastructure development projects have to cope with high levels of uncertainty and unpredictability related to costs, revenues and time scale, and also in terms of potential long-term technical, juridical or political consequences. As a result, protective and conservative policies are adopted as a risk mitigation measure. These policies typically fail to attract new sources of investments. The lack of finance creates a barrier for the development of infrastructure and for the adoption of new technologies and innovations in the sector (tackled also in Action A2a Use of new financing instruments).

European-level action is needed in order to create a forum to draft innovative models and approaches that could be later adapted and adopted at the national level. RDI activities should embrace methodologies aiming at enabling more efficient resource allocation and smarter decision-making processes based upon better quality information such as:

- Definition of life-cycle cost and cost-benefit methods that would allow more accurate predictability of revenues and expenses throughout the whole life-cycle of the infrastructure. These methods would be especially relevant when

⁴⁷ <http://www.infravation.net/>

considering the introduction of new technologies that typically at first increase the construction or maintenance costs, but actually lead to reduced total costs over the infrastructure life span. These tools should contribute to clearly identifying the life-cycle costs and benefits for operating, maintaining, upgrading or expanding a transport infrastructure throughout the life-cycle and to help to select the best technology option taking into account the impacts on user satisfaction, and construction, rehabilitation or preservation requirements.

- Adapting the risk sharing and business models: Alternative models for risk and profit sharing and innovative funding and financing schemes should involve private agents better. Private sector actors can play a range of roles, including mitigating the tendency of the sector to rely on “traditional” risk-sharing and compensation arrangements, especially in the case of new technology adoption. Innovative risk-sharing and business models promoting the integration of transport sector stakeholders (government and public institutions, contractors, market parties, users), forward and backward, could also enhance the adoption of new technologies and innovation within the transport infrastructure development as the whole value chain would be involved from the very start of the initiative. This would ensure that the stakeholders are aware not only of the challenges and risks but also the benefits that may take place at the different stages of infrastructure. For example, the application of new material for bridge structures may be more costly at the design and construction phase but require much less maintenance and refurbishment. Thus, the costs and benefits should be better adjusted to the life-cycle of the infrastructure and shared more evenly between the stakeholders.
- Development of impact assessment methodologies adapted to transport infrastructure specificities.
- Key performance indicators (KPIs) that enable assessment of transport infrastructure performance in objective manner. The KPIs should be adapted to the priorities of each transport infrastructure administration. The existence of accurate data about transport infrastructure performance could reveal to what extent there is a path for innovation and adoption of new technologies in order to reach optimised management of infrastructures.

In addition to the development of new methods and models, measures devoted to knowledge transfer and broad dissemination of the results obtained should be undertaken. Examples of such measures could be for instance adequate technical assistance or dissemination of lessons learnt in format of real-life case studies.

This action (Research and development of innovative tools for infrastructure life-cycle management (A4a)) should be implemented as soon as possible to avoid some of the identified barriers. However, in the future, it could happen that these models and tools may have had their day and new models are needed. Thus, this action should be maintained and updated according to the future needs and context

Actions at the European Union level should also include an **improvement and continued adaptation of the regulation and standard frameworks** to the new transport infrastructure demand to boost innovation and technology in the sector **(A5a)**.

The European Union has put in place a comprehensive legislative and regulatory framework for the construction sector covering important parts of the design of civil

engineering works, including bridges and other highway structures⁴⁸. This regulation is focusing, for example, on health and safety in construction and the free movement of engineering/construction services and products. The European-level legislation defines the essential requirements that goods must meet when they are placed on the market and the European standards bodies have the task of drawing up the corresponding technical specifications that are facilitated by the common European technical standards for structural design: Eurocodes. Currently Eurocodes sets basic requirements for construction works in terms of mechanical resistance and stability; safety in case of fire; hygiene, health and the environment; safety and accessibility in use; protection against noise; energy economy and heat retention; and sustainable use of natural resources.

Updating and maintenance of Eurocodes is a continuous process and the second generation of the Eurocodes is planned to be published in 2020⁴⁹. This work should further appraise the innovation aspects of transport infrastructure by incorporating aspects into the existing rules, such as enhanced assessment and retrofitting of existing infrastructures, concepts towards more energy-efficient and sustainable construction methods and materials, and aspects related to infrastructure resilience against climate change.

Furthermore, it is considered essential that the new standards embrace the performance, output- or functional goal-based design (when applicable)⁵⁰. This is reflected to allow incorporation of user requirements and new technologies much better to transport infrastructure development than the standards that give detailed prescriptive regimes⁵¹. During the SINTRAS workshops, the performance-based framework was considered to best encourage innovation in transport infrastructure development. It was, however, also noted that prescriptive standards are in some cases more appropriate and efficient, depending on the context (e.g. railway infrastructure).

Apart from construction standards, the European Union-level regulation and standardisation plays an integral role in the uptake of ERTMS or new fuel infrastructure⁵². Technologies are usually in a more advanced stage of development and deployment than the needed standardisation for the system to work properly. Thus it is suggested to enhance the planning and execution of the standardisation process and establish a roadmap taking into account the timing of actions⁵³. Here, European-level policy action mandating the European Standards Organisations is needed in order to provide a solution ensuring interoperability across the European Union. In addition, it is suggested that the standardisation bodies should be increasingly engaged in the technology development process at an earlier stage in order to improve the timing of standards and the process of standardisation. In this direction, the research and innovation projects funded by H2020 should better integrate standardisation into transport infrastructure development projects in order to

⁴⁸ See JRC (2016), Eurocodes – Building the Future. Available at: <http://eurocodes.jrc.ec.europa.eu/showpage.php?id=2>

⁴⁹ European Commission (2014) The present and the future of the Eurocodes. Presentation by Steve Denton. Available: http://eurocodes.jrc.ec.europa.eu/doc/2014_07_WS_Steel/presentations/02_Eurocodes_Steel_Workshop_DENTON.pdf

⁵⁰ The performance-based vs. prescriptive standards were discussed during the SINTRAS workshop.

⁵¹ See in general Pelkmans, J. and Renda, A. (2014) Does EU regulation hinder or stimulate innovation? CEPS Special Report. Available:

<https://www.ceps.eu/system/files/No%2096%20EU%20Legislation%20and%20Innovation.pdf> and related to transport infrastructure:

⁵² DIRECTIVE 2014/94/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 October 2014 on the deployment of alternative fuels infrastructure.

⁵³ The timing of standardisation was extensively discussed during the SINTRAS workshop.

kick start and support the process. It is also recommended that the regulatory and standardisation bodies should increasingly rely on new web-based interactive tools in order to make the processes faster without jeopardising multi-stakeholder participation. The European standardisation processes should also be fully aligned with the preparations of international standards and the European regulation and standards should be promoted at global level in order to support the competitiveness of European industry.

Initiatives towards improvement and continued adaptation of the regulation and standard frameworks (A5a) are already in place (e.g. 2nd generation Eurocodes) thus SINTRAS is merely agreeing on the measures taken and underlining the importance of certain aspects (e.g. performance-based standards, involvement of standardisation bodies at earlier stage in the technology development process).

The transport management systems initiatives being currently undertaken are aimed at their **optimisation and ensuring their internal interoperability** in the European dimension (**A6a**). This pertains to railway (ERTMS), air transport (SESAR), maritime (VESSEL), and inland waterways (RIS) systems. Europe has to play the role in the coordination among the Member States regarding interoperability, as well as ensuring rapid cooperation between all transport infrastructure modes. For example, the H2020 project REFINET relies on a sustainable innovation network that integrates relevant stakeholders from all transport modes (road, railway, maritime, air) and transport infrastructure⁵⁴. REFINET introduces a Multi-Modal Transport Infrastructure (RMMTI) model and framework, with the overarching aim to create a shared European vision and strategic implementation plan about how the multi-modal European transport infrastructure network of the future should be specified, designed, built or renovated, upgraded and maintained.

There is considerable strategic interest from across and beyond each transport platform involved (ERTRAC, ERRAC, Waterborne, ACARE and ECTP)⁵⁵. The ERTRAC-ERRAC-Waterborne-ACARE-ECTP Task Force also highlighted the need for research and innovation actions in order to enable an improvement of 50% in infrastructure performance, risk and cost versus a 2010 baseline as well as to enable seamless door-to-door services for passengers and freight by 2030.

Transnational deployment of continuous cross-border services for travel information and traffic management cannot be done independently by each Member State. Instead, synergies and lessons learnt from SESAR, ERTMS and RIS system should be systematically exploited to reduce the risk of errors and bring about the full benefits.

This ongoing action of optimisation and ensuring interoperability between transport modes should be reinforced and kept in the agenda in the long-term through regular exchange of experiences of Member States.

Developments in transport infrastructure technology show very high “technology readiness levels” according to RDI stakeholders interviewed in this project. However, these developments have often not yet reached the market due to uncertainties and risks⁵⁶. New technologies should be tested in **large-scale pilot infrastructure (A7a)** to establish their performance in real environment meeting the security and reliability requirements. Public support at the European Union level for investments in a large-scale pilot infrastructure can have a very high leverage effect on both new infrastructures and maintenance of the existing infrastructure.

⁵⁴ REFINET (2016) Deliverable D3.1 REFINET multi-modal transport infrastructure (RMMTI) at http://ectp.org/fileadmin/user_upload/documents/REFINET/CE_REFINET_D3.1_RMMTI_v06.pdf

⁵⁵ Joint ETP task force roadmap

⁵⁶ REFINET (2016) Deliverable D3.1 REFINET multi-modal transport infrastructure (RMMTI) model, Page 12, available at http://ectp.org/fileadmin/user_upload/documents/REFINET/CE_REFINET_D3.1_RMMTI_v06.pdf

In this respect, SINTRAS recommends establishment of a network of recognised Trial Centres in order to systematically test the results of RDI in areas of special interest. The Trial Centres should be in conformity with the procedures approved by the competent authorities in topics such as security, resilience, etc. Nowadays the trials are carried out only on an ad hoc basis, but there are no systematised processes. These “quality-labelled” Trial Centres or demonstration infrastructures could be formed from existing European research infrastructures but their role should be formalised and the testing processes should have homogeneous quality requirements. The SERIES Platform⁵⁷ of FP7 projects could be a reference experience to take into account. In this platform, transnational access to a portfolio of world-class research infrastructure is offered to selected talented European researchers. Users are given an access to the infrastructure for the design of the test specimens, instrumentation, execution of the tests and processing and interpretation of results.

As building this network of trial centres requires consensus between Member States, long-term commitment and extensive planning, the initial steps need to be launched as soon as possible

The creation of an integrated and shared vision and strategy provides stronger agreement and commitment among all the stakeholders. However, this strategic action should be complemented with broader **diffusion initiatives (A8a)** targeted at Member States, the sector and final users. The state of play of the transport infrastructures requires structural changes related to societal mind-sets, towards a culture conscious of the benefits of sustainable, integrated and connected transport infrastructure at the European level, beyond regional and national interests.

In this sense, the promotion of cross-border spatial planning initiatives would help to increase awareness of the key role of transport infrastructures for the economic growth and quality of life of all of the European territories at national, regional and local levels.

Moreover, the diffusion activities should also address the key specific challenges European transport sector is currently facing, such as energy efficiency and climate change. The aim is to increase the demand on new fuels vehicles to push the development of the supporting infrastructures further. Regarding environmental issues, communication actions would be oriented to enhanced understanding of the impacts of climate change, and the need to adopt resilient measures to adapt infrastructure to extreme events.

This **A8a** action (*diffusion initiatives*), as a facilitating activity, is relevant for supporting other actions of this plan. It should be tackled in the short term in order to maximise its impact.

3.3.2 National level

Though the challenges of transport infrastructure are well-recognised, the resources for maintaining, improving and upgrading the transport infrastructure are scarce at the Member State level. Coordination among Member States regarding interoperability and joint investments further complicates the issue, as at the end, the main competences regarding transport infrastructure are kept by the Member States.

Countries need **to attract additional public and private finance (A2b)**. As mentioned by G20/OECD Guidance Note⁵⁸, many governments seek greater levels of private finance in infrastructure due to their investment constraints. Thus, the efforts

⁵⁷ <http://www.series.upatras.gr/lab-access>

⁵⁸ G20 OECD guidance note diversification of financial instruments for infrastructures and SMEs

are already underway and new mixed models of finance and risk allocation are being developed. Further promotion of project pooling and building investor networks with local authorities and partners is however recommended. This is considered to be especially useful in cases where there are important synergies and common interests between transport infrastructure, telecommunications and energy sector.

The financing needs and instruments of small-scale infrastructure projects, which may have different characteristics from large-scale projects, should also be considered. Member States are encouraged to cooperate more in terms of exchanging good practice and practical experiences of the new financial models.

This action should be formulated and implemented together with the Action A2a and launched in near term future and is subject to regular reviews.

The better alignment of RDI funding allocation and instruments (A3b) also requires the participation at the national and local levels. Public authorities should implement the principles raised at European level in terms of:

- Better integrating transport infrastructure strategy and RDI-related policies
- Better reflecting the interests of sector stakeholders, including users.

However, actions should be tailored to national or local context and needs. When referring to national RDI funding and instruments, the focus should be on:

- The local context, to tackle national transport infrastructure gaps and interests
- The concept of national transport systems as part of the European network, complementing European funding.

Regarding **the adaptation and promotion of innovative tools for infrastructure life-cycle management (A4b)** at the national level, the scope of the action would be to complement the European research initiative by introducing the local context in the model. With that aim, resources (economic and human) should be committed for the adaptation and adoption of the results achieved to the local scenario aiming at contributing to the better justified and informed investment decision-making processes, the attraction of new investors, sponsors or stakeholders in transport infrastructure projects and further integration of the national value chain.

Thus, the last two mentioned actions should be implemented at the national level once European guidelines have been established.

Although, according to the Public Procurement Directive⁵⁹, European Union contracting authorities must follow the use of the Eurocodes in structural design aspects of tenders, the European Commission recommendation on the implementation and use of Eurocodes for construction works and structural construction products is non-binding. Consequently, the implementation of Eurocodes varies amongst Member States⁶⁰. So there is a need for **Member States to go more deeply into the implementation of Eurocodes (A5b)**. The analysis of the state of implementation concludes that in 83% of the analysed countries, Eurocodes are implemented; whereas some countries should speed the progress in adoption of the National Annexes and other should remove the legal restrictions impeding the implementation of Eurocodes. In addition, national level standardisation bodies should ensure the implementation of European standards as national standards and to withdraw any conflicting national standards. National level standardisation bodies are also invited to act as intermediates between

⁵⁹ DIRECTIVE 2004/18/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts

⁶⁰ European Commission (2015) The Eurocodes are implemented in 23 EU Member States. JRC Science Policy Brief. November 2015.

European standardisation processes and industry, especially actions engaging SMEs better to standardisation processes (e.g. awareness raising, training, transparent information, expert support, etc.). This is considered to enhance the incorporation of innovative technologies to transport infrastructure development.

In terms of national infrastructure management system, there is a lack of adoption of digital infrastructure and intelligent transport services. At this point, it is necessary to **guarantee compatibility among the versions of the existing systems or implement change/transition management processes to improve efficiency and interoperability (A6b)**. This action should be worked closely together with action (A6a) and the implementation should start immediately. The action should be maintained until the compatibility among the versions is guaranteed.

The Member States should also foster the **exchange of good practice (A8b)** to learn from the best experiences of dissemination to disseminate and adopt at national level. Initiatives already underway at the European level could become suitable forums for the Member States to jointly share, debate and learn. This action should be tackled along the implementation period of this action plan, since it is a support action and should help Member States to improve their performance in the field of transport infrastructure in the short, medium and long term.

3.3.3 Transport sector

The transport sector is characterised by a large number of agents who do not always have the same goals or an integrated way of working together. As a result, actors along the value chain do not give the same relevance to the adoption of new technologies as they do not have the same priorities. In this sense, the transport sector should increase the collaborative initiatives⁶¹ participated in by agents of the different stages of the value chain in order to take advantage of the existing synergies amongst them and to improve the innovation performance by the transport infrastructure sector. Thus, following the experts' opinion, **the adoption of open innovation dynamics (A1b)** could greatly benefit the sector. The SINTRAS work has clearly showed that the main barriers preventing the advancement towards addressing the infrastructure challenges are not so much related to technology itself. Technology and solutions exist but they are not necessarily deployed as shown by the barrier analysis. Transport infrastructure sector can be described as a settled, cost-driven and a traditional sector, which is not so much driven by new technology solutions or innovation. The firms in the sector are typically distant from science-based research and the innovations applied are often produced in other industries, such as the chemical industry, material science, or ICT. The distance and lack of communication between the RDI solution providers and the actors that actually deploy the solutions have led to additional challenges. On the one hand, RDI has not always considered short-term, concrete solutions tailored to meet the actual market need, or missed appropriate deployment planning. On the other hand, potential investors/deployers have not clearly voiced their need for new technologies or solutions to the RDI work stream, or are not aware of what has been made available by research providers⁶².

⁶¹ According to the experts consulted during the Workshops carried out in the project, there is a need to foster collaborative mentality. This is a problem mainly for road, maritime and aviation transport modes. In rail, on the other hand, the actors work more together under the Shift-to-Rail initiative. The incentives for infrastructure and vehicle sector are becoming more visible, e.g. in the aviation sector, the European Aviation Safety Agency and industry are establishing the strategic priorities together. Also, the OEMs and infrastructure developers are starting to work together that can significantly improve market take-up. However there is a need to support open innovation dynamics across the European transport infrastructure sector.

⁶² Trautmann, C. (2016) Boosting New Technologies and Innovation, Issue Paper in TEN-T Corridors: Forerunners of a forward-looking European Transport System, European Commission.

Thus open innovation dynamics would not only foster the knowledge transfer amongst the agents involved in the transport infrastructure, but also integrate visions and efforts by means of the definition and development of joint innovative initiatives and projects. This action should be supported from the very beginning given the strategic role of collaboration amongst agents to improve the innovation performance of the sector. Open innovation approach should become a common practice in the sector, and national or regional level clusters could become key platforms for collaboration.

Related to the **research and development of innovative tools for infrastructure life-cycle management (A4c)**, transport sector representatives should take active part in the research process, where its participation and considerations are of the utmost importance. To encourage their participation, it should be communicated to what extent these new tools award them new relevant roles in transport infrastructure development projects as a consequence of the freshly developed business or risk sharing models. Special attention should be required from transport sector stakeholders regarding the key performance indicators that should be adapted to each transport infrastructure.

Regarding the timing, it is relevant that the transport industry supports national institutions in the development and implementation of this action throughout the whole process and with the same time frame.

The companies along the transport infrastructure value chain need to collaborate more in order to **jointly define standards (A5c)** that enhance the competitiveness of the industry. In this sector, industry is strongly influenced by regulation and thus industry joint endeavours to monitor and influence public policy would be beneficial. Industry-initiated and led standardisation processes (ahead of regulation) can shape the public policy and lead to more optimal standards. Improved collaboration within the sector would also help to meet the ever increasing need for development of cross-industry standards, e.g. in the field of alternative fuels infrastructure. The industry should thus be better aligned for speeding up the standardisation process within the sector, having higher influence on cross-industry standards, and shaping the public regulation affecting transport infrastructure development. The European Construction Technology Platform and its Infrastructure and Mobility Committee are already working towards engagement across the construction supply chain, facilitating the dialogue between different stakeholders and influencing standards. Standardisation and interaction with regulatory bodies should however become an integral part of these activities.

3.3.4 Other stakeholders

Border regions and cities play a major role in the cross-border transport infrastructure projects. Regional and local authorities should **increase their participation in leading this type of initiatives (A1c)** to make the most of the driving capacity of subnational levels as a demanding force of cross-border connectivity. The initiatives promoted by regional and local authorities should be supported by the European Commission with the already existing instruments such as the European Structural and Investment Funds or initiatives such as JASPERS⁶³. This action should be tackled in the short to medium term to maximise its impact. This bottom-up approach would let the regional and local levels to make the most of their driving capacity in the field of cross-border transport infrastructure. Regions and cities would play a leading role as a sophisticated demand for innovative solutions.

<http://ec.europa.eu/transport/sites/transport/files/themes/infrastructure/news/doc/2016-06-20-ten-t-days-2016/issues-papers.pdf>

⁶³ <http://www.jaspers-europa-info.org/>

New financing instruments should also contribute towards optimising the risk-sharing amongst all the stakeholders involved in the transport sector. Improving data and information could support more diversified and innovative financing of infrastructure, and also broaden its appeal to a larger base of investors. It is also necessary for policy makers to be able to understand and monitor such information in order to be able to make appropriate policy responses⁶⁴ (**A2c**). This action should be work closely to A2a and A2b from now and keep it alive in the longer term through regular reviews of the financial context.

Research infrastructures can play an important role in knowledge transfer from research to industry by providing a platform for pre-normative research, test beds for performance and feasibility assessment of new standardised concepts and harmonisation of standards⁶⁵. Thus the **access of users to large research infrastructures would benefit the standardisation process (A5d)**.

Regional and local levels are also important in **the diffusion of new mobility patterns amongst citizens (A8c)** in order to increase the demand of connected, efficient and intelligent transport infrastructures at the European level. In this sense, several initiatives are already implemented, such as the European Mobility Week⁶⁶. However, there is a need to improve the systematisation and integration of these diffusion initiatives at regional and local levels, which should be implemented in the short term and maintained in the medium term in order to keep the awareness regarding sustainable and integrated mobility trends amongst citizens.

3.4 Cost-benefit analysis

Error! Reference source not found. This section sums up the cost-benefit analysis (CBA) for Focus Area 2 sub-actions. The results of this analysis have been validated through extensive stakeholder consultation. In the following paragraphs we discuss briefly the key features of each action⁶⁷.

Table 7. Summary table on costs and benefits of Focus Area 2 actions.

Benefit	High		A3a RDI funding allocation	
			A4a Tools for infrastructure life cycle management	A1a Vision and strategy
			A2b Public and private financing	A5a Regulation and standard frameworks A6a Optimise management systems
			A7a Pilot RDI infrastructure	
			A8a Broader diffusion initiatives	
			A3b RDI funding allocation –	

⁶⁴ G20-OECD Guidance Note on Diversification of financial instruments for infrastructures and SMEs

⁶⁵ European Commission (2015) Summary of presentations in European Forum for Science and Industry, JRC side-event to the Standardisation Summit, Construction Standards, Riga, 3 June 2015.

⁶⁶ <http://www.mobilityweek.eu/>

⁶⁷ Refer to Table 1 and Table 2 in Chapter 1 for the elaboration of the guidelines on assessing the costs and benefits for each action

			<p>National level</p> <p>A4b Tools for infrastructure life cycle management – National level</p> <p>A5b Regulations and standards by Member States</p> <p>A6b Improvements to the existing management</p> <p>A1b Open innovation dynamics</p> <p>A4c Tools for infrastructure life cycle management – Sector level</p> <p>A5c Joint definition of standards</p> <p>A1c Role of regions and cities</p> <p>A5d Access of users to large research infrastructures</p> <p>A8c New mobility patterns</p>	
	Medium	A8b Exchange of good practices	A2c Optimisation of the risk sharing	A2a Innovative financial instruments
	Low			
		Low	Medium	High
		Cost		

(A1) **Building a shared long-term strategy based on the stakeholders’ agreement and commitment.** Even though this action cannot be considered a trigger in itself, it is a type of action that facilitates and contributes to the success of the rest of the actions included in the Focus Area 2 action plan. This horizontal action is considered a key facilitating activity. The A1 sub actions deal with the need to overcome the fragmented and heterogeneous group of stakeholders that make up the transport infrastructure innovation ecosystem. One can expect a large resistance and debate to this action, since it covers a broad cross-section of stakeholder communities. There might be some reluctance to collaborate, to leave individual interests aside towards a common vision and to build and adopt an integrated vision.

The changes needed to achieve this require a medium term perspective and the involvement of all of stakeholders, including specific actions oriented not only to Member States, but also to agents at industry and regional and urban levels. This type of sub-action implies large financial costs since it requires cross-Europe cooperation. . According to the experts consulted, the sub-actions included in this action have high benefits, while the costs are also high for the definition of an integrated vision and strategy (A1a), while costs are medium for the open innovation dynamics action (A1b) and increasing the leading role of regions and cities (A1c).

(A2) Innovation in financing instruments. The new approach to design new innovative financial instruments (sub action A2a) requires attracting public and private financing to allow its implementation (sub action A2bc). Otherwise, the benefits and expected impact of this sub-action would be minimised. New financial systems are necessary but not sufficient to be a major game-change for European transport. New attractive business models, stability of transport policies and clear conditions of regulatory landscape are needed to attract private capital. The number of transport infrastructure projects adopting private funding will be clearly recognised and valuable for a group of stakeholders groups but new technologies or innovative solutions and advantages should also be clearly incorporated to achieve the full benefit. Multiplier effects could be generated for quite a large number of stakeholders (investors, operators, research and innovation institutions, end-users), if public and private funding adoption in infrastructure leads to clear benefits, economic profitability, etc. The new financial instruments require a long term and sustained persistence and commitment from the stakeholder group to make them succeed. Periodic reviews are needed for continual improvements towards the goals. The correct operation of these instruments will require that stakeholders start collaborating among themselves when designing the funding measures/instruments in order to create the best conditions to minimise funding gaps. There is an urgent need to use new attractive financing instruments regarding transport infrastructure. If this measure is not adopted, the public-private investment levels in the long-run will be slower. According to the opinion of the stakeholders consulted, these actions will have medium benefits and high costs.

(A3) Alignment of RDI funding allocation and instruments (at the European and national level) with transport infrastructure public policy priorities and with sector's stakeholders needs, including users. There is an urgent need to incorporate innovation in the market regarding transport infrastructure and policy can strongly promote this change. If this measure is not adopted and research and innovation is not considered from an integrated perspective in transport infrastructure policy, the transformation of the transport system into a multi-modal, inclusive, seamless and safer one would be slower.

However, this is a group of actions that is costly as it targets a broad cross-section of transport communities from different countries and roles (public institutions, industry, regulators, consumers, financing agents, etc.), transport modes or links of the value chain, with different needs and perspectives, interests and capacities. The challenge is to reach a consensus on priorities, action lines, sources of funding, application conditions of funding, etc. This is time-consuming and major efforts are needed in terms of monetary resources, manpower and governance. Nevertheless, the potential impact of such action is high as it could lead to substantial and long-lasting impact across the entire transport system, both at the European and national level. Thus, the adoption of technology and innovative solutions into infrastructure could contribute to a more efficient, effective, reliable, safer, etc. transport system generating substantial economic value and multiplier effects for quite a large number of stakeholders (investors, operators, research and innovation institutions and end-users). Experts

consulted stated the high benefits these actions offer, and medium costs to adopt them.

(A4) R&D of innovative tools for infrastructure life cycle management. Knowledge generation on transport infrastructure life-cycle management models is medium-costly and also delivers medium-high benefits. The main costs are those related to the resources associated to RDI activities. The potential benefits of this action affect a big range of stakeholders of the transport sector as it aims at providing more accurate and reliable information as well as more balanced win-win transport infrastructure management models which will be useful for all of them. However, it is a precautionary action, necessary to minimise future barriers to the implementation of innovative infrastructure projects due to a high risk perception. According to the experts surveyed, these actions offer high benefits at medium costs.

(A5) Improvement and continued adaptation of the regulation and standard frameworks to the new transport infrastructure demand to boost innovation and technology in the sector. The enhanced standardisation process (A5a) is expected to speed-up the uptake of new technologies within transport infrastructure development. Eventually, it will benefit the stakeholders broadly along the infrastructure value-chain, i.e. construction sector, infrastructure operators, maintenance, and end-users. As the benefits are not immediate, the enhanced process may not be seen as beneficial by all stakeholders. Appraisal of new technologies and innovation may lead to resistance, e.g. in terms of safety concerns. Similarly, moving away from normative regulation towards performance-based standards is likely to create resistance. The timing of standardisation is another aspect complicating the process as the regulation and standards should better incorporate new technologies and at the same time be based on mature, consensus knowledge, not on recent, untested research outcomes. The regulatory framework guiding transport infrastructure construction, maintenance and demolition is a continuous and persistent task whose benefits are only realised over a long time perspective. The work towards second generation Eurocodes⁶⁸ already incorporates many of the recommended thematic aspects (e.g. energy efficiency, recyclability, retrofitting, climate resilience, etc.) and functional aspects (simplification, ease of use, reduction in number of Nationally Defined Parameters (NDPs), wide stakeholder involvement, etc.), and in this sense the work towards enhanced standardisation is already on-going and does not involve large extra costs. The importance of those initiatives cannot be stressed enough. The timing of standardisation is another aspect complicating the process as the regulation and standards should better incorporate new technologies and at the same time be based on mature, consensus knowledge, not on recent, untested research outcomes. According to the stakeholders surveyed, this action is considered to have high benefits but also high costs.

The implementation of Eurocodes (A5b) is done on a voluntary basis and thus progress varies across Member States. It is crucially important that the benefits of a single market for transport infrastructure development are clear to all: the protection of national/local markets may act as a barrier for new investments and slowdown the technological development, leading eventually to higher costs of transport infrastructure use. The Joint Research Centre (JRC) has a 3-year programme (2015-2017) for “Administrative Arrangements on support to policies and standards for construction” with DG GROW. It encompasses the objectives of further harmonisation of policies and technical tools in the field of sustainable construction (IT support, implementation support, new fields of application and resource efficient construction) and promotion of the construction sector outside the European Union. Most likely

⁶⁸ JRC (2017) The EN Eurocodes. Available: <http://eurocodes.jrc.ec.europa.eu/home.php>

many of the suggested actions may already be covered by the JRC support, thus reinforcing the role of transport infrastructure specific needs is not expected to involve large additional costs, whereas the benefits of regulatory compliance are large.

Involvement of industry (A5c), especially actions engaging SMEs better to standardisation processes (e.g. awareness raising, training, transparent information, expert support, etc.) is considered to enhance the incorporation of innovative technologies to transport infrastructure development and lead to significant benefits resulting from more optimal standards. Apart from support of European Technology Platforms and national standardisation bodies, gearing H2020 calls to better incorporate standardisation will encourage industry involvement in standardisation. Improved collaboration within the value chain of the sector would also facilitate the development of cross-industry standards, e.g. in the field of alternative fuels infrastructure.

The role of research infrastructures (A5d) as platforms or test-beds for performance and feasibility assessment of new standardised concepts and harmonisation of standards is considered to provide significant benefits and although support measures are needed, it is not expected to involve significant costs. Both of the actions (A5c and A5d) were reported as high benefit-medium cost actions by the SINTRAS stakeholder survey.

(A6) Optimisation and compatibility of the existing management systems. The design of compatible and optimised management systems (A6a) is a necessary, but not sufficient precondition to achieve the intended impact. For that, special attention needs to be paid to the efficient and effective implementation of the enhanced management systems (A6b). Otherwise, the benefits and expected impact of this sub-action would be minimised. The main costs associated with compatible and optimised management models and approaches are those related to the resources associated to the design and implementation of the systems. There are many missing links between the networks of the Member States. Multi-modal platforms, linking the various transport modes, such as transshipment platforms in ports and airports or rail-road terminals, also need important further development. Even if they all agree on the relevance of optimisation and compatibility of the existing management systems, the challenge is to get an agreement on the way of doing so, establish priorities, etc. This requires high levels of European commitment and involvement of a large number of stakeholders. Thus, this action is very likely to provoke debate. What to do is quite clear but there are different interests between all involved stakeholders so is likely to generate debate or resistance. When considering the potential benefits of this action, these affect a wide range of stakeholders of the transport infrastructure sector. The capacity to increase connectivity by achieving a better interconnected transport system is recognised as a major game-changer for European transport. Smarter infrastructure has direct benefits in providing a safer and more secure transport system and simultaneously ensuring efficient services. For all these reasons, the agents consulted consider that these actions will have high benefits and high costs.

(A7) Piloting research, development and innovation. A large-scale pilot RDI infrastructure establishes a pan-European common instrument to accelerate the adoption of novel technologies and innovation. This could lead to substantial multiplier effects and generation of economic value for various stakeholders and could be seen as a big step forward to better comply with mobility demand and current relevant requirements in terms of safety, quality, energy efficiency, connectivity, etc. In this sense, benefits are considered high and widely appreciated. The main costs regarding investments in a large-scale pilot infrastructure and trial centre are linked to the allocation of financial resources. For this, cross-Europe cooperation is required. According to the stakeholders consulted the cost of a large scale pilot RDI infrastructure requires medium European funding and implies the adoption of a more

sophisticated benefits model. Benefits are considered high, especially in the short and medium term.

(A8) Development of diffusion initiatives to increase the awareness of the key role of transport infrastructures for the economic growth and quality of life amongst all stakeholders. This action is also a key facilitating activity, supporting the successful implementation of other actions included in the Focus Area 2 action plan. It aims at raising the awareness of the relevance of improving the cross-border connectivity, resilience and efficiency of European transport infrastructures amongst all the stakeholder communities, leading to the rest of actions to be welcomed more widely. This diffusion action is less likely to provoke resistance, as the steps to implement it are quite clear. Given its role as a key facilitating activity, it is considered to have a substantial impact in the infrastructure transport sector and to be a big step forward, supporting the necessary structural changes related to societal mind-sets, towards a culture conscious of the benefits of sustainable, integrated and connected transport infrastructure. However, it is a type of action for which it is difficult to identify and appreciate the direct benefits and immediate outcomes. Experts surveyed stated the high levels of benefit of this type of diffusion activity, at medium cost.

3.5 Prioritisation

Amongst the actions described above, the highest priority should be given to those which offer an attractive benefit-to-cost ratio (in particular, those which impact the entire European transport system) and which are urgent or will yield results in the relatively short term. Urgent actions are especially important if they will unlock a series of positive changes. Short-term results are important as they will quickly demonstrate that the efforts to transform the European transport system are paying off. This will help to build momentum and continued support for change.

The second priority should go to actions which still offer an attractive benefit-to cost ratio but which will yield results in the medium to long term. These actions are important because they yield valuable results; but, as they need to persist for some time before the results become visible, they will be less effective in building momentum and support.

The third priority actions are those which yield less attractive benefit-to-cost ratios. For example, the benefit of such actions, while still substantial, may be limited to an individual issue or a narrow group of stakeholders. The results of such actions, whether short- or long-term, will have less impact on the functioning of the European transport system as a whole.

Based on the discussions of timing and cost-benefit in the previous sections, we propose the following prioritisation of actions. Within each group, we list actions in decreasing order of priority:

Table 8. Action prioritisation

Priority 1: Attractive benefit-to cost ratio and urgent or short term results	
A1a	Development of a shared long-term vision and strategy
A2a	Design the new innovative financial instruments
A2bc	Attracting public private financing
A3a	Improve the alignment of RDI funding allocation and instruments (at the European level)
A5a	Enhanced regulation and standardisation process (appraisal of innovation, timing, performance-based, utilising web-based platforms, coordination with international processes)
A5b	Implementation of Eurocodes

Priority 2: Attractive benefit-to-cost ratio and medium- to long-term results

- A1b Promotion of open innovation dynamics across the transport infrastructure value chain agents
- A1c Encouragement the leading role of regions and cities in cross-border projects
- A4a Research and development of innovative tools for infrastructure life cycle management (at the European level)
- A4b Adaptation and promotion of innovative tools for infrastructure life cycle management (at the national level)
- A4c Research and development of innovative tools for infrastructure life cycle management (at transport sector level)
- A5c Joint definition of standards
- A5d Implementation of regulations and standards by Member States and involvement of industry in the processes
- A6a Design of compatible and optimise management systems
- A6b Implementation of compatible and optimised enhancements of the existing management.
- A7a Establishing a network of large scale pilot RDI infrastructure
- A8a Development of broader diffusion initiatives targeted at Member States, industry and final users
- A8c Development of diffusion actions of new mobility patterns amongst citizens

Priority 3: Less attractive benefit-to-cost ratio

- A3b Better alignment of RDI funding allocation and instruments (at the national level)
- A8b Promotion of the exchange of good practice amongst Member States

3.6 Key performance indicators

In order to measure the impacts of the FA2 Actions (A1 to A8), key performance indicators (KPIs) along the four impact pathway steps (Effort-Action-Outcome-Impact) are shown in following Table⁶⁹. The KPIs measure the success of implementation of the proposed actions and evaluate the achievements during the whole innovation path from R&D to diffusion. This approach results in four measurable KPIs for each action.

⁶⁹ See elaboration of assessment framework for monitoring and evaluation in Chapter 1, Figure 4

Table 9. Focus Area 2 key performance indicators.

Effort-KPIs	Action-KPIs	Outcome-KPIs	Impact-KPIs
(A1) Resources for reinforcing a shared long-term strategy and stakeholders' agreement and commitment [€]	(A1) Ongoing initiatives carried out to reinforce the integrated strategy and stakeholders' agreement and commitment [number]	(A1) Long-term strategies defined at EU level based on the stakeholders' agreement and commitment [yes/no]	(A1) National and regional strategies defined aligned with the EU long-term strategy [number]
(A3) Resources (monetary and person-month) devoted to boost the development and implementation of transport infrastructure policies oriented to the adoption of innovative solutions or new technologies [€]	(A3) Completed specific transport infrastructure policies oriented to the adoption of innovative solutions or new technologies finally adopted [number]	(A3) Increase in the number of TEN-T transport infrastructure projects adopting new technologies and/or innovative solutions [%]	(A3) Improved evaluation results in terms of reliability, capacity utilisation, safety, environmental performance, multimodal transport effectiveness, cost-efficiency of transport infrastructures [%]
(A4) Monetary and human resource investments for RDI and transference of knowledge and results activities in the fields [€]	(A4) RDI and transference of knowledge and results activities supported by the European Commission on transport infrastructure life cycle management models and approaches [number]	(A4) TEN-T transport infrastructure projects adopting innovative tools for infrastructure life cycle management [number]	(A4) Improved evaluation results in terms of reliability, capacity utilisation, safety, environmental performance, multimodal transport effectiveness, cost-efficiency of transport infrastructures [%]
(A5) Resources for process design, tool-box, support and monitoring [€]	(A5) On-going regulation/standardisation processes applying enhanced elements [number, %]	(A5) Uptake of new regulation/standards nationally/European-wide/globally [yes/no or number]	(A5) Faster technology uptake and more harmonised and simplified European regulation/standards [yes/no]
(A7) Investments in pilot infrastructure trial centres [€]	(A7) On-going initiatives of trial centres development [number]	(A7) Number of "quality-labelled" trial centres [number]	(A7) Speed up the implementation of technologies related to new and existing transport infrastructures [yes/no]
Effort-KPIs	Action-KPIs	Outcome-KPIs	Impact-KPIs
(A2) Resources for the further development of the new innovative financial framework (monetary, manpower) [€, number]	(A2) Establishment of European/local forums encouraging cooperation at both regional and European levels and the pooling of knowledge and information about PPP [yes/no or number]	(A2) TEN-T projects incorporating public funding and private financing [number]	(A2) New business models and financing instruments leading to enhanced investment level in the long-run [yes/no or number]
(A6) Resources for enhanced management interoperability systems (monetary, manpower, governance structures for cooperation, lessons learnt) [€]	(A6) Establishment of European forums for the exploitation of synergies and lessons learnt from the management systems of the transport modes, [%, number]	(A6) Main infrastructures with a fully interoperable system among countries [%]	(A6) Achievement of a single, fully interoperable transport system permitting seamless cross border connections between countries leading to significantly enhanced reliability, safety, capacity of the system, and cost savings [yes/no]
(A8) Resources for diffusion initiatives targeted at MSs, sector and final users [€]	(A8a) On-going diffusion initiatives [number]	(A8) Diffusion initiatives carried-out [number]	(A8a) National and regional strategies defined aligned with the EU long-term strategy [number]

Next, we list all KPIs per action, some of which are broken down to sub-actions in order to give more concrete examples within action groups. The potential units of measurement are shown in brackets after each indicator.

- **(A1)** Building a shared long-term strategy based on the stakeholders' agreement and commitment
 - Resources for reinforcing a shared long-term strategy and stakeholders' agreement and commitment [€]
 - Ongoing initiatives carried out to reinforce the integrated strategy and stakeholders' agreement and commitment [number]
 - Long-term strategies defined at European Union level based on the stakeholders' agreement and commitment [yes/no]
 - National and regional strategies defined aligned with the European Union's long-term strategy [number]
- **(A2)** Innovation in financing instruments
 - Resources for the further development of the new innovative financial framework (monetary, manpower) [€, number]
 - Establishment of European/local forums encouraging cooperation at both regional and European levels and the pooling of knowledge and information about PPP [yes/no or number]
 - TEN-T projects incorporating public funding and private financing [number]
 - New business models and financing instruments leading to enhanced investment level in the long-run [yes/no or number]
- **(A3)** Alignment of RDI funding allocation and instruments (at European and National level) with transport infrastructure public policy priorities and with sector's stakeholders needs, including users
 - Resources (monetary and person-month) devoted to boost the development and implementation of transport infrastructure policies (integrated strategies, funding instruments, regulations) oriented to the adoption of innovative solutions or new technologies [€]
 - Completed specific transport infrastructure policies (integrated strategies, funding instruments, regulations) oriented to the adoption of innovative solutions or new technologies finally adopted [number]
 - Increase in the number of TEN-T transport infrastructure projects adopting new technologies and/or innovative solutions. (New technologies or innovative solutions and advantages provided by them should be clearly identified in project description documents) [%]
 - Improved evaluation results in terms of reliability, capacity utilisation, safety, environmental performance, multimodal transport effectiveness, cost-efficiency of transport infrastructures [%]
- **(A4)** R&D of innovative tools for infrastructure life-cycle management
 - Monetary and human resource investments for RDI and transference of knowledge and results activities in the fields [€]
 - RDI and transference of knowledge and results activities supported by the European Commission on transport infrastructure life-cycle management models and approaches (life-cycle cost and cost benefit analysis, risk sharing and business models, impact assessment methodologies, "key performance indicators") [number]

- TEN-T transport infrastructure projects adopting innovative tools for infrastructure life cycle management [number]
- Improved evaluation results in terms of reliability, capacity utilisation, safety, environmental performance, multimodal transport effectiveness, cost-efficiency of transport infrastructures [%]
- **(A5)** Improvement and continued adaptation of the regulation and standards frameworks to the new transport infrastructure demand to boost innovation and technology in the sector
 - Resources for process design, tool-box, support and monitoring [€]
 - On-going regulation/standardisation processes applying enhanced elements [number, %]
 - Uptake of new regulation/standards nationally/European-wide/globally [yes/no or number]
 - Faster technology uptake and more harmonised and simplified European regulation/standards [yes/no]
- **(A6)** Optimisation and compatibility of the existing management systems
 - Resources for enhanced management interoperability systems (monetary, manpower, governance structures for cooperation, lessons learnt) [€]
 - Establishment of European forums for the exploitation of synergies and lessons learnt from the management systems of the transport modes, [%, number]
 - Main infrastructures with a fully interoperable system among countries [%]
 - Achievement of a single, fully interoperable transport system permitting seamless cross border connections between countries leading to significantly enhanced reliability, safety, capacity of the system, and cost savings [yes/no]
- **(A7)** Piloting research, development and innovation
 - Investments in pilot infrastructure trial centres [€]
 - On-going initiatives of trial centres development [number]
 - Number of “quality-labelled” trial centres [number]
 - Speed up the implementation of technologies related to new and existing transport infrastructures [yes/no]
- **(A8)** Development of diffusion initiatives to increase the awareness of the key role of transport infrastructures for the economic growth and quality of life amongst all stakeholders
 - Resources for diffusion initiatives targeted at MS, sector and final users [€]
 - On-going diffusion initiatives [number]
 - Diffusion initiatives carried out [number]
 - National and regional strategies defined aligned with the European Union’s long-term strategy [number].

4 Focus Area 3. Smart mobility services (including provision and use of data, and urban mobility), freight and logistics

4.1 Overview

In the SINTRAS study, Focus Area 3 “Smart mobility services” has been defined as follows:

The field of Smart Mobility Services (SMS) refers to the application of Information and Communication Technologies to the transport sector through an integrated and multi-modal perspective. Smart Mobility Services are already applied across the European Union – but in a fragmented manner, in mono-modal instances, in geographically isolated domains and incompletely. Although the Intelligent Transport Systems industry is highly innovative and competitive, use of scarce public and private resources remains inefficient. The essence of this Focus Area 3 is the collection of data⁷⁰, its interpretation, processing and real-time provision as relevant and reliable information to individual transport participants. The underlying purpose of such Smart Mobility Systems is the better use of existing infrastructure, time and financial savings, a reduction of emissions, congestion and accidents and the smooth integration of various modes of transport into inter-modal trips. The users of SMS get equipped with better information or stimuli to make better, more rational choices, for example, about which mode to use, about driving times, styles, speeds and routes, whether to use public transport or a shared vehicle, a conventional or electric vehicle, where to park or where to charge an electric vehicle and so forth. Some human decisions do not even have to be made cognitively if, for example, drivers get presented with dynamic “green waves”.

For these reasons and because Smart Mobility Systems exist in very diverse areas, we differentiate the following thematic areas within Focus Area 3:

1. Data quality, standards and availability
2. Mobility as a Service (MaaS)
3. Multi-Modal Information and Ticketing Systems (MMITS)
4. Smart City Logistics
5. Synchromodality
6. E-Freight

Data quality, standards and availability are vital in providing smart (multi-modal) travel information. The availability of information about travel time and routing alternatives is considered to be the most important element to foster a modal shift and encourage a change in travel behaviour. This requires comprehensive, accurate and reliable travel information on all possible travel options. Multi-modal travel information should provide travellers with a wide range of real-time travel options based on multiple modes of transport, ideally across Europe so they can make well informed travel decisions. This thematic area is a prerequisite to effective Mobility as a Service (MaaS).

⁷⁰ Data from various sources like public transport timetables, the location and availability of shared vehicles, tarmac-embedded induction loops, floating-car-data, environmental measurements, etc.

Mobility as a Service (MaaS) refers to the purchase of mobility services as packages based on consumers’ needs instead of buying the actual means of transport. Traditionally, mobility has been provided for by managing fleets of vehicles around networks framed by strategic transport planning objectives. MaaS turns this traditional concept on its head by putting the customer first and framing the mobility systems around customer preferences (CATAPULT 2016). MaaS platforms provide an intermodal journey planner, a booking system, easy-payment and real time information. MaaS is only an emerging concept and not yet very widely used in practice.

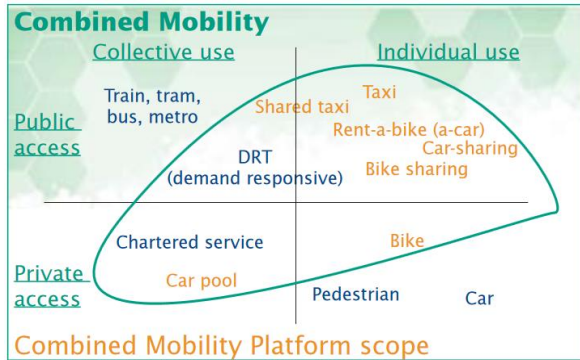


Figure 10. MaaS diagram⁷¹

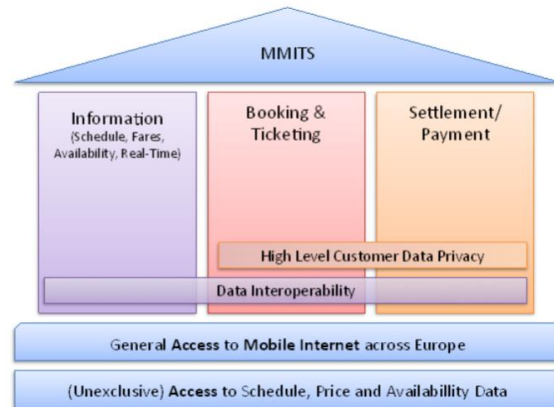


Figure 11. MMITS pillars⁷²

The ultimate goal of MaaS is the development of a European multi-modal journey planner. Applications to provide passenger with information before and during the journey, reservation and payment systems and management of connections between trains and with other modes of transport are usually referred to as **Multi-Modal Information and Ticketing Systems (MMITS)**. This key area refers to the usage of multi-modal journey planners to get from A to B — typically on the web — which can save people time and money, and perhaps also help to promote sustainable modes of transport and competition between modes. The modal shift facilitated by MMITS will lead to further positive effects with estimated costs savings of around 13 billion € per annum, and will allow investments in infrastructure and capacity, thus further increasing efficiency. Public transport can especially benefit from MMITS by creating and making available completely new travel options to existing and new users. As the City of Lyon has demonstrated, multi-modal information provision is by far the most cost-efficient way of reducing CO₂ emissions in cities, with 10€ invested per tonne CO₂ saved⁷³.

Freight and logistics services are also expected to benefit from innovative Smart Mobility Services, primarily through the better use of existing track, road, storage, vehicle and staff capacities. This effect is facilitated by a better overview about the type, weight, size, handling need, location and destination of goods in combination with information about the mobile and stationary infrastructure required for its delivery. Applications for freight services include, information systems (real-time monitoring of freight and trains), allocation systems, reservation, payment and

⁷¹ Source: UITP. <http://www.uitp.org/sites/default/files/cck-focus-papers-files/FComMob-en.pdf>

⁷² See: <http://ec.europa.eu/transport/themes/its/studies/doc/20140812-july9thversion-awtfinalreport.pdf>.

⁷³ Urban ITS Expert Group (2013): Guidelines for ITS deployment in urban areas http://ec.europa.eu/transport/themes/its/road/action_plan/doc/2013-urban-its-expert_group-guidelines-on-multimodal-information.pdf

invoicing systems, management of connections with other modes of transport and generation of electronic documents. This applies for long-distance freight (**Synchromodality**) as well as urban deliveries/ first and last mile deliveries (**Smart City Logistics**). Synchromodality is the flexible and sustainable deployment of different modes of transport in a network under the direction of a logistics service provider, so that the customer is offered an integrated solution for the transport of goods. The decision on the mode(s) of transport to be used is left to the logistics service provider who has the flexibility to seamlessly switch between modalities. This applies to both the planning of transport and dealing with unexpected circumstances just before or during the transport. Synchromodality would also allow for the consolidation of consignments of cargo, thus achieving additional efficiency benefits.

Through the application of ICT tools, all freight stakeholders should be able to track and trace freight across transport modes and to automate the exchange of freight data (paperless documentation with electronic information flow linked to the physical flow of goods), usually referred to as **E-freight**.

Currently, road haulage dominates freight logistics with a market share of around 45% of total freight transport. Advances in technology are needed to integrate freight transport modes more efficiently and to overcome the complexity of multi-modal supply chains, which is considered a major barrier compared to the single-mode, door-to-door road delivery.

Progress in these areas calls for joint decisions and actions by stakeholders from the passenger and logistics world, at the European, national and regional levels. The thematic actions described later in this document need to be complemented by strategic actions across the themes contributing to the following issues:

- Fragmentation within the scope of this Focus Area is an issue in general, as identified at the stakeholder consultation days. Both in the world of passenger as well as freight transport, the services offered to customers and users suffer from being highly fragmented. This is, first and foremost, visible when looking at the realm of Multi-Modal Information and Ticketing Services which are still in their infancy even though the technology is there. The Digital Transport and Logistics Forum is a good starting point to reach more cooperation amongst logistics stakeholders but much more work is needed to be able to offer truly integrated services.
- Currently, there are still gaps in relation to data needed for Smart Mobility Services. Overall, the results from our consultation days showed that both the public as well as the private sector can and should take more action regarding data-quality, accessibility, and availability, as these are the underlying components which serve as the foundation for smart mobility services. For new business models and services to emerge in passengers transport, the public sector needs to ensure a minimum data quality with interoperable standards across data-sets. This could be solved by national data and management contact points, operating as clearing houses. Likewise, cities need to take more action in the realm of urban logistics. Environmental key performance indicators could help in this context as they would allow for the introduction of transparent and fair interventions for a better internalisation of the external costs of logistics and freight; they could also be a cornerstone of measures by public authorities to stipulate logistics performance standards such as the bundling of freight, in order to improve load factors and reduce delivery runs.
- Overall, policies in the field of Smart Mobility Services should be more aligned with the European Union's goals regarding environmental sustainability and climate protection. As was pointed out by many stakeholders, currently, there is a lack of coherence among European Union funding programmes (e.g. focus

on heavy infrastructure instead of soft measures) and climate protection is not used to its fullest as a European Union instrument. Also, improving the conditionality of funding is necessary in order to support policy goals in the field of Multi-Modal Information and Ticketing Services or sustainable logistics (as is, for instance, already the case with Sustainable Urban Mobility Plans or European Regional Development Fund funding).

- Establishment of a global view on the state of play of Multi-Modal Information and Ticketing Services covering all transport modes and new sharing services and their future prospects. Currently, a wider picture of Multi-Modal Information and Ticketing Services and their development is missing in Europe.

For Focus Area 3, 11 barriers were identified during early work on the SINTRAS project. The elaboration for each barrier can be found in the annex. This list was further condensed to the following seven key barriers characterising the current field of Smart Mobility Services, as several barriers could be merged with others to higher aggregation levels due to their similarities and synergies:

- Barrier FA3-(A1+C1) Weak cooperation between transport operators and other relevant stakeholders
- Barrier FA3-(A2+A5+B2) Scarcity of high-quality data, gaps in data standards and scarcity of open data
- Barrier FA3-(A3) Over-emphasis of investments in infrastructure and hardware and disregard of soft measures
- Barrier FA3-(A4+C2) Little coordination of data management and exchange between and within Member States
- Barrier FA3-(B1) Poor modal integration at system and data level
- Barrier FA3-(B3) Gaps in existing regulation and funding schemes for smart mobility services
- Barrier FA3-(C3) Insufficient consideration for eco-performance

These seven key barriers are also illustrated as the present situation in *Projected Development for Focus Area 3* (Figure 12 **Error! Reference source not found.**). All eleven individual barriers (i.e. the disaggregated list) are presented below:

General barriers (A)

- Barrier FA3-A1: Stakeholders do not collaborate well with each other hampering the development of integrated payment services)
 - Relevant stakeholders on multiple levels are not collaborating well with another. For instance, inter-departmental conflicts and silo-thinking tends to hamper better collaboration of different public authorities. Often public policy lacks a more holistic vision and clear incentives to work across various departments. This lack of collaboration and coordination holds also true for the various infrastructure owners, the different public transport operators and industry actors. In the context of Smart Mobility Services this means that although new public transport information and booking services manage to cover information on several travel options, they do not yet cover the option of payment.

- Barrier FA3-A2: Insufficient availability of data (lack of open data)
 - A big challenge is to make transport data publicly available including geographical coverage, real-time information, transport modes, etc. as well as to ensure high quality and up-to-date data. Currently however, many travel and traffic data needed for comprehensive European Union-wide smart mobility services are not readily available. Underlying root causes are related to: (1) high costs in polishing data, converting data into appropriate formats and making them available; (2) little knowledge about benefits of making data publicly accessible; (3) lack of incentives to make data publicly accessible; and (4) constraints of existing data protection laws.
- Barrier FA3-A3: Over-emphasis on hardware and infrastructure and undermining of the benefits brought by integration of (real-time) data in spatial/ urban planning
 - There is an obstacle in utilising real-time data-based spatial and urban planning. Spatial/urban planning in the European Union is often based on data that is already quite outdated. In order to move towards a more dynamic planning culture, more real-time data needs to be incorporated into planning. This also has to do with the prioritisation of efforts and money. Data and data collection is seen as a 'nice-to-have' and not as essential for the daily operation. Also, the focus in transport is often on investing on heavy infrastructure and hardware on- and off-street, not so much on soft measures. This can, for instance, be very well observed in the case of TEN-T which is, by and large, conceived as an infrastructure programme in which service provision and ITS service deployment has only a marginal presence.
- Barrier FA3-A4: Fragmented responsibility and/ or lack of coordination with respect to transport-related data management and digital services
 - Even though each European Union Member State has a national ITS office, there is little coordination with respect to smart mobility services and data-related aspects between and within Member States. In many Member States, there are several ministries (fragmented) in charge of different aspects of Smart Mobility Services (SMS), as SMS cover a wide range of transport modes as well as both passenger and freight services. Often the ministries themselves do not even have a department that is mainly responsible for the application of SMS, data, digital services etc. . In order to allow for European Union-wide multi-modal journeys (both passenger as well as freight-related), it is essential for service providers to know where the required travel data is stored and how it can be re-used.
- Barrier FA3-A5: Systems, services and data lack interoperability (lack of standards)
 - The lack of interoperable data formats, protocols and interfaces requires the development or definition of data formats and standards that ensure flexibility and the promotion of interoperability. There are standards available but these are not coherently used across the European Union. Establishing better interfaces between transport modes would not only improve the organisation of transport and mobility solutions, but help to create robust business models for supplying information and services

Mobility-as-a-Service (MaaS) and Multi-Modal Information and Ticketing Systems (MMITS) barriers (B)

- Barrier FA3-B1: New mobility services, such as car-, ride or bike-sharing, are barely integrated in MMITS
 - MMITS need to include the information provided by these new sharing services in order to give users a complete set of mobility options. In order to allow for more integrated MMITS, urban data sets need to be standardised. To facilitate interoperability of software from one country to another, more effort should be dedicated towards the standardisation and architecture for multi-modal datasets. Additionally, to facilitate overcoming this barrier, the transport stakeholders in Member States need to further improve their strategies on a system level with regards to multi-modality.
- Barrier FA3-B2: The quality of data is insufficient making Multi-Modal Information Systems very inconvenient
 - The quality level of transport-related data in terms of how up-to-date, accurate, accessible, reliable and timely the information is given to the traveller is inconsistent across Europe. It is essential that basic levels of service quality are consistent across the European Union to ensure traveller satisfaction and their continued use of MaaS-related services. Although in some Member States there are certain regulations on how often data should be updated and how to ensure accuracy and reliability etc., this practice is not widespread across the European Union, resulting in fragmented service quality.
- Barrier FA3-B3: Gaps in existing legislation and funding schemes for on-demand mobility services require new legislation and funding schemes
 - New mobility solutions that involve on-demand services differ very much from the traditional concept of public transport. Often liability systems, public transport laws and regulations prevent the funding of shared services. One example is the question whether it should be legal for a PT provider to pay for two people using the taxi when this is cheaper than operating a whole bus? Another example is the introduction of car-sharing which in many countries was held back because of existing parking regulations. The question remains as to how can regulations and laws be adjusted so that on-demand and sharing services can be facilitated?

Smart City Logistics, Synchronomodality and e-Freight barriers (C)

- Barrier FA3-C1: Logistics Sharing: the bundling of freight does not materialise due to a lack of cooperation and trust among the logistics stakeholders
 - Currently, it is difficult to develop new services and create synergies due to the reluctance of big logistics players to share their data. Also, the lack of knowledge about load factors and complementary incentives to increase these prevents the combination of logistic flows. Companies, such as parcel deliveries, are reluctant to share vehicles due to branding problems. Improving interaction between logistics stakeholders to enhance the potential for horizontal cooperation and fostering synergies is seen as crucial. This would result in an increase of load factors, a reduction of empty movements and a stimulation of co-modality which would ultimately make delivery more efficient.

- Barrier FA3-C2: Little work towards a freight system based on synchromodality, including a lack of use of ICT and data governance
 - A prerequisite for synchromodality is the integration of information technologies that can show capacities and free resources, predict waiting and handling times and manage slots and workflows. The barrier is that many hubs are not yet well developed in terms of ICT and communication between logistics operators is limited, despite the fact that the amount of data that passes through hubs is large. Thus, to surpass this challenge, a common platform needs to be designed to coordinate synchromodal transport chains. This should be able to answer how information can be better synchronised and made available to other operators such that shipments can be bundled and switched more flexibly.
- Barrier FA3-C3: No internalisation of environmental impacts of logistics operations (eco-performance)
 - It is considered very important to improve the eco-performance of logistics operations in terms of energy use and emissions and incorporate these values into traditional KPIs, such as costs, service performance and effectiveness. In recent years a wide range of calculation methodologies, tools and emission factor databases have been developed without much coordination. This results in a situation in Europe in which it is difficult to compare the true environmental performance of different logistics operations with little compatibility between methodologies and databases (e.g. geography, sector, companies, etc.).

4.2 Projected developments

Figure 12 **Error! Reference source not found.** presents the projected developments for Focus Area 3. In the next subsections, we explain this graph in detail, layer by layer, using the numbers in parentheses when referring to specific boxes within. In the graph also the codes for identified barriers are used to link present-state items (boxes in grey) to specific Focus Area 3 barriers identified during the SINTRAS project. Projected changes are in light blue boxes.

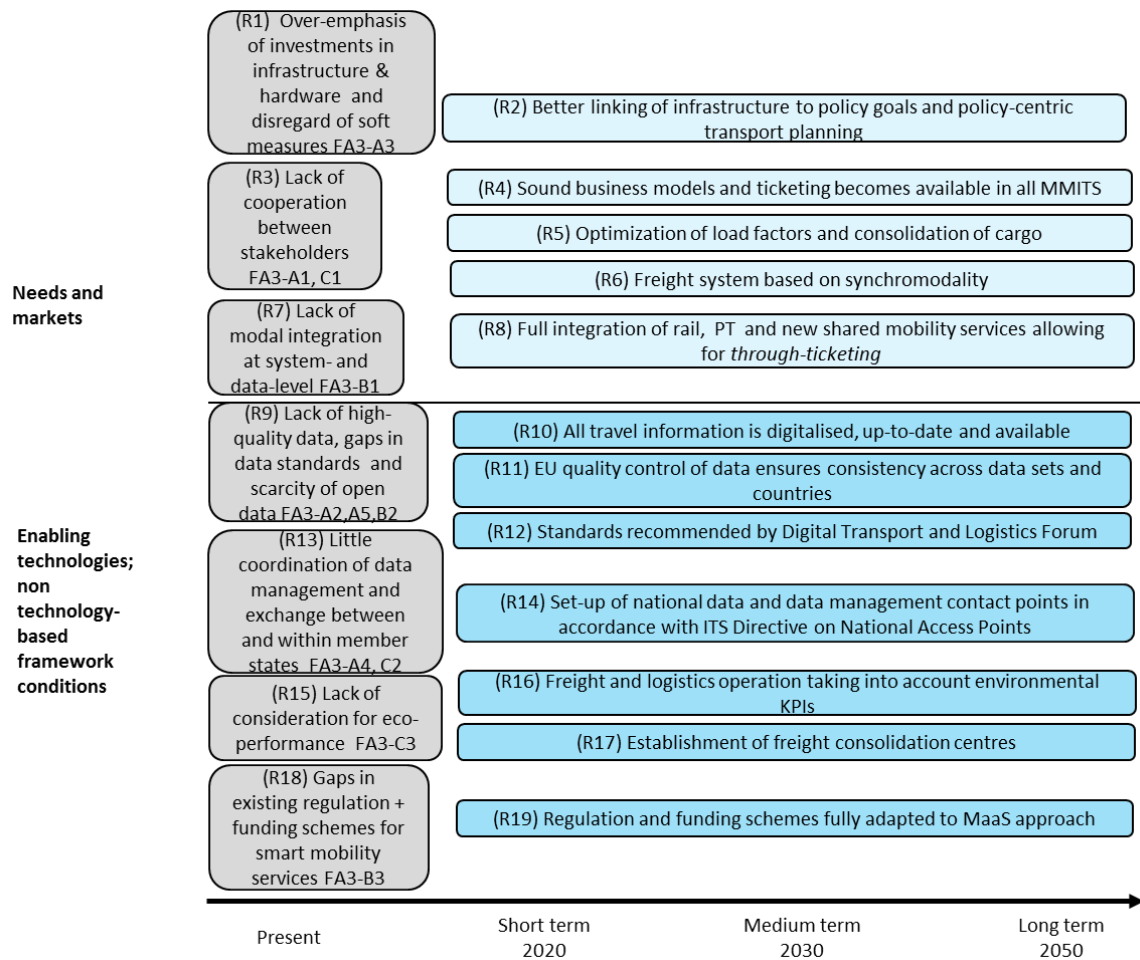


Figure 12. Projected developments in Focus Area 3.

4.2.1 Needs and markets

For Focus Area 3, the layer for **needs and markets** looks into matters of supply and demand for Smart Mobility Services, most importantly the availability of ticketing in MMITS to allow for the purchase of mobility packages as well as the optimisation of load factors in freight operation.

Current policy and operational practice tends to be characterised by an (over-) **emphasis on hardware and infrastructure (R1)**⁷⁴. As multiple stakeholders signalled, infrastructure lobbying is perceived as having a disproportionate impact on the formulation of policy goals and the allocation of resources. Soft measures, such as data and data collection, are seen as a ‘nice-to-have’ and not as essential for the daily planning operation. However, growing concerns among citizens regarding mega infrastructure projects, austerity measures and less availability of infrastructure funding raise questions concerning the long-term possibility and public acceptability of this practice. , This implies an opportunity to spawn a planning and policy culture

⁷⁴ Codes R and A provide cross-references to project developments (R) and proposed actions (A), defined in sections 4.2 and 4.3 respectively

shaped by the **better linking of infrastructure to policy goals and policy-centric transport planning (R2)**.

The present **lack of cooperation amongst transport stakeholders (R3)** and **lack of modal integration on a system- and data-level (R7)** make it impossible to put into practice the MaaS concept that relies on the idea of integrated mobility packages that cover the whole mobility chain irrelevant of the actual mode. However, currently MMITS only offer piecemeal information – not all services are offered and integrated – and several tickets have to be bought for one single trip – rail is rarely integrated with public transport nor with bicycle sharing schemes. **The development of sound business models, integrated travel information and ticketing becoming available in MMITS (R4)** is vital in the success of smart mobility services and would facilitate and support the **full integration of rail, public transport and new shared mobility services** (e.g. bike-sharing, car-sharing, car-pooling, etc.) **(R8)**. This full integration would strengthen the sustainable modes of transport since it allows for the through-ticketing of trips as well as avoid car-dependence and save transport emissions. Moreover, integrated multi-modal information is beneficial in achieving sound business models for the aforementioned integration. As a first milestone, it would be important that smart ticketing services (e.g. Oyster Card London) become available in all Member States, as some Member States currently tend to rely heavily on paper tickets.

For the world of logistics, a lack of cooperation among freight handlers can be noticed, which leads to low loading factors and prevents the more efficient delivery of goods in urban areas. These **load factors can be optimised through regional consolidation centres (R5)** and the joint delivery of goods through a neutral 3rd party. Likewise, the lack of modal integration between ship, train and truck in long-distance freight leads to a high dependency on truck haulage. If the decision on the mode(s) of transport to be used is left to the logistics service provider, who has the flexibility to seamlessly switch between modes, **a more synchromodal transport system can be achieved encompassing the consolidation of consignments of cargo (R6)**.

4.2.2 Enabling technologies; non technology-based framework conditions

For Focus Area 3, the layer for **enabling technologies and non-technology-based framework conditions** covers data-related questions (e.g. standards, quality, and availability) but also aspects such as necessary regulation changes and funding schemes.

Currently, there is a **lack of high-quality data and gaps in data standards⁷⁵ and interfaces between data sets from different countries (R9)**. Many travel and traffic data needed for comprehensive European Union-wide smart mobility services are not readily available and digitised. Often there are significant costs involved in gathering and/or converting travel and traffic information into a digital format for journey planning and information service purposes. Supposed obligations to open data sharing that would enable smart services could interfere with requirements of data

⁷⁵ As cited in Standards and actions necessary to enable urban infrastructure coordination to support Urban-ITS (2016, p.4): "Key issues identified by Urban Administrations as identified barriers to implementation of Urban ITS, where standards are needed to remove/reduce the barrier to the implementation of urban ITS are identified as follows: a) Awareness of what is available b) Location referencing c) Vendor lock-in d) Standards for "New Modes" and "new measures e) Data exchange/data management f) Immaturity of some concepts." For further details please see the report at <http://www.urbanits.eu/publicdocuments>

protection and control. The European Commission needs to assess the data obtained from service/data providers (i.e. operators and/or transport authorities) and **ensure that all travel information is digitalised, available, up-to-date, and accessible,(R10)** but also **improve quality control to ensure consistency across data sets and countries (R11)**. The level of quality of data should meet the Urban ITS Standardisation Mandate and needs to allow for interoperable usage by the relevant stakeholders. In the world of logistics, the Digital Transport and Logistics Forum (DTLF) was set up in 2015 to solve issues regarding non-interoperable standards, the lack of interconnected systems, not-recognised e-transport documents and the lack of shared data. Due to its recentness, the DTLF has not come up yet with suggestions and recommendations. However, it can be expected that the DTLF will work on standards regarding data exchanges and bring about more coordination in freight transport.

A crucial element currently missing regarding data quality and availability is the fact that there is **little coordination of data management and exchange between Member States but also within Member States (R13)**. To overcome this fragmented situation, Member States should clearly identify ministries, departments and staff that are to be tasked with data coordination resulting from transport. Even though each Member State has a **national ITS office**, these **do not yet function reliably and comprehensively as national data management contact points and clearinghouses (R14)**. A vital step towards achieving this is the European Union ITS Directive⁷⁶, which calls for Member States to set up national access points for the relevant travel and traffic data and priority action specifications. This is highlighted in the forthcoming priority actions 'a' (multi-modal travel information services) and 'b' (real-time traffic information)⁷⁷.

Eco-performance currently only plays a very marginal role in logistics and freight and is rarely considered in the daily operation of goods (R15). However, it is considered very important to improve the eco-performance of logistics operations in terms of energy use, use of (road) space, noise and emissions and incorporate these values into traditional KPIs, such as costs, service performance and effectiveness. Thus, **freight handlers and logistics stakeholders should take into account environmental KPIs in their operation of goods (R16)**. As a result of this, more information will be available on loading types, routes, vehicles and fuels as well as load factors. One solution to then improve efficiency is, for instance, the establishment of regional logistics platforms that would be run cooperatively by industry actors. Another solution would be **local consolidation centres from which a 3rd party would deliver goods from all logistic companies to avoid all individual delivery vehicles entering the city core (R17)**.

Currently, there are gaps in **existing regulations and funding schemes (R18)** which present an issue when it comes to new sharing services. These would offer the possibility to be integrated into public transport systems to widen the service and cover, ideally, the whole mobility chain. Quite often, liability systems, public transport laws and regulations prevent the funding of these new shared services (e.g. car-sharing, car-pooling). In order to overcome this, training on MaaS requirements should be developed as a first milestone to enable public authorities to best combine both public as well as private transportation services that cover actual travel needs. Ultimately, **current regulations and funding schemes should be adapted to**

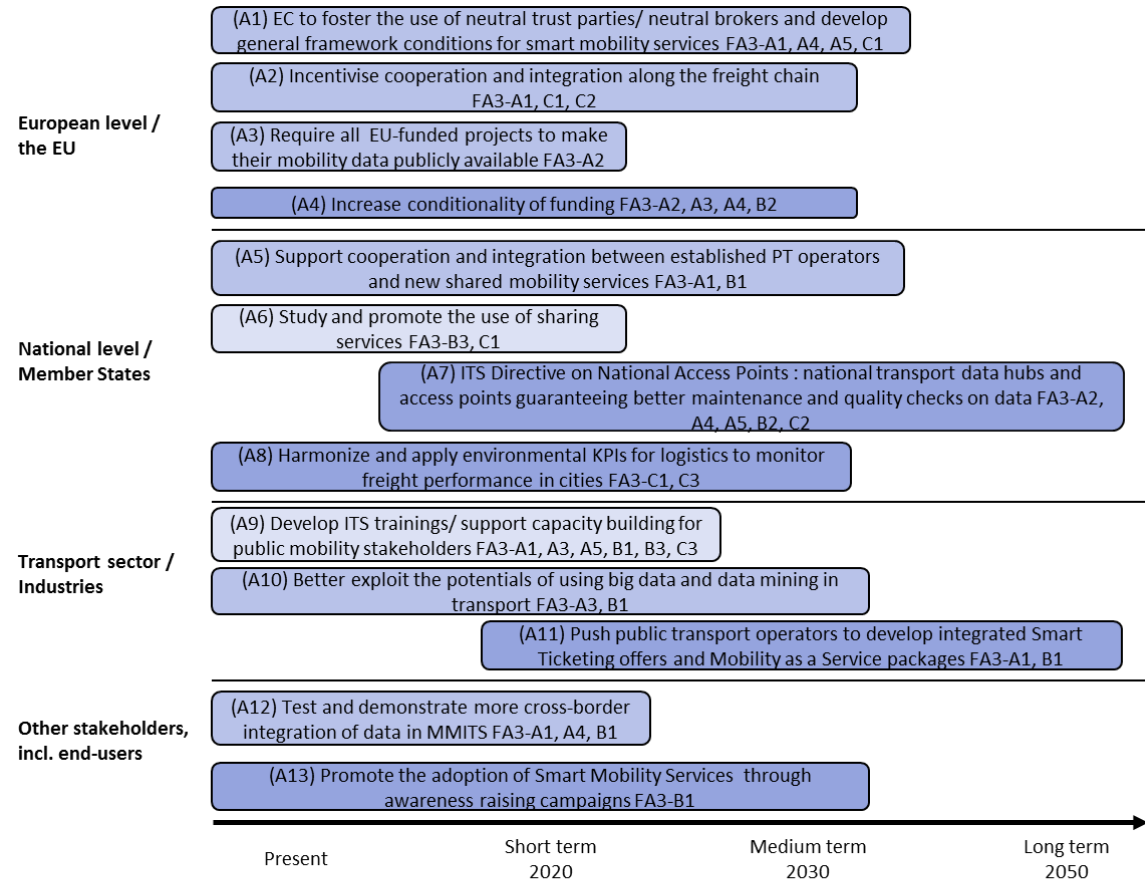
⁷⁶ For the details of ITS Directive 2010/40/EU see: <http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32010L0040&qid=1416937001320&from=EN>

⁷⁷ For details see: http://ec.europa.eu/smart-regulation/roadmaps/docs/2015_move_021_travel_info_services_its_en.pdf

allow for the use of sharing services as an integral part of mobility packages (R19).

4.3 Action plan

Figure 13 **Error! Reference source not found.** presents the proposed actions for Focus Area 3. In the next subsections, we explain this action plan in detail, layer by layer using the numbers in parentheses when referring to specific boxes within the action plan. In the action plan, the codes for identified barriers are also used to link items to specific Focus Area 3 barriers.



Box Colour Legend

- Research, development and innovation / Concept development
- Standardisation, regulation / Pilots and demonstrations
- Deployment / Implementation and Diffusion

Figure 13. Focus Area 3 action plan.

List of actions:

- (A1) EC to foster the use of neutral trust parties/ neutral brokers and develop a general framework condition to enable smart mobility services
- (A2) Incentivise cooperation and integration along the freight chain
- (A3) Require all European Union-funded projects to make mobility (i.e. travel and traffic) data and evaluation results publicly available

- (A4) Increase conditionality of funding
- (A5) Support cooperation and integration between established PT operators and new shared mobility services
- (A6) Study and promote the use of sharing services
- (A7) ITS Directive on National Access Points: national transport data hubs and access points, guaranteeing better maintenance and quality checks on data
- (A8) Harmonise and apply environmental KPIs for logistics to monitor freight performance in cities
- (A9) Develop Intelligent Transport Ssystem trainings/ support capacity building for public mobility stakeholders
- (A10) Better exploit the potentials of using big data and data mining in transport
- (A11) Push public transport operators to develop integrated Smart Ticketing offers and Mobility as a Service (MaaS) packages
- (A12) Test and demonstrate more cross-border cooperation in MMITS
- (A13) Promote the adoption of Smart Mobility Services through awareness-raising campaigns

4.3.1 European level

Generally speaking, cooperation among public transport operators (both privately and publicly managed) and freight handlers is possible but typically requires complex and well thought-through collaborative systems. The decision where and how much variation across Europe is appropriate and where harmonisation is essential but also questions regarding fragmentation among Member States should be addressed at the European level. The European Commission is therefore ideally placed to contribute to the overcoming of the current situation with its high degree of fragmentation and non-collaboration. The consulted stakeholders agreed that the **European Commission should foster the use of neutral trust parties/ neutral brokers, to facilitate collaborative activities, and develop a general framework conditions and enabling condition to enhance smart mobility services (A1)**. A study of regulatory, technological and financial aspects of collaborative structures and frameworks for smart mobility services should be initiated to learn more about requirements and best practices of neutral trust parties in Europe. These might prove to be a good idea in the case of data privacy issues, however, yet too little research is carried out and too little experience has been made in this field. Where successful neutral trust parties/ neutral brokers have already been established on a regional or national level, however, these should be supported financially and their experiences disseminated as best practice examples in Europe.

In the field of logistics, stakeholders suggested that **cooperation and integration along the freight chain should be more incentivised (A2)**. The European Union should support the initiation of local and regional round tables for freight handlers and stakeholders to tackle the issue of low load factors and foster the consolidation of cargo. To sustain cooperation and integration in the long-run, cities should be supported and incentivised to establish freight partnerships by developing Sustainable Urban Logistics Plans (SULPs). The same holds true for long-distance freight where the concept of synchromodality needs to be pushed further by developing more pilots, raising awareness about the concept and allocating more funding.

This goes hand-in-hand with **requiring all European Union-funded projects to make their mobility (i.e. travel and traffic) data and evaluation results**

publicly available (A3), as this is currently not made obligatory by the ITS Directive. A good initiative in this regard is the Open Research Data Pilot⁷⁸ (ORD Pilot) by the European Commission which aims to improve and maximise access to and re-use of research data generated by Horizon 2020 projects, while balancing openness with privacy concerns. The ORD Pilot only covered selected areas of Horizon 2020 projects for the work programmes 2014-16 and is being extended to the entire work programme of Horizon 2020. Starting in 2017, related Data Management Plans (DMP) are required for all Horizon 2020 projects that are participating in the Pilot. The DMP requires projects to make data *Findable Accessible, Interoperable and increase the data Re-use* (FAIR). First of all, all data being produced by funded projects should be provided to the public in an open data portal that is highly user-friendly, up-to-date and well-maintained and equipped with sufficient long-term funding. Once this data infrastructure is established, the DMP initiative should be extended to all European Union-funded projects (including INTERREG, LIFE, etc.), such that all evaluation results and data generated are open for citizens and businesses to use.

Another action to be taken on the European level is to **increase the conditionality of funding (A4)**. When funding ITS-related projects, vendor lock-in should be avoided, it should be ensured that staff receives sufficient training for long-term capacity building and that there is a robust, well thought-through and widely accepted institutional framework for ITS. Another option would be to link EBRD or EFRD funding to the development of data and ITS-related plans (similar to transport funding being linked to the existence of a high-quality Sustainable Urban Mobility Plan).

4.3.2 National level

European Union Directives and frameworks are largely implemented and put into action on the national level. Member States should **support the cooperation and integration between established public transport operators and new shared mobility services (A5)** in order to make intermodal travelling as smooth as possible. This close-knit cooperation should also, in-line with the MaaS principle, allow for the offering of mobility packages and integrated ticketing services. While this action targets the national level, it requires, first and foremost, the regional transport associations to better cooperate and integrate new shared mobility services.

Member States should also **study and promote the use of sharing services (A6)** to further incentivise and increase their usage. This should (initially) happen on the national level, since Member States have their own regulations and laws regarding, for instance, parking for car-sharing vehicles.

In order for new mobility services to emerge and to foster national but also European Union-wide integration, **national transport data hubs and access points should be set up to ensure maintenance and perform data quality checks (A7)**. The national transport data hubs need to be in line with the ITS Directive on setting up National Access Points for the actions listed as priority 'a' (multi-modal travel information services) and 'b' (real-time traffic information). While these data clearinghouses would be set up on a national level, the European harmonisation must be borne in mind early on in order to prevent sunk costs into nationally over-specific approaches. Although national contact points have already been set up (<http://itsnetwork.org/members/>), these are not yet sufficiently staffed nor given the remit to truly work as data clearinghouses. Another crucial requirement is that these clearinghouses must not only concentrate on automobile-related data, as this is

⁷⁸ http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf

currently sometimes the case (e.g. traffic information, road works, etc.), but truly cover all modes of transport, including real-time public transport information.

In the field of logistics, the stakeholder suggested Member States should **harmonise and apply environmental KPIs to monitor freight performance in cities (A8)**. Currently, the WBCSD set of indicators⁷⁹, which is officially endorsed by the European Commission to be used by European cities to measure their mobility footprint and analyse their performance in terms of sustainable mobility, does not include questions regarding the environmental operation of logistics in cities. The only two questions target the usage of package delivery services and the satisfaction with these. A truly comprehensive indicator set should also consider whether planning regulations targeting dimensions such as parking space, noise emissions or load factors are taken into account in freight planning, e.g. in the procurement of local freight distribution centres.

4.3.3 Transport sector

There is currently a lack of information and awareness regarding MaaS requirements in the transport sector. For that reason **ITS/ MaaS training (A9)** should be developed for public mobility stakeholders to increase awareness regarding Smart Mobility Services. This includes training on framework conditions, requirements of the ITS Directive, costs and benefits of ITS and well as technical knowledge. This action also implies other capacity building measures, such as, for example, peer exchanges.

Furthermore, regional and national transport associations, like ASSTRA in Italy or VDV in Germany, are not yet fully aware of the potentials of Big Data and data mining in transport. Thus, these actors need to better understand and push public transport operators to **exploit the potential of data in transport (A10)**. This requires working closely with privacy-protecting institutions and customer/ passenger associations to ensure a good understanding about data protection and the dangers of data misuse and hacking.

The wider use of Smart Mobility Services in Europe also requires partnerships of public and private stakeholders at national levels. **Public transport operators should be pushed to develop Smart Ticketing offers and Mobility as a Service (MaaS) packages (A11)** in cooperation with new, and often private, sharing services. Services such as contactless payment, smart cards, direct payment with credit card or smartphone/app-based tickets need to become available in all Member States to generate more data, make intermodal travelling smoother and make payment easier. This importance of Smart Mobility Services should also be more reflected in the tendering process in which the integration of these new payment forms and shared services should become crucial, while at the same time avoiding vendor lock-ins and considering data privacy issues.

4.3.4 Other stakeholders

Cities and regions play a key role in the implementation and up-take of Smart Mobility Services. These are particularly important in border regions where integrated MMITS across countries have a direct effect and a locally high impact on people. In order to ensure more integration and compatibility, more **cross-border data integration projects need to be tested and demonstrated in MMITS (A12)** to fully allow commuters and tourists to travel across countries multi-modally. These tests and

⁷⁹ <http://www.wbcd.org/Projects/Sustainable-Mobility-Project-2.0/Resources/SMP2.0-Sustainable-Mobility-Indicators-2nd-Edition>

demonstrations should work complementarily as a bottom-up process to the European Union's advancement of the single European journey planner.

Finally, to achieve wider usage of Smart Mobility Services, broad user acceptance is required. Citizens should be provided with quality and trustworthy information so as to endorse the technological changes brought about by Smart Mobility Services and, eventually, to adopt new mobility patterns. This is why the **adoption of Smart Mobility Services should be promoted through awareness raising campaigns (A13)** that answer questions regarding data privacy and the safe use of new ticketing services.

4.4 Cost-benefit analysis

The Focus Area 3 cost-benefit analysis in the Table below **Error! Reference source not found.** shows that, overall, no actions have been identified with low benefit and corresponding low, medium or high costs.⁸⁰ The results of this analysis have been validated by extensive stakeholder consultation.

The low-hanging fruits in Focus Area 3 are those actions that can be implemented without too much effort and through already existing competences that lie within the public authorities. Thus, these low-hanging fruit-actions do not involve a lot of stakeholders or require many financial resources. Both actions, *increasing the conditionality of funding (A4)* as well as *pushing public transport operators to develop integrated Smart Ticketing offers and new Mobility as a Service (MaaS) packages (A11)* primarily require the European Commission/ public authorities to adapt their tendering procedures, such that Smart Mobility Service requirements, such as open data, interoperability and avoiding vendor lock-in, are covered more rigorously.

Due to the fact that Smart Mobility Measures mostly relate to the realisation of soft and policy measures, there are no actions that imply high financial costs. This reflects very well the general perception of stakeholders we conducted interviews with as well as the impression from the discussions during our consultation days. Generally speaking, stakeholders were of the opinion that the necessary technologies are already there, however, they are not being deployed due to legal reasons and the lack of coordination and trust.

Thus, most Focus Area 3 related costs have to do with other cost dimensions. These are, for instance, time components (actions can be completed in the medium term or need sustained persistence to make them work) as is the case with the action *support cooperation and integration between established public transport operators and new shared mobility services (A5)*, for which the complexity will only get bigger as there is an increase in shared services offered and a corresponding changing landscape of mobility provision.

There are also actions for which costs are associated with the social dimension (actions target a relatively broad cross-section of stakeholder communities), as is the case with the action *setting up national transport data hubs and access points, guaranteeing better maintenance and quality checks on data (A7)*, as this requires many stakeholders to cooperate.

Finally, there are actions for which costs are associated with the objective (what to do is not always entirely clear and needs work to clarify), as is the case with the action *better exploit the potential of data and data mining (A10)*. Since most transport associations and public transport operators do not have experience in this and it is not

⁸⁰ Refer to Table 1 and Table 2 in Chapter 1 for the elaboration of the guidelines on assessing the costs and benefits for each action.

clear what kind of new services Big Data can generate, this action needs quite some work.

In the case of actions that deal with inefficiencies in the freight and logistics sector caused by the lack of cooperation and integration (A2a-c), an amalgamation of cost dimensions can be observed. Currently, there are only few existing initiatives in the public sector to make logistics more efficient and generate higher load factors. Thus, for most public authorities it is neither clear whom to involve nor what the objective exactly is, thus also resulting in high time-related costs.

In terms of high-level policy aims, several of the proposed actions would benefit the European Union’s overall goals of cohesion (e.g. A3, A8), sustainable development (A2, A5), job creation (A7, A10) and the improvement of citizens’ quality of life (A11, A12).

Table 10. Summary table on costs and benefits of Focus Area 3 actions.

Benefit	High		<p>A1b Support successful neutral trust parties*,</p> <p>A13 Awareness campaigns for Smart Mobility Services*,</p> <p>A11 PT operators develop integrated smart ticketing and Mobility as a Service (MaaS) packages,</p> <p>A4 Increase conditionality of funding●,</p> <p>A5 Integration between public transport operators & new shared mobility service,</p> <p>A7 Set up of national transport data hubs and access points in accordance with ITS Directive*,</p> <p>A2b Incentivise cities establishing freight partnerships by developing Sustainable Urban Logistics Plans●,</p>	A2c Incentivise and develop the concept of synchro-modality in long-distance freight●
	Medium	A1a Study of collaborative structures and	A3a Develop open data portal*,	

	frameworks□, A2a Initiate local & regional stakeholder round tables*, A9 Capacity building*, A10 Exploit potentials of big data and data mining in transport*	A8 Harmonise and apply environmental KPIs for freight, A3b Extend the data management plan to all EU-funded projects (i.e. the extension of Open Research Data Pilot) A6 Study and promote the use of sharing services□, A1 Test and demonstrate more cross-border integration of data in MMITS□	
LOW	-	-	-
	Low	Medium	High
Cost			

The categorisation into the various cost and benefit groups is primarily based upon the feedback received during the five SINTRAS stakeholder consultation days, the stakeholder interviews and the stakeholder surveys. The results of the latter were particularly valuable for placing certain actions into specific benefit- and cost-categories. In addition, strong signals from the literature – especially if it contained stakeholder-validated conclusions – were consulted for this purpose. Some selected types of actions deserve special mention:

* Actions highlighted with an asterisk fall into a group of actions which were mentioned repeatedly by the attendees of the SINTRAS stakeholder consultation days around the desirability of framework conditions that facilitate a trusting cooperation among various stakeholders. There was broad consensus that such “soft” aspects (compared to interventions focussed on hardware or direct subsidies) can be very effective and thus deserve attention. Into this category of strongly endorsed measures also falls the fostering of human knowledge, skills and awareness and the promotion and exploitation of the potentials of “big data” and data mining.

● SINTRAS stakeholder also agreed on the assumed effectiveness of financial incentives and funding conditions by the European Commission. These aspects related to the incentivisation of new forms of partnerships (e.g. among urban logistics and long-distance freight actors) as well as the stipulation to disclose research findings for European Union-funded projects. Both types of actions were considered rather effective.

□ Certain actions related to the development of new research insights and pilot tests were considered slightly less effective in terms of the directness and scale of their impacts. The SINTRAS stakeholders agreed that such activities are genuinely desirable nevertheless.

4.5 Prioritisation

Amongst the actions described above, the highest priority should be given to those which offer an attractive benefit-to-cost ratio (in particular, those which impact the entire European transport system) and which are urgent or will yield results in the relatively short term. Urgent actions are especially important if they will unlock a series of positive changes. Short term results are important as they will quickly demonstrate that the efforts to transform the European transport system are paying off. This will help to build momentum and continued support for change.

Second priority should go to actions which still offer an attractive benefit-to cost ratio but which will yield results in the medium to long term. These actions are important because they yield valuable results; but, as they need to persist for some time before the results become visible, they will be less effective in building momentum and support.

The third priority actions are those which yield less attractive benefit-to-cost ratios. For example, the benefit of such actions, while still substantial, may be limited to an individual issue or a narrow group of stakeholders. The results of such actions, whether short- or long-term, will have less impact on the functioning of the European transport system as a whole.

Based on the discussions of timing and cost-benefit in the previous sections, we propose the following prioritisation of actions. Within each group, we list actions in decreasing order of priority:

Table 11. Action prioritisation

Priority 1: Attractive benefit-to cost ratio and short term results	
A4	Increase conditionality of funding
A9	Capacity building
A7	Set up of national transport data hubs and access points in accordance with ITS Directive
A1a	Study of collaborative structures and frameworks
A2a	Initiate local & regional stakeholder round tables
A13	Awareness campaigns for Smart Mobility Services
A3b	Extend the data management plan to all European Union-funded projects (i.e. the extension of Open Research Data Pilot)
Priority 2: Attractive benefit-to-cost ratio and medium- to long-term results	
A11	Public transport operators develop integrated smart ticketing and Mobility as a Service (MaaS) packages
A1b	Support successful neutral-trust parties
A2b	Incentivise cities establishing freight partnerships by developing Sustainable Urban Logistics Plans
A5	Integration between public transport operators & new shared mobility service
A10	Exploit potentials of big data and data mining in transport
A3a	Develop open data portal
A6	Study and promote the use of sharing services
A2c	Incentivise and develop the concept of synchromodality in long-distance freight
Priority 3: Less attractive benefit-to-cost ratio	
A8	Harmonise and apply environmental KPIs for freight
A12	Test and demonstrate more cross-border integration of data in MMITS

4.6 Key performance indicators

To measure impacts of the Focus Area 3 actions, key performance indicators (KPIs) along the four impact pathway steps are shown in the following Table⁸¹.

Table 12. Focus Area 3 key performance indicators.

Effort-KPIs	Action-KPIs	Outcome-KPIs	Impact-KPIs
(A1a) Allocate H2020 resources (€/year)	(A1a) Calls for study (Number)	(A1a) Number and quality of studies completed (Number)	(A1a) New and robust knowledge, guidelines, calls for demonstrations/ pilots
(A2b) Allocate funding (€/year)	(A2a) Calls for demos/ pilots (Number)	(A2b) SULPs incentivised and produced (Number)	(A2b) Logistics stakeholders that share data (Number); higher efficiency of delivery runs (%)
(A2c) Allocate funding (€/year)	(A2c) Calls for demos/ pilots (Number)		
(A7) Allocate national funding (€/year)	(A7) Staff allocated (Number, person months/year)		
(A9) Allocate national funding (€/year)			
(A11) Revise tendering procedure		(A11) Smart Cards, app-based tickets, etc. available (Number)	(A11) Increase of multi-modal trips, increase of data generated by PT users (Number, %)
(A1b) Allocate funding (€/year)		(A1b) Neutral trust parties supported (Number)	(A1b) Exchange platforms successfully established with long-term viability and clear business plan (Number)
(A2a) Allocate funding (€/year)		(A2a) Round tables initiated (Number)	(A2a) Logistics stakeholders that share data (Number); higher efficiency of delivery runs (%)
(A3a) Allocate sufficient funding for open data portal + maintenance (€/year)		(A3a) Users/ use intensity of open data portal (Number)	(A3a) Availability of open data portal that is user-friendly, open, accessible to everyone and regularly fed with data (yes/no)

⁸¹ See elaboration of assessment framework for monitoring and evaluation in Chapter 1, Figure 4

(A4) Revise funding requirements		(A4) Percentage of projects that meet conditionality requirements (%) (A5) Successful cooperations (Number) (A8) Harmonised set of logistics KPIs produced and applied in number of cities (Number)	(A4) Cities/ regions in the European Union that accept institutional ITS framework/ commit to open data (Number) (A5) Use intensity of integrated MMITS (A8) Higher efficiency of delivery runs/ higher load factors (%)
(A3b) Data management plan requirement for any European Union project (yes/ no)		(A3b) Percentage of European Union-funded projects that make results publicly available (%)	(A3b) Availability of open data portal that is user-friendly, open, accessible to everyone and regularly fed with data (yes/no)
(A6) Allocate resources (€/year)		(A6) Number and quality of studies completed (Number)	(A6) Users of sharing services (Number)
(A10) Train staff person months/year,)		(A10) PT operators with dedicated Big Data staff/ departments (Number) (A12) Cross-border MMITS (Number)	(A10) New services/ improved services resulting from data mining (Number) (A12) Use intensity of cross-border MMITS; share of multi-modal cross-border trips
	(A13) Awareness-raising campaigns carried out (Number)	(A13) Smart Cards, app-based tickets, etc. used (Number)	(A13) Increase of multi-modal trips, increase of data generated by PT users (Number, %)

Next, we list all KPIs per action, some of which are broken down to sub-actions in order to give more concrete examples within action groups. The potential units of measurement are shown in brackets after each indicator.

(A1) Foster the use of neutral trust parties/ neutral brokers and develop a general framework condition and enabling condition to enhance smart mobility services

- **(A1a) Study of regulatory, technological and financial aspects of collaborative structures and frameworks**
 - Allocate H2020 resources (€/ year)
 - Calls for study (Number)
 - Number and quality of studies completed (Number)
 - New and robust knowledge, guidelines, calls for demonstrations/ pilots
- **(A1b) Support successful neutral trust parties/ neutral brokers and disseminate best practice results**
 - Allocate funding (€/ year)
 - Neutral trust parties supported (Number)

- Exchange platforms successfully established with long-term viability and clear business plan (Number)

(A2) Incentivise cooperation and integration along the freight chain

○ **(A2a) Initiate local and regional stakeholder round tables**

- Calls for demos/ pilots (Number)
- Round tables initiated (Number)
- Logistics stakeholders that share data (Number); higher efficiency of delivery runs (%)

○ **(A2b) Incentivise and support cities in establishing freight partnerships by developing Sustainable Urban Logistics Plans (SULPs)**

- Allocate funding (€/ year)
- SULPs incentivised and produced (Number)
- Logistics stakeholders that share data (Number); higher efficiency of delivery runs (%)

○ **(A2c) Further incentivise and develop the concept of synchromodality in long-distance freight**

- Allocate funding (€/ year)
- Calls for demos/ pilots (Number)
- Logistics stakeholders that share data (Number); higher load factors in long-distance freight (%)

(A3) Require all European Union-funded projects to make mobility data publicly available

○ **(A3a) Develop open data portal and infrastructure**

- Allocate sufficient funding for open data portal + maintenance (€/ year)
- Users/ use intensity of open data portal (Number)
- Availability of open data portal that is user-friendly, open, accessible to everyone and regularly fed with data (yes/no)

○ **(A3b) Launch the extension of Open Research Data Pilot which extends the data management plan to all European Union-funded projects**

- Data management plan requirement for any European Union project (yes/ no)
- Percentage of European Union-funded projects that make results publicly available (%)
- Availability of open data portal that is user-friendly, open, accessible to everyone and regularly fed with data (yes/no)

(A4) Increase conditionality of funding

- Revise funding requirements
- Percentage of projects that meet conditionality requirements (%)
- Cities/ regions in the European Union that accept institutional ITS framework/ commit to open data (Number)

(A5) Support cooperation and integration between established public transport operators and new shared mobility services

- Successful co-operations (Number)
- Use intensity of integrated MMITS

(A6) Study and promote the use of sharing services

- Allocate resources (€/ year)
- Number and quality of studies completed (Number)
- Users of sharing services (Number)

(A7) ITS Directive on National Access Points – set up national transport data hubs and access points, guaranteeing better maintenance and quality checks on data

- Allocate national funding (€/ year)
- Staff allocated (Number, person months/ year)
- National data hubs set up successfully (Number)
- Data availability and quality improved (Number)

(A8) Harmonise and apply environmental KPIs for logistics to monitor freight performance in cities

- Harmonised set of logistics KPIs produced and applied in number of cities (Number)
- Higher efficiency of delivery runs/ higher load factors (%)

(A9) Develop ITS training/ support capacity building for public mobility stakeholders

- Allocate national funding (€/ year)

(A10) Better exploit the potentials of using big data and data mining in transport

- Train staff (€/ year, person months/ year)
- PT operators with dedicated Big Data staff/ departments (Number)
- New services/ improved services resulting from data mining (Number)

(A11) Push public transport operators to develop integrated Smart Ticketing and Mobility as a Service offers

- Revise tendering procedure
- Smart Cards, app-based tickets, etc. available (Number)
- Increase of multi-modal trips, increase of data generated by PT users (Number, %)

(A12) Test and demonstrate more cross-border cooperation in MMITS

- Cross-border MMITS (Number)
- Use intensity of cross-border MMITS; share of multi-modal cross-border trips

(A13) Promote the adoption of Smart Mobility Services through awareness raising campaigns

- Awareness raising campaigns carried out (Number)
- Smart Cards, app-based tickets, etc. used (Number)
- Increase of multi-modal trips, increase of data generated by PT users (Number, %)

5 Focus Area 4. Standardisation and interoperability

5.1 Overview

This chapter presents the evolution of standards over a 30-50 year horizon. It does not examine the differences between existing and future standards.

In the SINTRAS study, Focus Area 4 “Standardisation and interoperability” has been defined as follows:

A truly integrated transport system for sustainable and efficient transport is based on an open and global system of transport and logistic assets, hubs, resources and services operated by individual companies in a complex network environment. They are fully visible and accessible to market players. Coordination of logistics, transport, infrastructure and supply networks aims to promote movement, storage, supply and use of physical objects and services throughout the world in a manner that is economically, environmentally and socially efficient, secure and sustainable. The efficient logistics system should be based on physical, digital, and operational interconnectivity, enabled through modularisation as well as standardisation of interfaces and protocols.

The standardisation of transport means considering transport as a whole, establishing technology standards of the structure, mechanical instruments, special tools as the working standard of packaging, warehouses, loading and unloading, transportation and the logistics information which is seen as the outstanding characteristic of present-day logistics.

The Physical Internet as a standardised system will be implemented nation-wide, however for the the full concept to work it needs to operate internationally. Standardisation in transport is an international problem; internal standards should be brought into line with international ones progressively. One global standard in data exchange will help to speed up worldwide transportation processes.

The term interoperability is very closely related to interconnectivity. To achieve interconnectivity is a necessary step for full interoperability. Missing links of physical infrastructure, Information and Communication Technologies (ICT) systems and transport-related services must be removed to achieve interconnectivity. Interconnectivity means that the transport systems are physically and operationally linked to make the service chain available to the customer. This requirement is valid between the different transport modes, too. The nodal points need to be interconnected with their surrounding industrial areas, logistics centres, sea ports and airports. Further, the nodal points must be interconnected with transport corridors which lead to sea ports and the hinterland. Interoperability means the ability of two or more transport systems to operate efficiently together to fulfil the customers' needs. Not only is interconnectivity needed to achieve this but the interconnected services must be seamless in such a manner that there are no technical, corporate or juridical barriers to an integrated transport service.

In order to ensure that the Physical Internet idea is widely implemented in logistics and transportation by 2050, it is mandatory to reach a set of milestones within the coming decades, They cover all of the aspects of transport and since this chapter focuses on standardisation and interoperability it should be noted that some of the issues are relevant even though they are indirectly connected.

A review of the barriers in the area of standardisation and interoperability revealed that they form four main categories of obstacles that need special attention. They are related to:

- standardisation in cooperation on the level of information flow,
- the use of Information and Communication Technologies,
- data models that have been developed locally,
- specific sectors or modes of transport.

In the area of optimisation, it is necessary to prove that standards and interoperability are capable of integrating the supply chain and therefore a set of Key Performance Indicators must be agreed globally and not just on a point-to-point basis. These challenges will require special attention to technologies in transport. These technologies already exist in many areas but in many cases they need to be developed from the bottom up. To withstand the challenges in the business reality it is essential that technologies and organisational changes work without extra funding and are self-sustainable after the research period. Due to this, new business models need to be identified so that changes take place quickly and in line with new technologies and organisational solutions.

The barriers identified for Focus Area 4 (FA4) early in the SINTRAS project are:

- Barrier FA4-01 Poor collaboration between stakeholders
- Barrier FA4-02 Trust on sharing information services and systems
- Barrier FA4-03 Lack of industry well recognised business and operational models in horizontal collaboration
- Barrier FA4-04 Lack of flexible Information and Communication Technologies
- Barrier FA4-05 Collaboration between modes
- Barrier FA4-06 Modular units facilitating inland and air transport
- Barrier FA4-07 Interoperable solutions for transshipment
- Barrier FA4-08 Standards that hinder optimisation in transport
- Barrier FA4-09 Market dynamics

5.2 Projected developments

Figure 14 **Error! Reference source not found.** presents the projected developments in Focus Area 4. In the next subsections we explain this graph in detail, layer by layer.

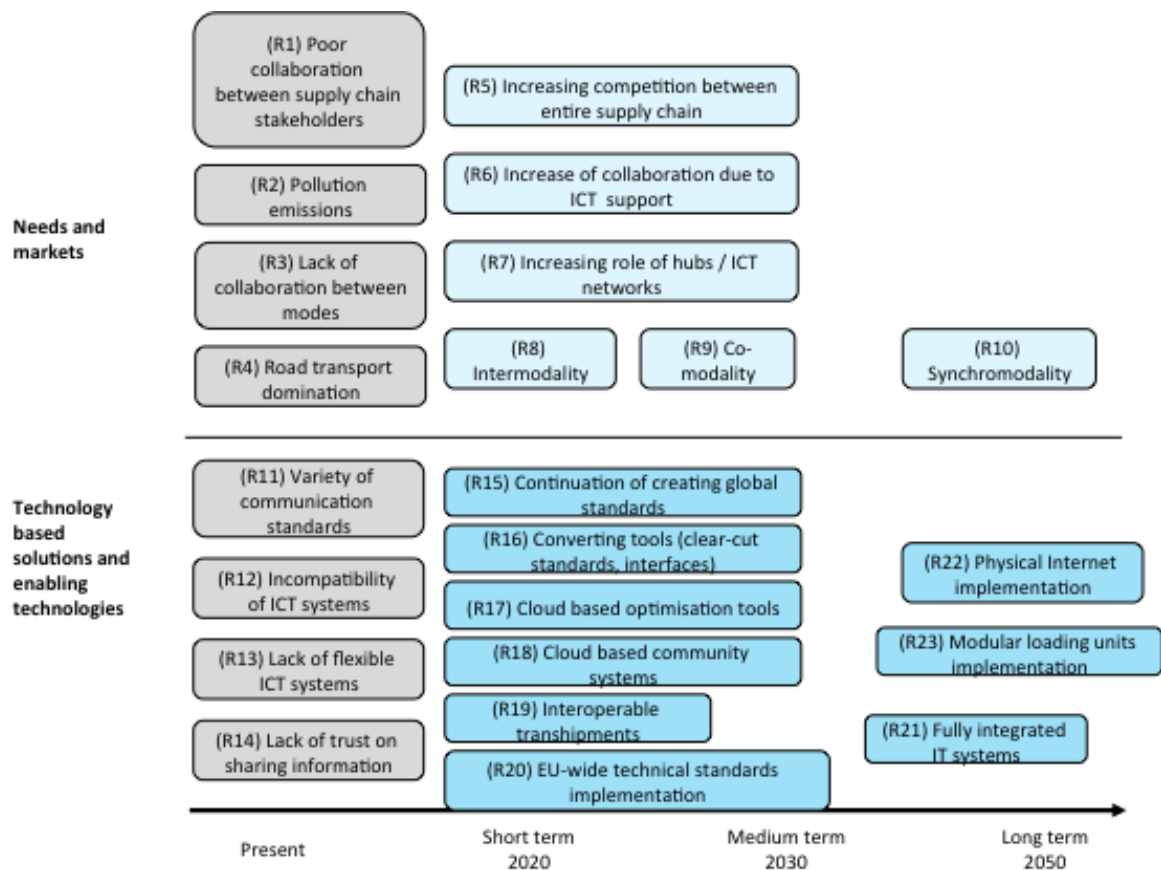


Figure 14. Projected developments in Focus Area 4.

5.2.1 Needs and markets

The current level of cooperation between enterprises in the implementation of ICT solutions for sharing information and e-documents is still insufficient (R1)⁸². It is paradoxical that at the time of dynamic development of Internet and the whole ICT branch, the benefits for the transport industry are very modest. There are many reasons for this. The logistics and especially transport markets are highly competitive and complex. Service providers collaborate in some supply chains and compete in others. This is why achieving any form of collaboration between operators in different modes is a barrier which is very difficult to overcome (R3).

Road transport is highly competitive comparing to the sustainable modes of transport. It results in domination of road transport, traffic congestion and air pollution (R2, R4).

One of the noticeable market trends is the evolution of competition. Nowadays, competition between individual companies is less and less important while the rivalry between entire supply chains is becoming essential (R5). In such type of competition, all supply chain partners use compatible ICT systems to jointly optimise distribution networks (R7). What is important for customers is immediate delivery of personalised products so a very significant factor for companies operating in the market is not only full availability of goods at shop or in stock but also immediate and accurate delivery to the final consumer. Large commercial, manufacturing or logistics companies that can afford implementation of expensive ICT solutions try to develop unique systems of

⁸² Codes R and A provide cross-references to project developments (R) and proposed actions (A), defined in sections 5.2 and 5.3 respectively

communication with transport partners treating those systems as a competitive advantage (R13, R14). Therefore such companies are not supporters of unification of standards but rather strive to keep their solutions secret. This is accompanied by a lack of confidence in information systems that do not fully protect against possible hacker attack.

Competition between entire supply chains will become more and more intensive. This means that the companies managing supply chains will be pressed to go into closer cooperation with their transport partners. They will be more determined to create effective communication systems increasing the efficiency of their logistics network. The barrier of reluctance of companies to collaborate will be eventually overcome by parallel development of such technologies as (R12):

- technologies providing security in data exchange,
- converters translating communication standards into others (agreed as basic ones),
- electronic platforms supporting paperless collaboration within business communities, such as ports and inland nodes,
- cloud-based optimisation tools increasing efficiency of supply chain competitiveness.

The European vision of co-modality (R9) is aimed at creating strong framework conditions for each mode of transport in its own right and, where possible, in co-operation with other modes. Intermodality (R8) is the form of transport where this co-operation materialises by the use of more than one mode within the transport chain. Synchromodality (R10) builds on these two and concerns a very strong alignment at the operational level between transport services of different modes, with the aim of best serving supply chain needs. Synchromodality, or synchronised intermodality, can be defined as a service which, through informed and flexible planning, booking and management, allows for making mode and routing decisions at the individual shipment level, as late as possible in the transport planning process including the trip itself. Although this might seem overly complex, its implementation has become realistic due to the rapid development of information systems in transport and logistics.

As a step towards the vision of the Physical Internet, the technologies and logistic approaches behind synchromodality need to be disseminated more widely to other segments of freight transport. As in the Physical Internet, synchromodality combines individual private networks into one supernetwork and allows combinations of services of different providers. The result of this increased flexibility is that the best possible mode is used at all times, given the logistics requirements and the prevailing network conditions. As such, synchromodality creates more efficient transport services that are more responsive to customer needs and more resilient to changing external conditions.

5.2.2 Technology-based solutions and enabling technologies

Companies managing their supply chains have created a variety of data exchange systems. Each of them is based on communication standards (as protocols, information standards, terminology, XML (Extensible Markup Language) message standards, e-documents, digital signatures, etc.) tailored to individual needs (R11).

These standards are not compatible with information sharing systems built by other companies. So we have to deal with a great number of different customised ICT systems that are not able to communicate with each other (R12). Transport companies providing their services within one supply chain cannot use their software systems in another supply chain.

European standardisation organisations have elaborated a large number of global standards to be used by supply chain stakeholders in their information sharing systems. Creating these universal standards turned out to be a long and difficult process but their common acceptance and application seems to be far more difficult to achieve. In free market conditions, it is difficult to require companies to use specific ICT solutions.

A Logistics Centre is the hub of a specific area where all the activities relating to transport, logistics and goods distribution take place. The operators may be either owners or tenants of the buildings or facilities (warehouses, distribution centres, storage areas, offices, truck services, etc.) built there. In order to comply with free market rules, a Logistics Centre must be accessible to all companies involved in the activities set out above.

A Logistics Centre must also be equipped with all the public facilities necessary to carry out the abovementioned operations. If possible, it should also include public services for the staff as well as users' equipment. In order to encourage intermodal transport for goods handling, a Logistics Centre should preferably be served by a variety of transport methods (roads, rail, sea, inland waterways, air).

It is vital for a Logistics Centre to be integrated with an intermodal terminal. It is also important that such Logistics Centres are integrated into Europe-wide networks being interoperable physically and digitally.

Intermodal transport is a complex transport process where freight is moved by vehicles representing various modes of transport (road, rail, inland waterway, sea, air). The businesses' main reason to use it is the fact that intermodal transport enables them to take advantage of an optimum set of the service and cost features characterising particular means of transport. Unfortunately, despite many attempts to develop intermodal transport, its share in Europe remains very low. The issues of intermodal transport development in Europe are very complex and require multifaceted consideration. There are a number of legal, administrative and organisational, economic and financial, technical and technological barriers which hinder greater collaboration between transport modes.

Prompt development of Information and Communication Technologies will finally change the way the companies cooperate in achievement of a better position on the market (R6).

The data sharing systems will be increasingly based on global standards. On the other hand, companies managing their supply chains will be free to customise their systems in any way to fulfil their requirements. This is possible due to development of conversion tools that are able to handle many different standards and that easily connect to mobile technologies, making starting electronic cooperation with a new business partner very easy (R16).

In parallel, of course, the public sector at the European level will continue its work through standardisation authorities to produce more global standards (R15). There will be a trend under which global standards are implemented among big players (R20). Later on, the usage of global standards will become more common thanks to the increased number of users of logistics platforms. In parallel, the development of the abovementioned converting tools will eventually eliminate the problem of standards diversity.

On the other hand, the future forms of collaboration between companies will to a large extent depend on ICT cloud-based applications securing cheap access of the user. Solution of Service as a Service or Platform as a Service may be available to the user without the need to purchase a license or hardware because the software runs on the provider's server (R21). The moderate cost of access to modern programmes will

greatly decrease the number of companies that cannot afford a higher level of computerisation.

For some time, electronic information exchange systems between companies have taken the form of electronic platforms providing on-line access to each participant. These platforms are managed by large manufacturing, trading or logistics companies and recently seaports (R17).

Ports are complex business organisations. By creating and implementing electronic platforms of the Port Community System type, ports have greatly accelerated handling of goods. Such platform usually includes (R19):

- communication module for sending online messages and e-documents between shippers, port terminals, ship owners, road and rail carriers and all other companies responsible for movement of cargo through the port,
- information sharing module to exchange data between companies serving ships, such as port authorities, clarifying agents, tug companies maritime pilots, port fire brigades, etc.,
- single window customs service,
- booking portal for clients searching for sea and hinterland transport services enabling review of offers and concluding contracts of carriage.

Applications of this type are more developed in Western Europe. In the eastern part of Europe, their implementation is delayed. The direction was charted – such applications will be created in the future for the needs of logistics centres, intermodal terminals and transport nodes. Nodes and hubs are taking the initiative in creating information systems to improve and optimise flows of goods between them. The integration of hubs and networks is expected to happen by 2020, enabling shippers or freight integrators to take optimal decisions in planning co-modal deliveries.

In the near future, we should expect rapid growth in the number of applications supporting transport decision makers by offering multiple optimisation solutions such as (R18):

- decisions on selection of transport service provider taking into account the criterion of cost, delivery time, CO₂ emissions and key performance currently obtained, all based on databases of carriers and their offers. This application is known as “multi-modal journey planner”,
- consolidation of “Less than Container Load” shipment with shipments provided by other shippers resulting in lower transportation costs for shippers and better use of the loading space by a carrier. Optimisation includes also back loads and cross-docking use of tender mechanism in negotiating freights. Today, freight exchanges are widespread in road transport and in the future they will include other modes of transport,
- optimal loading of vehicles involved in the distribution of small shipments taking into account sequence of stops, loading windows, etc.,
- the capacity for dynamic plan supplies by carriers with the use of online track and trace and direct connection with a driver. Such monitoring is again widespread in road transportation but not yet used in multi-modal chains.

These solutions are already implemented to some extent on the freight market, although they are not yet in general use.

Probably these ICT tools will be common by 2020-2025. Later on, the collaboration between companies is expected to rise to a higher level. It will be a time of joint use

of vehicles, warehouses, distribution and consolidation centres or even manufacturing space (R22).

To enrich cooperation between stakeholders, specific adjustments of hubs to be able to handle modular loading units are proposed (R23).

To reach the required collaboration between all transport modes, the following measures should be implemented by the different stakeholders involved in transport activity:

- more international harmonisation at technical, legal and organisational level is needed to ensure interoperability to enable an increase in cross-border intermodal transport. This includes:
 - open transport market (there is a need of a more transparent, customer-oriented approach. Further liberalisation of the railway market in practice is necessary to enable more competition between the railway companies, so that the market becomes more customer oriented);
 - European Union-wide technical standards. Consistent rail technical parameters (e.g. gauges, minimal train lengths, total train weight, weight of carriages, security, noise, etc.) are needed throughout Europe, as well as a standardised certification of railway rolling-stock for cross-border acceptance resulting in complete interoperability of services;
 - harmonised customs regulations (the documentation procedures for transporting goods need to be further harmonised, so that a more reliable planning of the logistics supply chain is possible; introduction of paperless systems should be supported);
 - better hinterland connection of ports;
 - improvement of the reliability of inland waterway services;
 - public funding should be focusing on the development of intermodal infrastructure, creating equal market conditions for every transport mode.
- Railway companies and infrastructure managers need to develop a more holistic and international view of the intermodal market, with a more transparent and comparable set of services ensuring high reliability and competitive prices. Efficiency of terminal handling should be increased by greater standardisation of terminal design. There is a need to develop an automatic transshipment system, consisting of a set of equipment featuring a high degree of flexibility, scalability, dependability and ease of integration. Interoperable transshipments have to enable fast and low cost handling of freight in loading and unloading operations: vehicle to vehicle, vehicle to warehouse, warehouse to vehicle for long distance and urban transport and respecting the need of efficient operation in networks. If terminal modules follow the same standard, they may become interchangeable, which may be helpful when planning a network of intermodal terminals, resulting in a more efficient use of their capacity and services.
- Intermodal operators and logistics service providers need to optimise the transparency of intermodal solutions to their customers and increase collaboration among each other to enable new intermodal connections that are necessary to further push intermodal transport.
- Shippers need to take a more active role in evaluating the most sustainable and efficient mode of transport and define expectations and objectives to their

respective logistics service providers. Their willingness to increase the share of intermodal transport should be demonstrated by actively supporting the development of intermodal alternatives.

ICT and ITS tools and services will enable the creation of ad hoc collaborative environments allowing the real time, transparent and seamless interconnection, networking and information exchange between the stakeholders of a specific logistics scenario or use case.

5.3 Action plan

Figure 15 Error! Reference source not found. presents the actions for Focus Area 4. In the following subsections we explain this action plan in detail, layer by layer, using the numbers in parentheses when referring to specific boxes within the action plan. In the action plan, the codes for identified barriers are also used to link items to specific Focus Area 4 barriers.

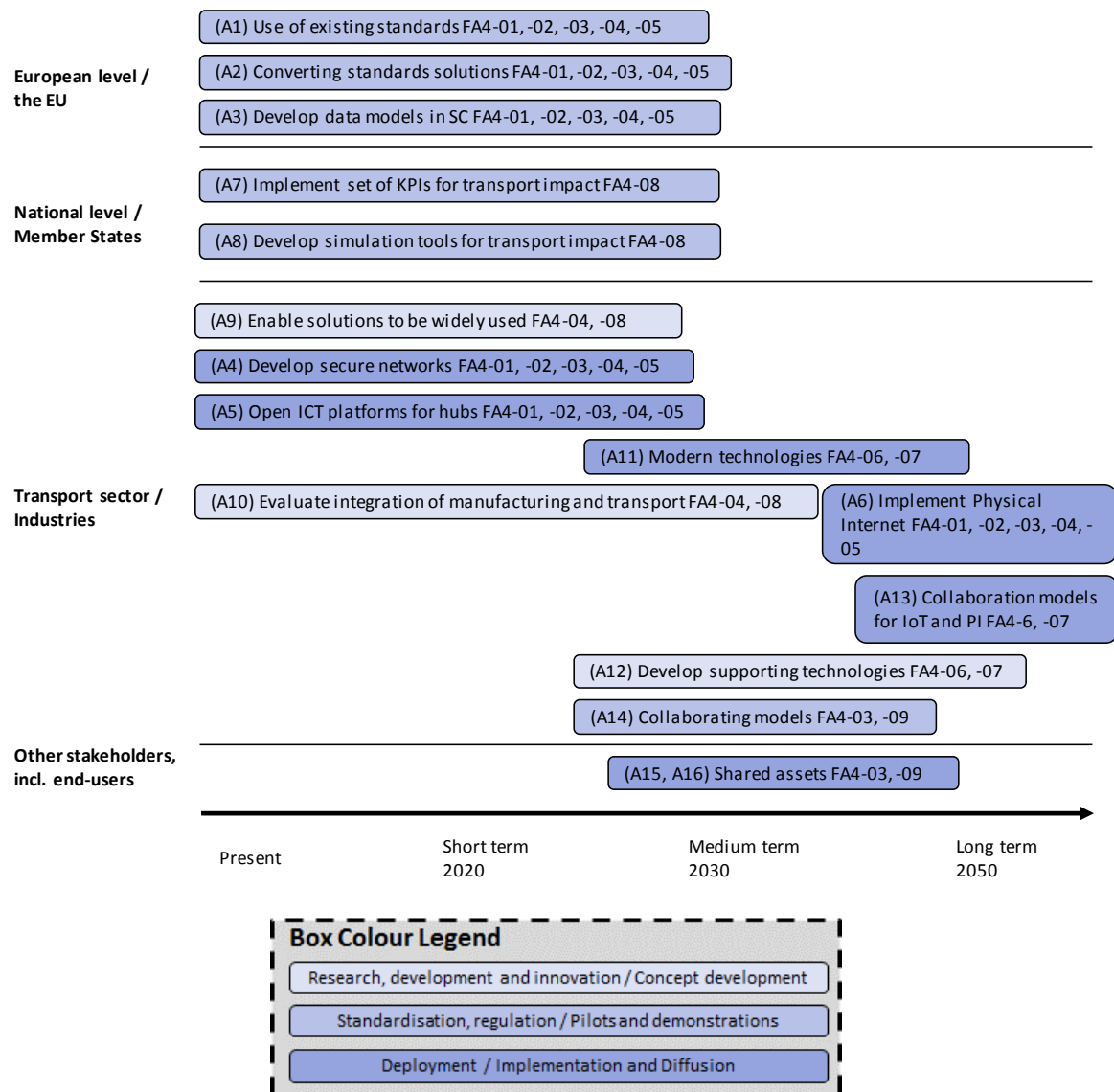


Figure 15. Focus Area 4 action plan.

List of actions:

- (A1) Use of existing standards
- (A2) Converting standards solutions
- (A3) Develop data models in SC
- (A4) Develop secure networks
- (A5) Open ICT platforms for hubs
- (A6) Implement Physical Internet
- (A7) Implement set of KPIs for transport impact
- (A8) Develop simulation tools for transport impact
- (A9) Enabling solutions to be widely used
- (A10) Evaluate integration of manufacturing and transport
- (A11) Modern technologies
- (A12) Develop supporting technologies
- (A13) Collaboration models for Internet of Things and Physical Internet
- (A14) Collaborating models
- (A15, A16) Shared assets

5.3.1 European level

The **diversity of standards used today (A1)** in communication between companies is one of the problems hindering effective collaboration of companies in supply chains. This problem is not new. Even before the spread of the Internet, the first attempts to create EDI systems in transport processes were made in the United States in the mid-60s.

Since that time leading manufacturing and trading companies have tried to organise cooperation with selected transport service providers taking advantage of electronic communication systems tailored to their needs. A multitude of customised closed information systems was created in this way. They were incompatible with each other. Transport companies serving many customers had to deal with many different systems of exchanging information which made the service expensive. Adding new participants to an existing supply chain was also quite expensive and technically difficult.

Just as the companies managing supply chains are focused on their individual needs, the individual transport sectors are concentrated on themselves. The different transport modes do not work together, leading to multiple communication standards which make it extremely difficult to create an interoperable system of exchange of messages and documents used in intermodal transport demanding transshipments between modes.

In a free market environment, the problem of the diversity of standards for collaboration between partners in transport networks could not be solved entirely by the private sector. For these reasons, a public sector took the initiative and got involved in proposing basic standards intended as universal.

Standardisation work in Europe has been conducted mainly by three organisations: the European Committee for Standardisation (CEN), the European Telecommunications Standards Institute (ETSI) and the European Committee for Electrotechnical Standardisation (CENELEC). The results of this work are standards for the Intelligent

Transport Systems. There are a few important initiatives focused on communication standards for supply chains.

The E-FREIGHT framework is a standard for information exchange covering the entire transport domain with the objective of fostering interoperability between businesses and systems.

E-FREIGHT, for example, aimed at paperless freight transport processes where the electronic flow of information is linked to the physical flow of goods. Specifically E-FREIGHT contributes to the goals of the Freight Transport Logistics Action Plan (October 2007), and the ITS Action Plan (October 2008) pertaining to the development of:

- a standard framework for freight information exchange covering all transport modes;
- a European Single Transport Document for carriage of goods with all the necessary legislative support, irrespective of mode;
- a Single Window (single access point) for administrative procedures in all modes;
- simple, harmonised border crossings for all modes of transport for European Union Member States;
- simple procedures and the necessary infrastructure for establishing secure and efficient transport corridors between Europe, USA, and Asia.

The other initiative is FREIGHTWISE. The overall objective of FREIGHTWISE was to support the modal shift of cargo flows from road to intermodal transport using road in combination with short sea shipping, inland waterways and rail, as well as to make transport more efficient.

The FREIGHTWISE framework being developed divides the freight transport domain into manageable sub-domains and defines the main roles that need to interact as well as the necessary interactions in between these domains. The main roles identified are: the Transport User and the Transport Service Provider, supported by the Transportation Network Manager and the Transport Regulator.

The standards developed for the exchange of information between these entities during the conclusion and implementation of the contract of carriage are the solution recommended by the European Union for all the companies that make up the electronic information exchange system for supply chain management.

Encouraging business circles to apply certain standards is a long and unsure process so it is important to work in parallel on ICT solutions enabling conversion of existing standards to those being selected by the European Union as the basic ones what will eliminate the problem of a multitude of **customised standards (A2)**.

For the optimal development of a sustainable European transport system, it is important that those who decide on the choice of transport service providers have full access to all transportation alternatives, including intermodal solutions. Only then will those receiving the offers from a large number of carriers or freight forwarders representing various modes of transport shippers be able to make a rational decision. It will be possible if the pan-European database of companies offering transport services is built, including such information as scope of services, geographical coverage, lead-times, time schedules and tariffs.

Creation of such database will be based on **data models (A3)** used in all countries to gather necessary information reported in a unified format. Efficiency of multi-modal

delivery planning tools relies on their completeness and validity. However, the development process is very challenging.

Since this process is time consuming, it is expected that databases will be built gradually corridor by corridor. Selection of the corridors is a crucial decision determining the tool's efficiency. Only corridors providing competition between transport modes will be taken into account. It is most likely to happen in containerised transport leading from the sea ports to the final inland destination (and vice versa).

5.3.2 National level

Nowadays, logistics companies as well as their customers attach great importance to the analysis of transport efficiency. Several KPI sets have been developed by transport service providers as well as researchers to measure the quality of transport services that enable their further improvement. Similar to what has been developed for the private sector, it is important that transport activity may be also analysed at the national level to provide the public sector with the necessary data to optimise national transport policy. We foresee a necessity to develop a similar set of **KPIs at the national level (A7)** to provide the public sector with the necessary data to optimise implementation of transport policy. Thus both sets of KPIs would enable reaching a compatibility of goals set forth by commercial and public stakeholders.

Using KPIs will enable national decision makers to analyse the past or present state of affairs, which will be very important for the ability to simulate the development of national transport system according to different scenarios.

(A8) Simulation would be most important for analysis of expected flow of goods across the national transport system, defining infrastructure bottlenecks and development of guidelines to carry out investments in linear and point infrastructure. Traffic simulations are now widely used in city transport systems. Many municipalities analysed their transport systems which led to such improvements as the implementation of intelligent systems for traffic management, construction of ring roads and closing the city centres to traffic and transfer of industry and logistics services to suburbs.

A more advanced solution would be the joint use of storage space and loading surface of vehicles by transport operators in order to considerably reduce traffic between logistics centres and transport nodes. Such solutions are not yet used, encountering the barrier of reluctance of competitors to cooperate. However, the implementation of the Physical Internet concept will serve the purpose of overcoming this barrier.

5.3.3 Transport sector

Industry 4.0 and the Internet of Things (IoT) will dramatically affect how transport service providers of all sizes operate. It is crucial for transportation management services, warehouse management systems, and other aspects of logistics to take the new technology systems on board to be able to increase the efficiency and lower the cost of their services.

Obviously there are many data exchange software applications in use by different logistics actors, but their main weakness is that they are separated from each other and require an effort to **build and maintain bridges between untold numbers of data storage systems (A4)**. There have been attempts to build data exchange platforms (TradeNet EDI), but their concept is usually centralised and uses computer-to-computer exchange of business documents in a standard electronic format between business partners. Hence there have been no truly efficient solutions to the problem of data flow. Blockchain technology is a non-centralised system that allows a network of users to sign off and police data. The blockchain concept can be widely used in all

sectors, and it will become a foundational element of industrial IoT solutions in the near future. It has been assumed that blockchain technology will have as wide impact as the World Wide Web.

The blockchain concept will remove “noninfrastructural” bottlenecks within transport corridors and activities, easing administrative and technical obstacles to transport. This will be done by the new blockchain based data exchange solution optimising all aspects of the integrated services (transportation, warehousing, cross-docking, inventory management, packaging, and freight forwarding) by eliminating the need for routine human interaction with computer systems and giving access to vast amounts of anonymised data outside an organisation. That will result in decreased operational costs and reduced delivery time. For increased interoperability, the blockchain approach will bring greatly increased and in some cases, novel factors into play. Foremost, it will enable all participating actors in the blockchain to retrieve the relevant information directly from one specified source, without any need for data access requests, permission level adjustments or other intermediary actions. This means that each actor or other party requesting access to information can obtain it either by semi-autonomous processes or directly. Authorities can have instant access to all relevant event information, along with all the documentation pertaining to their needs. Public and private logistic and transport operators can have real time access to relevant business intelligence and operational information streams, which will in turn enable them to plan their resource allocations and operations much more in advance, and more accurately than ever before. Sea and dry ports, as well as freight village and other transport hubs, can receive operational real time transport data from all their direct clients and indirect partners, enabling them to increase vastly their operational efficiency and business planning capabilities. Governmental and research institutions can have access to a vast data corpus which has been properly anonymised for their use, and make that data available to their research and infrastructure planning initiatives. All actors contribute to the big data mass almost in real time, and can have tailored access to it, depending on their specified needs.

Sea ports and their hinterland play an important role in global transport networks, particularly as the interface between the maritime and surface components of transport chains. It is important to encourage hubs to enable use of open ICT platforms by all stakeholders located in their vicinity **(A5)**. To streamline the flow of cargo from the manufacturers to the clients, further integration of manufacturers’ activities and transport should be evaluated. The integration would need to happen either on a location basis, i.e. move certain or all manufacturing activities closer to the hubs or integrate manufacturers’ ICT systems with transport service providers’ **(A10)**. The traffic density is concentrated to and from port areas.

This concentration brings opportunities with it: cargo flows can be consolidated, waiting times between sea and hinterland can be reduced, empty containers can be reused more efficiently, last mile transportation by road can be combined for multiple shippers on single pallets to increase truck capacity utilisation. But the problem is that those benefits are not so easy to achieve. At the moment each individual freight forwarder organises the transportation with its own limited cargo volume – choosing traditional road transport, given its limited volume and the complexity of the intermodal process. There is a need to be able to merge these cargo volumes for the benefit of better planning by systematically selecting the best from multiple transport options. This choice can also be a-modal (i.e. the choice of modality can be freely selected up to the last moment) and result from real-time consolidation with other shippers’ booked cargo. The solution to this problem is to enable groups of (direct) shippers and freight forwarders to form a collaborative community, merge their transport volumes and decide on the best transportation options based on this

aggregated volume. This is achieved by enabling interoperability between several value-added services and between multiple regional community initiatives.

Achievement of all these benefits is feasible with the use of Information and Communication Technologies to provide **enabling solutions to be widely used (A9)**. As an example of such enabling solutions, many ports have already strengthened their competitive power by creating ICT platforms called Port Community Systems for exchanging real-time messages and documents and thereby improving their common operational performance. A Port Community System is an electronic platform that connects the multiple systems operated by a variety of organisations that make up a seaport or airport community. It is shared in the sense that it is set up, organised and used by firms located within the vicinity of the same hub – in this case, a port community. This platform is also a Single Window for stakeholders seeking for any kind of port or transport services required. This kind of innovation will certainly spread to other ports.

A second example of enabling solutions is the “Intermodal Route Planner”. This is another innovation requiring development and adoption of widely spread standard devoted to transport users. While a Port Community System helps to achieve improved information exchange between various entities operating within a given hub, an Intermodal Route Planner is a tool used to identify and plan optimal, more efficient and cost-effective journeys between distant departure and destination points. Based on the freely available maps and real data from providers, the Intermodal Route Planner calculates the fastest freight route by road, rail and sea against estimated journey times and provides associated costs.

Several Intermodal Route Planners are available on the Internet. Although they may find alternative intermodal routes from origin to destination, these systems only show what these alternatives are. The development of a new Intermodal Route Planner standard for the future platform should enable one-stop-shopping for planning and executing all the services needed to move cargo from port of discharge to destination (in case of import) and from point of origin to loading port (in case of export), either as “Full Container Load” or via distribution centres as “Less than Container Load”.

The implementation of the Physical Internet concept will completely change the transportation system as we know it.

We envisage the development of a generic collaboration scenario within the **Physical Internet (A14)**. The scenario would have to take into consideration the following activities: the Logistics Service Providers collaborate in providing a common system for modular logistics, sharing assets (trucks, storage, etc.) and using their own IT supporting systems for managing their capabilities and needs for collaboration. TIP (Transport Incentive Program) provides to the Logistics Service Providers the cloud resources needed for enabling interoperability (Platform as a Service, PaaS), exchange of information, security and integrity of sensible data. ISP (Interface Segregation Principle) provides connectors and adapters for application communication and data exchange. Furthermore, they develop cloud-based solutions for collaborative planning, booking, shipment management, accounting and Track & Trace (Software as a Service (SaaS)), providing the global functionality lacking in the systems of the single Logistics Service Providers.

The **IT model and business model strongly influence each other**. IT architecture corresponds to the business model in order to satisfy activities of the Physical Internet. Every actor of the Physical Internet defined in the business model has their role assigned and described within the IT infrastructure. Realisation of the full collaboration model requires widely spread data exchange, thus it is crucial to develop IT solutions that incorporate new capabilities of data and information exchange

between machinery and equipment (Internet of Things, Machine to Machine communication) **(A6, A13)**.

Development of new software tools has to be encouraged that enable collaboration of 4PL (fourth party logistics service provider (LSP), i.e. logistics service integrator), 3PL (third part logistics, i.e. provider of logistics services), and carriers (providers of transport services) in planning the delivery and booking the needed resources, based on the capabilities of each participant.

It is important to develop smarter and widely accepted ways of defining the Business Model of the Physical Internet. The model is not easy to describe due to the multiplicity of parties involved (manufacturers, shippers, IT providers, LSP/transport service providers, LSP/hubs, M-box providers, retailers, consumers). The approach defining the Physical Internet concept should emphasise that value proposition can only be achieved if the whole system is fully interconnected and there is interoperability between the actors involved. No individual organisation can be considered an owner of the Physical Internet but the existence of each is vital for the business to run.

In economics and business, a network effect (also called demand-side economies of scale) is the effect that one user of a good or service has on the value of that product to other people. When a network effect is present, the value of a product or service is dependent on the number of others using it.

The classic example is the Internet. The more people own computers with Internet access, the more valuable the Internet is to each owner. This creates a positive externality because a user may purchase Internet access without intending to create value for other users, but does so in any case. It is getting more attractive as more users join.

The Physical Internet is the next level of cooperation and also requires mutual gain and fair allocation of the profits between parties in the transport network.

One of the main key enablers for the successful implementation of the Physical Internet scenario to enable competitors to share their logistics infrastructure and make full use of the transport assets requires development of a new standard for a so called **modular box (A12)** that meets all requirements of an interconnected transport network, and provides information about the product condition and its location in real time. The Physical Internet aims to bring maximum flexibility and interconnectivity to the supply chain. Modular boxes are key elements of this intention. They are equivalents of containers in maritime shipment industry. Contrary to the containers though, a multitude of standard boxes (or units) need to be defined with sizes considerably smaller than the mentioned container. Starting the design process, it was obvious that the gap between the supply chain in the Physical Internet vision and the supply chain system today will lead to two fundamentally different ways to build and design a modular box:

- rigid boxes,
- boxes built out of panels.

Panels mean modular panels which can be used as a top panel, bottom panel or side panel with no limitation to orientation. Using such modular panels will allow the building of many different boxes and using fewer different panels and as a consequence will bring more flexibility to the supply chain system.

This future scenario, allowing many different rigid boxes or detachable boxes built out of panels in the supply chains, can raise doubts about the efficiency and feasibility of pooling so many different boxes or parts and can lead to logistical and financial problems and obstacles. Challenges to overcome will be:

- in the complexities of the modern supply chain, keeping components together will be a huge logistical challenge.
- as soon as a part of a product is detached, it is at a risk of being lost and also damaged.
- a successful pooling business is based on having the right product available at the right location at the right time.
- one way to overcome this would be to budget the additional costs in oversupplying the network to overcome the risk of component shortage.

The Physical Internet scenario is that modular boxes will replace the pallets and cases that are currently used for intra-/inter-site transportation. The aim is to scale this up to an open interconnected network beyond company boundaries.

5.3.4 Other stakeholders

Nowadays, only a very few freight carriers cooperate with competitors. Most of them operate their own distribution centres, they have their own fleet of transport vehicles as well as their own goods delivery processes.

One of the most important tasks in a logistics collaboration is to provide the synergy to the companies participating in the **collaboration based on the shared usage of assets (vehicles, distribution or consolidation centres) (A15, A16)**. Therefore, there is a clear need for a well-defined, fair and understandable formula that collaborators can apply in practical projects. This formula should be attractive both centrally, i.e. for the group, and also individually, i.e. for every single participating company. This is not straightforward as individual decision makers, though often working towards a common objective, will always be guided by their own self-interest in the end.

5.4 Cost-benefit analysis

Table 13 sums up the cost-benefit analysis (CBA) for Focus Area 4. The results of this analysis have been validated by extensive stakeholder consultation. In the following paragraphs we briefly discuss the key implications for each Focus Area 4 action⁸³.

Table 13. Summary table on costs and benefits of Focus Area 4 actions.

		Low	Medium	High
		Cost		
Benefit	High	A7b Savings in transport cost (EU-wide)	A1b Adoption of standards (nation-wide)	A1c Adoption of standards (EU-wide)
			A4a Adoption of automatic data exchange tools	A2c Adoption of standard converters (EU-wide)

⁸³ Refer to Table 1 and Table 2 in Chapter 1 for the elaboration of the guidelines on assessing the costs and benefits for each action

Benefit			<p>A4b Data flow</p> <p>A5 Use of open ICT platforms for hubs</p> <p>A7a Savings in transport cost (nation-wide)</p> <p>A8a Number of smart cities</p>	<p>A3b Adoption of optimizing ICT tools</p> <p>A3c Territorial coverage of ICT tools</p> <p>A8b Use of simulation tools (nation-wide)</p> <p>A8c Use of simulation tools (EU-wide)</p>
	Medium		<p>A1a Spread of standards</p> <p>A2a Spread of standard convertors</p> <p>A3a Accessibility of optimizing ICT tools</p> <p>A6 Physical Internet concept implementation</p> <p>A9a Accessibility of enable solutions (nation-wide)</p> <p>A9b Accessibility of enable solutions (EU-wide)</p> <p>A10 Evaluated integration of manufacturing and transport</p> <p>A11 Use of modern</p>	<p>A2b Adoption of standard convertors (nation-wide)</p>

Benefit			technologies	
			A12 Use of supporting technologies	
			A13 New business and financial models for broad deployment	
			A14a Use of collaborating models (nation-wide)	
			A14b Use of collaborating models (EU-wide)	
			A15a Emissions reduction	
			A15b Level of modal shift	
			A16a Full transport assets utilization	
			A16b Load factor increase	
	Low			
		Low	Medium	High
		Cost		

- A1a Use of existing standards**
 Implementation of standards brings an effect provided that they are commonly used by a large number of participants of the supply chains (both shippers and logistics services providers). So the first phase of the implementation process is hardly ever beneficial.
- A1b Use of existing standards (national level)**
 Implementation of standards brings an effect provided that they are commonly used by a large number of participants of the supply chains (both shippers and

logistics services providers). So the first phase of the implementation process is hardly ever beneficial.

- **A1c Use of existing standards (European level)**
Implementation of standards brings an effect provided that they are commonly used by a large number of participants of the supply chains (both shippers and logistics services providers). So the first phase of the implementation process is hardly ever beneficial.
- **A2b Converting standards solutions (national level)**
The process of implementation of standard converters will be costly and time consuming due to variety of standards. High benefit is expected in turn.
- **A2c Converting standards solutions (European level)**
The process of implementation of standard converters will be costly and time consuming due to variety of standards. High benefit is expected in turn.
- **A3a Develop data models in the supply chain**
Creating data bases for the optimisation tools is costly and time consuming while the effect of the optimising tools is expected to be high.
- **A3b Apply data models in route and delivery planning**
Creating data bases for the optimisation tools is costly and time consuming while the effect of the optimising tools is expected to be high.
- **A3c Apply data models across regions**
Creating data bases for the optimisation tools is costly and time consuming while the effect of the optimising tools is expected to be high.
- **A4a Develop secure networks**
Concept of automatic data exchange between different parties involved in transport process is relatively well known in business reality. Most often, data exchange takes place in company to company relations (bilateral cooperation). It is necessary to build open and secure IT platforms allowing an exchange of information in line with current standards.
- **A4b Intensify automatic data exchange**
Automation of information exchange applied by the company for many years, but not widespread enough.
- **A5 Open ICT platforms for hubs**
The process of implementation of open ICT platforms used by hubs will be costly and time consuming due to the variety of platform functionality. High benefit is expected in return.
- **A6 Implement Physical Internet**
Full implementation of the Physical Internet concept allows to design a system to move, store, realise, supply and use physical objects throughout the world in a manner that is economically, environmentally and socially efficient and sustainable.
- **A7a Implement set of KPIs for transport impact at national level**
Implementation of the transport efficiency analysis is relatively inexpensive but brings a significant increase of efficiency of transport activities.
- **A7b Implement set of KPIs for transport impact at European level**
Implementation of the transport efficiency analysis is relatively inexpensive but brings a significant increase of efficiency of transport activities.

- **A8a Develop simulation tools for city transport impact**
Creating simulation tools is expensive but brings high effect in reducing transport expenses.
- **A8b Develop simulation tools for regional transport impact**
Creating simulation tools is expensive but brings high effect in reducing transport expenses.
- **A8c Develop simulation tools for European transport impact**
Creating simulation tools is expensive but brings high effect in reducing transport expenses.
- **A9a Enabling solutions to be widely used in countries**
The cost of implementing new technologies is very high, but the benefits are also high. This is necessary to create innovation.
- **A9b Enabling solutions to be widely used across the European Union**
The cost of implementing new technologies is very high, but the benefits are also high. This is necessary to create innovation.
- **A10 Evaluate integration of manufacturing and transport**
This is achieved by enabling interoperability between several value-added services and between multiple regional community initiatives.
- **A11 Modern technologies**
Modern technologies that enable collaboration of 4PL (fourth party logistics service provider, i.e. logistics service integrator), 3PL (third part logistics, i.e. provider of logistics services), and carriers (providers of transport services) in planning the delivery and booking the needed resources, basing on the capabilities of each participant.
- **A12 Develop supporting technologies**
Supporting technologies to enable competitors to share their infrastructure and make full use of the transport assets.
- **A13 - Collaboration models for Internet of Things and Physical Internet**
The specific characteristics of the Physical Internet concept emphasise that value proposition can only be achieved if the whole system is fully interconnected and there is interoperability between the actors involved. No individual organisation can be considered an owner of the Physical Internet, but the existence of each of them is vital for the business to run.
- **A14a Collaborating models in countries**
Cooperation models are very important from the point of view of transportation asset sharing. They will bring benefits for companies as well as society (lower CO₂, lower congestion).
- **A14b Collaborating models across the European Union**
Cooperation models are very important from the point of view of transportation asset sharing. They will bring benefits for companies as well as society (lower CO₂, lower congestion).
- **A15a Reduce emissions**
The process of implementation of the resource sharing concept will be moderately costly. High benefit and leverage is expected in return.
- **A15b Shift to environment friendly modes**
The process of implementation of the resource sharing concept will be moderately costly. High benefit and leverage is expected in return.

- **A16a Optimise use of vehicles**

The process of implementation of the resource sharing concept will be moderately costly. High benefit and leverage is expected in return.

- **A16b Increase vehicle load utilisation**

The process of implementation of the resource sharing concept will be moderately costly. High benefit and leverage is expected in return.

All actions listed in Focus Area 4 are aimed at one purpose – implementation of the Physical Internet leading to the freight market based on maximum optimisation of each aspect of individual orders as well as regional, nationwide or international networks.

To briefly sum up, the conclusions on the major Focus Area 4 challenges are the following:

- all companies involved in logistics processes have to be interconnected. The communication system for exchanging messages and documents between them has to be based on clear-cut standards. Companies will not be free to customise their communication systems according to their needs. Standards converters will make them understandable for any other participant of supply chain. Any limitations coming from variety of standards will no longer be a barrier to closer cooperation between enterprises. Another condition for allowing the full use of communication systems is the sense of security of stakeholders that their sensitive data cannot be leaked to others.
- cooperation between enterprises will have to climb on a much higher level. In addition to cooperation between the partners rendering their services in supply chains managed by large producing or trading companies, new initiatives emerged recently from ports to consolidate logistics services on their territories with the use of electronic platforms (Port Community Systems). This process will be followed by large container terminals or logistics centres, Implementation of a concept of sharing vehicles, storage or handling space as well as manufacturing area will be much greater challenge.
- development of optimisation tools will be a parallel process. Proper loading of a single vehicle, setting optimal route or management of a fleet of multiple trucks will be essential for a carrier. Shippers in turn will be interested in gaining ability to choose the cheapest possible or quickest means of transport. Container terminals will focus on optimisation of reloading process to shorten service time. The Ministry of Transport will be rather interested in development of nationwide functional transport system optimised with the use of simulation tools.

Thus all of these actions are necessary to achieve the main goal – full implementation of the Physical Internet. The gradual and balanced development of all the above-mentioned trends, processes and progress directions are expected.

Table 14 **Error! Reference source not found.** gives a tentative assessment of different European Union funding instruments that may be suitable in implementing the Focus Area 4 actions.

Table 14. Suitability of funding instruments for Focus Area 4 actions.

Action ID	Action Title	European Union Funding Instrument		
		H2020	CEF	Interreg
A1a	Use of existing standards	✓	✓	✓
A1b	Use of existing standards (national level)	✓	✓	✓
A1c	Use of existing standards (European level)	✓	✓	✓
A2a	Converting standards solutions	✓	✓	✓
A2b	Converting standards solutions (national level)	✓	✓	✓
A2c	Converting standards solutions (European level)	✓	✓	✓
A3a	Develop data models in SC	✓		
A3b	Apply data models in route and delivery planning	✓		
A3c	Apply data models across regions	✓		
A4a	Develop secure networks	✓	✓	✓
A4b	Intensify automatic data exchange	✓	✓	✓
A5	Open ICT platforms for hubs	✓		✓
A6	Implement Physical Internet	✓		✓
A7a	Implement set of KPIs for transport impact on national level	✓	✓	✓
A7b	Implement set of KPIs for transport impact on European level	✓	✓	✓
A8a	Develop simulation tools for city transport impact	✓		
A8b	Develop simulation tools for regional transport impact	✓		
A8c	Develop simulation tools for European transport impact	✓		
A9a	Enabling solutions to be widely used in countries	✓	✓	✓
A9b	Enabling solutions to be widely used across the European Union	✓	✓	✓
A10	Evaluate integration of manufacturing and transport	✓		
A11	Modern technologies	✓		
A12	Develop supporting technologies	✓		
A13	Collaboration models for Internet of Things and Physical Internet	✓	✓	

A14a	Collaborating models in countries	✓	✓	✓
A14b	Collaborating models across the European Union	✓	✓	✓
A15a	Reduce emissions	✓	✓	✓
A15b	Shift to environment friendly modes	✓	✓	✓
A16a	Optimise use of vehicles	✓	✓	✓
A16b	Increase vehicle load utilisation	✓	✓	✓

5.5 Prioritisation

Amongst the actions described above, the highest priority should be given to those which offer an attractive benefit-to-cost ratio (in particular, those which impact the entire European transport system) and which are urgent or will yield results in the relatively short term. Urgent actions are especially important if they will unlock a series of positive changes. Short term results are important as they will quickly demonstrate that the efforts to transform the European transport system are paying off. This will help to build momentum and continued support for change.

Second priority should go to actions which still offer an attractive benefit-to cost ratio but which will yield results in the medium to long term. These actions are important because they yield valuable results; but as they need to persist for some time before the results become visible, they will be less effective in building momentum and support.

The third priority actions are those which yield less attractive benefit-to-cost ratios. For example, the benefit of such actions, while still substantial, may be limited to an individual issue or a narrow group of stakeholders. The results of such actions, whether short- or long-term, will have less impact on the functioning of the European transport system as a whole.

Based on the discussions of timing and cost-benefit in the previous sections, we propose the following prioritisation of actions. Within each group, we list actions in decreasing order of priority.

Table 15. Action prioritisation

Priority 1: Attractive benefit-to cost ratio and urgent or short-term results
(A1b) Use of existing standards (national level) (A4a) Develop secure networks (A4b) Intensify automatic data exchange (A5) Open ICT platforms for hubs (A7a) Implement set of KPIs for transport impact on national level (A7b) Implement set of KPIs for transport impact on European level (A8a) Develop simulation tools for city transport impact
Priority 2: Attractive benefit-to-cost ratio and medium- to long-term results
—
Priority 3: Less attractive benefit-to-cost ratio

- (A1a) Use of existing standards
- (A1c) Use of existing standards (European level)
- (A2a) Converting standards solutions
- (A2b) Converting standards solutions (national level)
- (A2c) Converting standards solutions (European level)
- (A3a) Develop data models in supply chain
- (A3b) Apply data models in route and delivery planning
- (A3c) Apply data models across regions
- (A6) Implement Physical Internet
- (A8b) Develop simulation tools for regional transport impact
- (A8c) Develop simulation tools for European transport impact
- (A9a) Enabling solutions to be widely used in countries
- (A9b) Enabling solutions to be widely used across the European Union
- (A10) Evaluate integration of manufacturing and transport
- (A11) Modern technologies
- (A12) Develop supporting technologies
- (A13) Collaboration models for Internet of Things and the Physical Internet
- (A14a) Collaborating models in countries
- (A14b) Collaborating models across the European Union
- (A15a) Reduce emissions
- (A15b) Shift to environment friendly modes
- (A16a) Optimise use of vehicles
- (A16b) Increase vehicle load utilisation

5.6 Key performance indicators

To measure impacts of the Focus Area 4 actions, key performance indicators along the four impact pathway steps are shown in the following Table⁸⁴.

⁸⁴ See elaboration of assessment framework for monitoring and evaluation in Chapter 1, Figure 4

Table 16. Focus Area 4 key performance indicators.

Effort-KPIs	Action-KPIs	Outcome-KPIs	Impact-KPIs
(A6) Physical Internet concept implementation		(A9a) Accessibility of enable solutions (nation-wide)	(A12) Use of supporting technologies
	(A3b) Adoption of optimizing ICT tools (A5) Use of open ICT platforms for hubs	(A1b) Adoption of standards (nation-wide) (A2b) Adoption of standard convertors (nation-wide) (A3c) Territorial coverage of ICT tools (A7b) Savings in transport cost (EU-wide) (A8c) Use of simulation tools (EU-wide)	(A2c) Adoption of standard convertors (EU-wide) (A9b) Accessibility of enable solutions (EU-wide) (A11) Use of modern technologies
(A13) New business and financial models for broad deployment		(A14a) Use of collaborating models (nation-wide)	(A14b) Use of collaborating models (EU-wide) (A15a) Emissions reduction (A15b) Level of modal shift (A16a) Full transport assets utilization
(A3a) Accessibility of optimizing ICT tools	(A1a) Spread of standards (A2a) Spread of standard convertors	(A4a) Adoption of automatic data exchange tools (A4b) Data flow	
(A8a) Number of smart cities	(A7a) Savings in transport cost (nation-wide) (A8b) Use of simulation tools (nation-wide)		(A1c) Adoption of standards (EU-wide) (A10) Evaluated integration of manufacturing and transport

In the following, we list all actions and sub-actions suggested for Focus Area 4 and the Key Performance Indicators that show the results of each of the actions, along with the units of measurement for each:

- **A1a Use of existing standards**
Share of companies which use transport management systems TMS, based on general European Union standards to all registered enterprises (manufacturers, trading companies, logistics service providers)
Spread of standards, [%]
- **A1b Use of existing standards (national level)**
Number of standards used by more than 80% enterprises (manufacturers, trading companies, logistics service providers) at the national level
Adoption of standards (nation-wide), [units]
- **A1c Use of existing standards (European level)**
Number of standards used by more than 80% of enterprises (manufacturers, trading companies, logistics service providers) at the European Union level
Adoption of standards (European Union-wide), [units]
- **A2a Converting standards solutions**
Share of companies using customised Electronic Data Interchange systems with the use of standards converters to reach conformity with general standards - at the national level
Spread of standard converters, [%]
- **A2b Converting standards solutions (national level)**
Number of standards converted into general standards at national level
Adoption of standard converters (nationwide), [units]
- **A2c Converting standards solutions (European level)**
Number of standards converted into general standards at the European Union level
Adoption of standard converters (European Union-wide), [units]
- **A3a Develop data models in Supply Chain**
Size of data bases of transport companies and their services at the national level (no of records)
Accessibility of optimising ICT tools, [units]
- **A3b Apply data models in route and delivery planning**
Share of companies using ICT applications for optimisation of delivery planning equipped with data base of transport operators and their services at national level
Adoption of optimising ICT tools, [%]
- **A3c Apply data models across regions**
Share of European Union regions that use ICT tools for optimal deliveries planning easily accessible for all shippers at the European Union level
Territorial coverage of ICT tools, [%]
- **A4a Develop secure networks**
Number of partners exchanging data automatically
Adoption of automatic data exchange tools, [units]
- **A4b Intensify automatic data exchange**
The number of categories of messages and documents exchanged electronically
Data flow, [units]
- **A5 Open ICT platforms for hubs**
Number of open ICT platforms used by hubs
Use of open ICT platforms for hubs, [units]

- **A6 Implement Physical Internet**
Level of logistics inefficiency and unsustainability reduction
Physical Internet concept implementation, [%]
- **A7a Implement set of KPIs for transport impact at the national level**
Decrease of transport cost due to implementation of transport efficiency analysis at national level
Savings in transport cost (nation-wide), [%]
- **A7b Implement set of KPIs for transport impact at the European level**
Decrease of transport cost due to implementation of transport efficiency analysis at the European Union level
Savings in transport cost (European Union-wide), [%]
- **A8a Develop simulation tools for city transport impact**
Number of cities covered with the intelligent systems of traffic management supported by use of simulation tools
Number of smart cities, [units]
- **A8b Develop simulation tools for regional transport impact**
Share of regions that use simulation of freight and passenger traffic to plan strategic infrastructure investments in the country at different variants of economic growth
Use of simulation tools (nationwide), [%]
- **A8c Develop simulation tools for European transport impact**
Share of countries that use simulation of freight and passenger traffic to plan strategic infrastructure investments in the European Union at different variants of economic growth
Use of simulation tools (European Union-wide), [%]
- **A9a Enabling solutions to be widely used in countries**
Number of companies using enabling solutions at the national level
Accessibility of enabling solutions (nationwide), [units]
- **A9b Enabling solutions to be widely used across European Union**
Number of companies using enabling solutions at the European Union level
Accessibility of enabling solutions (European Union-wide), [units]
- **A10 Evaluate integration of manufacturing and transport**
Groups of (direct) shippers and freight forwarders to form a collaborative community, merge their transport volumes and decide on the best transportation options based on aggregated volume
Evaluated integration of manufacturing and transport, [units]
- **A11 Modern technologies**
Number of companies using modern technologies
Use of modern technologies, [units]
- **A12 Develop supporting technologies**
Number of companies using supporting technologies
Use of supporting technologies, [units]
- **A13 Collaboration models for Internet of Things and Physical Internet**
Number of studies on Physical Internet and Internet of Things based business models
New business and financial models for broad deployment, [units]

- **A14a Collaborating models in countries**
Number of companies using collaborating models at the national level
Use of collaborating models (nationwide), [units]
- **A14b Collaborating models across the European Union**
Number of companies using collaborating models at the European Union level
Use of collaborating models (European Union-wide), [units]
- **A15a Reduce emissions**
The level of emissions reduction
Emissions reduction, [%]
- **A15b Shift to environment friendly modes**
The share of freight carried by environmental friendly modes of transport
Level of modal shift, [%]
- **A16a Optimise use of vehicles**
The level of vehicles reduction
Full transport assets utilisation, [%]
- **A16b Increase vehicle load utilisation**
Transport cost optimisation and reduction across chains
Load factor increase, [%]

6 Focus Area 5. Alternative fuels other than electrification

6.1 Overview

In the SINTRAS study, Focus Area 5 “Alternative fuels other than electrification” has been defined as follows:

Promotion of alternative fuels is motivated by objectives to (1) reduce greenhouse gas emissions, (2) reduce local environmental impacts, (3) improve security of energy supply, (4) make use of local energy sources and/or (5) stimulate local activities, employment and self-sufficiency.

The main alternative fuels and energy carriers include electricity, liquid biofuels, natural gas and biogas, liquefied petroleum gas and hydrogen. However, electrification, which has been analysed in many other studies and programmes, has been excluded from the scope of this study in order to focus fully on other alternatives.

For Focus Area 5 (FA5), the six barriers identified early in the SINTRAS project are (in the approximate order of decisiveness as expressed by SINTRAS stakeholder workshop participants):

- **FA5-05 High cost of alternative fuels**
High costs of alternative fuels or vehicles capable of using them, especially because of high production costs, make alternative fuels typically more costly than conventional options that are already on the market.
- **FA5-07 Dominance of the existing system**
Lock-in situation in supply and demand practices with conventional fuels makes the business-as-usual situation seem comfortable, and change-resistance hinders progress with alternatives.
- **FA5-02 (+ FA5-06) Low demand and user acceptance**
Demand for alternative fuels and vehicles capable of using them is weak among end-users because of, for example concerns over purchasing price, technological aspects, infrastructure availability, safety and sustainability.
- **FA5-01 (+ FA5-03) Supply weaknesses and innovation chain discontinuities**
Inadequate refuelling and recharging infrastructure, low supply of alternative fuels (production and market availability) and lacking supply of vehicles and other means of transport capable of using alternative fuels hinder progress with alternative fuels. Part of the problem are the gaps along the innovation chain, e.g. between pilot-production and market-entry.
- **FA5-08 Fragmented market across Europe**
The fuel markets portray an unlevel playing field, and there is for example variability in availability of different alternative fuels across Europe as well as in support measures and strategies.
- **FA5-04 (+ FA5-09) Weak, short-term policy support**
Stated policy goals (at the European level) are not implemented as real long-term policy measures and actions, especially at national and local levels. Short-term commitment and uncertainty hamper progress by causing negative impacts on investments, commercialisation, user acceptance, etc.

Advancement in the field of alternative fuels, addressing the above barriers, calls for joint decisions and actions by multiple stakeholders, public and private, at European and national levels. Stability and predictability of the policy framework is an important prerequisite for the industries when they make decisions on large investments for periods as long as 15 to 30 years. Wide co-operation is crucial, especially with respect to the following issues.

To be fully implemented and effective, actions require agreements on long-term measurable targets, priorities, clear responsibilities and mandates for parties at European Union, national and local levels, as their basis. Global, systemic view on the state of play of fossil and alternative fuels covering all transport modes and their future prospects is part of the base knowledge. Further, the agreements also need to cover approaches and indicators measuring the achievement towards the targets.

Active solution searching, relying on cooperation between key public and private parties is also needed to solve the barriers of supply weaknesses and low user demand and acceptance with the interlinked issues of alternative fuels, compatible vehicles, and fuelling infrastructure. As there is no one right solution for all Member States, for all transport modes or for all transport needs, it is important to map national differences and preferences and build (bottom-up) on the emerging strengths, e.g. regionally in a technology-neutral way. The focus of support measures and monitoring indicators should be on outcomes and impacts, such as targeted CO₂ reduction, reduction of local emissions, cost savings, etc.

6.2 Projected developments

Figure 16. **Projected developments in Focus Area 5.**

presents the projected developments in Focus Area 5, the foundation of which is based on the state of play analysis of alternative fuels policies, technologies and markets. In the next subsections, we explain this graph in detail, layer by layer, using the numbers in parentheses when referring to specific boxes within the graph. In the graph, the codes for identified barriers are also used to link present-state items to specific Focus Area 5 barriers.

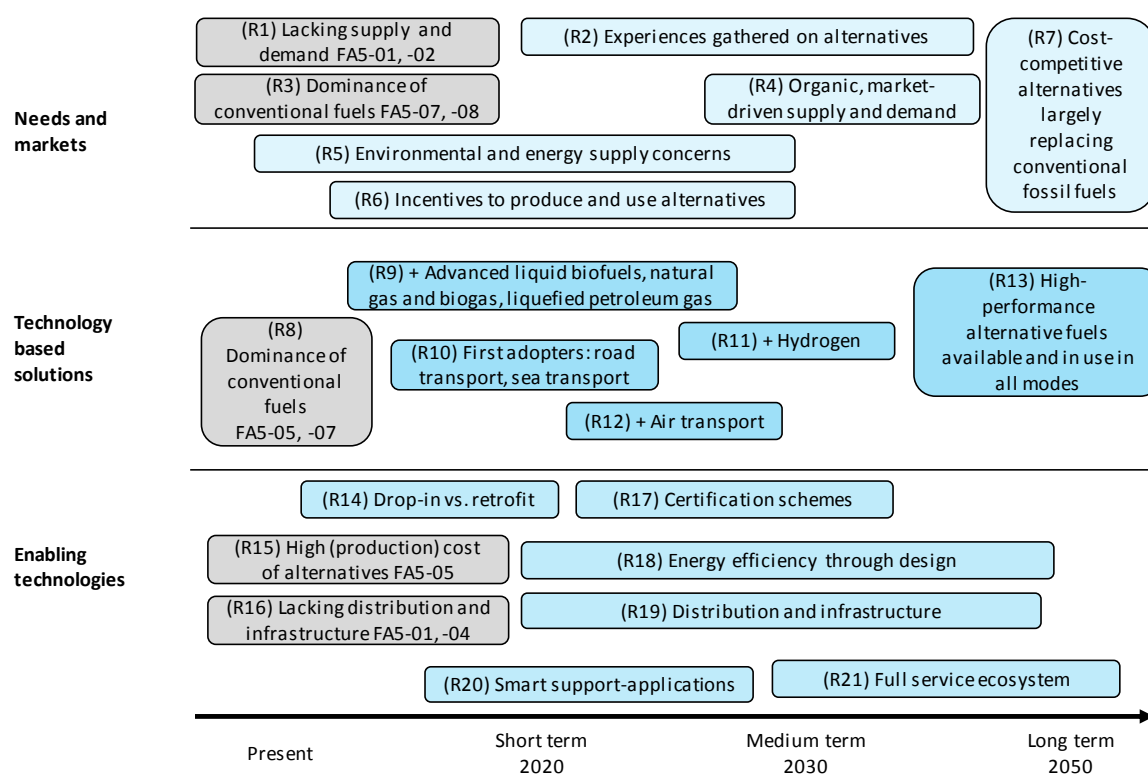


Figure 16. Projected developments in Focus Area 5.

6.2.1 Needs and markets

For Focus Area 5, the layer for **needs and markets** looks into matters of supply and demand for transport fuels and vehicles, most importantly alternative fuels and powertrain systems capable of using them.

Currently, the low supply and demand for alternative fuels (R1)⁸⁵ as well as of vehicles capable of using them is very characteristic. Although environmental concerns, among other driving forces advocating alternatives, are well understood, the market behaviour in practice largely relies on dominant conventional fuels and vehicles (R3). Conventional technologies and solutions are familiar, convenient, widely available and affordable, and alternatives in most use cases are not yet competitive in these dimensions.

The growing importance and urgency of environmental, health and energy supply concerns (R5) should nevertheless gradually have more impact on various levels of policy and decision making on both supply and demand sides. For example, air quality issues in cities are bound to create demand pull for more sustainable alternatives in urban environments^{86,87}. Supported by implementation of, for example, climate

⁸⁵ Codes R and A provide cross-references to project developments (R) and proposed actions (A), defined in sections 6.2 and 6.3 respectively

⁸⁶ European Parliament. Plenary sitting 13.11.2015 A8-0319/2015. Report on sustainable urban mobility (2014/2242(INI)) Committee on Transport and Tourism.

⁸⁷ OECD Environmental Outlook to 2050: The consequences of Inaction Key Findings on Health and Environment. <https://www.oecd.org/environment/indicators-modelling-outlooks/49928853.pdf> (Accessed 2.2.2017)

actions, incentives to produce and use alternative fuels and vehicles capable of using them (R6) will accelerate changes in the market. In fact, it will be important to monitor developments in both supply and demand sides, so that potential bottlenecks can be addressed and markets for alternatives to be able to grow in a balanced manner. An important factor in the needs and at the market level is how experiences gathered on alternatives (R2), by for example Member States and cities will help in establishing the market for various alternative fuels. Availability and visibility of options combined with proof of performance will strengthen user acceptance and interest. Build-up of experiences and knowledge is central both for private consumers as well as commercial actors and investors, all of whom will be more comfortable using alternatives as their markets mature.

While early markets for alternatives will, in most cases, need interference and support measures, in the long-term, alternative fuels need to be able stand on their own. Therefore, support actions should always aim to overcome barriers with the ultimate objective of organic, market-driven supply and demand for alternative fuels (R4). By this, we mean that when technologically and commercially mature, alternative fuels should be able to provide a cost-competitive option attractive enough largely to replace conventional fossil fuels (R7). The role of policies and support measures is therefore ideally to ensure the overall long-term framework (e.g. steady emission policies) and market conditions where market development towards this goal is possible and predictable, complemented by targeted support measures (e.g. fixed-term support for pre-commercial production to overcome a specific barrier in innovation chain). Also, policies and support measures should take into account the variability across the European market and it should be assessed carefully in which matter support measures should target aligned market developments and in which topics regional dissimilarities cause no problems.

6.2.2 Technology-based solutions

For Focus Area 5, the layer for **technology-based solutions** covers transport fuels and zooms particularly into alternative fuels and powertrain systems capable of using them.

Currently, conventional oil-based fuels dominate (R8) in road, waterborne and air transport. Rail transport presents an exception, where electricity is already the main energy carrier and further electrification is underway.

Advanced liquid biofuels, natural gas and biogas (methane fuels) and liquid petroleum gas (R9) are important alternatives in the short term and synthetic fuels in the mid-term. First adopters are the transport modes of road and waterborne (R10). Drop-in liquid fuels provide the easiest and fastest option, adaptable to existing vehicles and fuel distribution systems and causing practically no changes to the end user. For passenger cars and other light duty vehicles, hybrid-electric drives as well as fully electric powertrains are also expected to become a more available and affordable option in the short to medium-term. Although liquid biofuels and methane fuels are a viable option for both light duty and heavy duty road vehicles already with the current fleets, considering that the production of advanced biofuels by industry is estimated to be 4% or 5% by 2030 and its use should be mainly devoted to the aviation sector, the use of natural gas blended with biomethane or synthetic gas produced from power to

gas technologies seems the most attractive option to replace diesel in heavy duty vehicles.

Waterborne transport could also make use of biofuels, but the biggest potential in the short to medium-term is identified in LNG (liquefied natural gas) and methanol. Even if produced from fossil-based natural gas, these fuels provide a cleaner alternative to oil-based conventional fuels. Dual fuel systems allowing ships to introduce alternatives, such as LNG, alongside conventional fuels suit existing fleets but require investments.

In the medium to long term, hydrogen (R11) technologies are expected to mature towards commercial availability. Hydrogen could be an appropriate energy carrier especially in road transport, providing a more compact and energy-efficient option also suitable for longer ranges and heavier vehicles. Fuel cell vehicles are expected to become mainstream technology around the 2030s. It is also seen that hydrogen as an alternative fuel is not applicable to air transport and long-distance heavy road transport. In maritime transport, hydrogen could potentially play a role as a propulsion fuel in the long term (after 2030), and for auxiliary power much earlier, albeit limited to routes with hydrogen supply infrastructure. Air transport is likely to be the last to adopt alternative fuels on a large-scale (R12) because of, for example, limited selection of suitable alternatives and the sector's strict safety regulation. Advanced liquid biofuels are the most promising option but only after lengthy technical assessments and approvals. The worldwide dimension of acceptance of sustainability certification frameworks is especially important for the aviation sector. The European Advanced Biofuels Flightpath⁸⁸ ambition is to achieve 2 million tonnes of sustainable biofuels in aviation (blended with kerosene) by 2020 and that biofuels would be available in most European Union airports.

All in all, road transport has the widest selection of suitable alternative fuels. Towards 2020 and 2030, substitution of conventional fuels could, under favourable market conditions, proceed rapidly. Several options are also open for waterborne transport, and air transport, with a more limited palette, is expected to follow around 2030. By 2050, high-performance alternatives should be available and in use in all modes (R13).

6.2.3 Enabling technologies

For Focus Area 5, the layer for **enabling technologies** covers physical and service infrastructures that relate to transport fuels. These include, for example, vehicle and engine technologies, fuel distribution and some value-added services.

Some alternative fuel products, e.g. some advanced biofuels, are fully compatible with present-day engines, vehicles and refuelling infrastructure. In such cases, implementation can be fast and uptake and use of the alternative is as easy as with conventional fuels. In addition to such drop-in fuels, fuels requiring only small, affordable retrofitting (R14) can also enter the market quickly.

Other alternative fuels on the other hand are costly (R15) as they require major changes in distribution systems or other infrastructure (R16). Electricity, LNG and hydrogen are examples of such fuels, and development of their infrastructure coverage in Europe is planned to proceed step-wise (R19). European Union plans for

⁸⁸ European Commission. European Advanced Biofuels Flightpath
<https://ec.europa.eu/energy/en/topics/biofuels/biofuels-aviation> (Accessed 16.6.2016)

natural gas, electricity and hydrogen infrastructures along TEN-T (Trans-European Transport Networks) core network, urban areas and ports by 2020, 2025 and 2030. Hybrid-vehicles and dual-fuel systems are a notable option in the short to medium-term transition phase in road and waterborne modes, providing capacity to use conventional as well as alternative fuels. Hydrogen for road transport is in turn an example of a case where product development for dedicated fuel cell vehicles is rather far from large commercial scale and price competitiveness.

Somewhat connected to the alternative fuels topic is the objective of energy efficiency, and improvements in these aspects are driven in all transport modes using various mechanisms. Energy efficiency through design (R18) is topical in for example engine design for road, waterborne, rail and aviation engines as well as vehicle design and transport patterns. Uptake of alternative fuels and energy efficiency improvements bring synergetic impacts towards the ultimate goal of sustainable mobility.

An integral part of introducing alternative fuels is validation of these fuels in terms of technical and sustainable performance. Therefore, standards, certification schemes (R16), etc. are important at the early market phase for fuels and refuelling points. Additionally, value-added services and for example smart support-applications (R20) such as apps to locate refuelling points are important.

Finally, in order to establish a full service ecosystem that supports use of alternative fuels (R21), a transport system level view over individual transport mode considerations is necessary. Here, aspects such as distribution, certification and related information sharing are important enablers in building an attractive and functional market for alternative fuels.

6.3 Action plan

Figure 17. **Focus Area 5 action plan.**

presents the proposed actions for Focus Area 5. In the next subsections, we explain this action plan in detail, layer by layer using the numbers in parentheses when referring to specific boxes within the action plan. In the action plan, the codes for identified barriers are also used to link items to specific Focus Area 5 barriers.

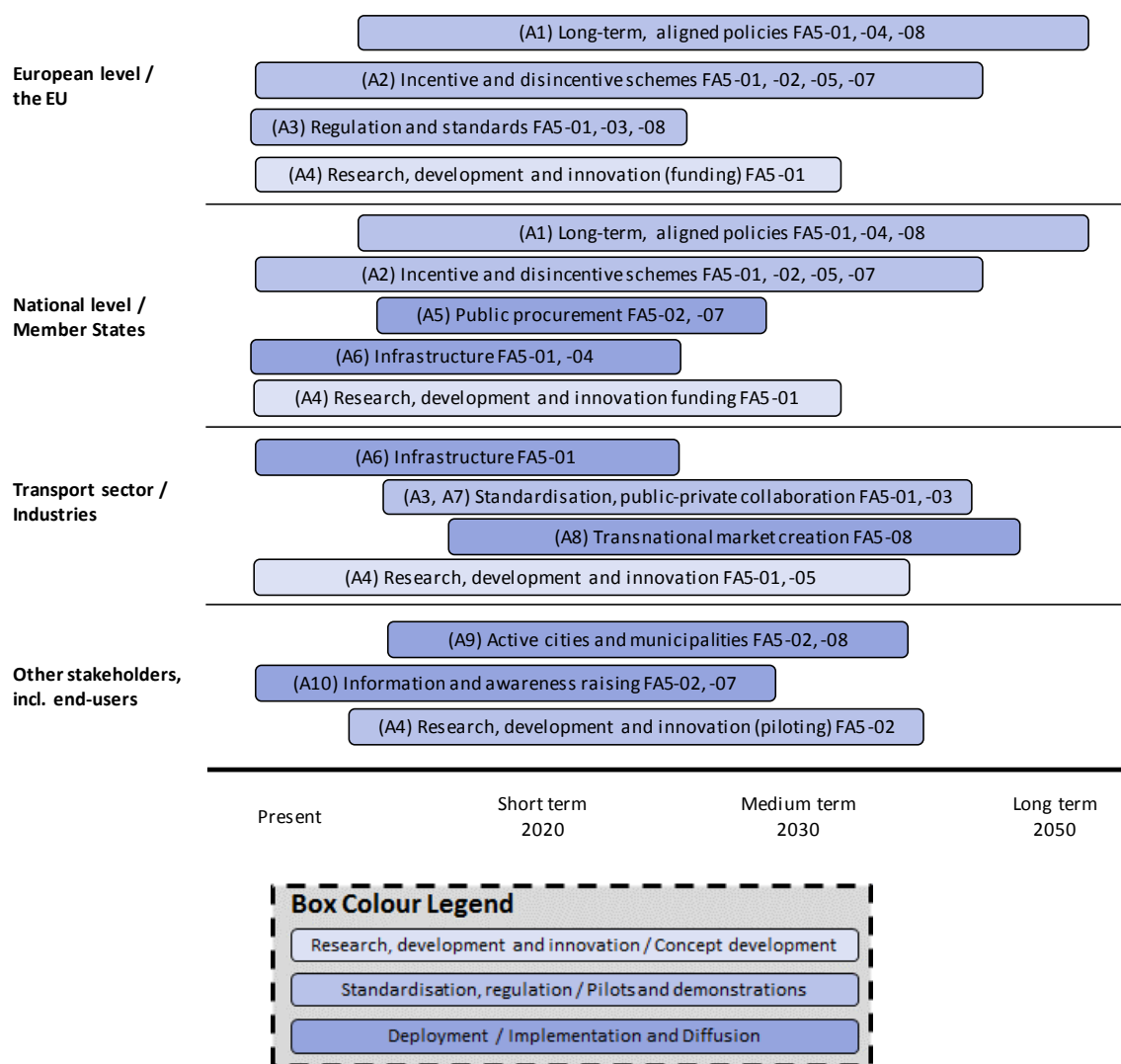


Figure 17. Focus Area 5 action plan.

List of actions:

- (A1) Long-term, aligned policies
- (A2) Incentive and disincentive schemes
- (A3) Regulation and standards
- (A4) Research, development and innovation (incl. funding and piloting)
- (A5) Public procurement
- (A6) Infrastructure
- (A7) Public-private collaboration
- (A8) Transnational market creation
- (A9) Active cities and municipalities
- (A10) Information and awareness raising

6.3.1 European level

The core of actions at European and national levels is to provide an appropriate level of **alignment in the long-term strategic policies (A1)**. This means that instead of short-term strategies without legally binding targets, long-term cross-sectoral approaches with vision, predictability and binding commitments should be enforced urgently. These should address both supply and demand sides of alternative fuels and compatible means of transport in order to create frameworks for European markets for these fuels. Target setting should also encompass goals such as reducing fossil oil [%], reducing CO₂ emissions [%], share of renewable energy [%], reducing local pollution [%], etc. Policy fields of energy, climate, natural resources, agriculture, land use and transport should be in sync. For example, European level targets for renewable energy in transport need to extend from 2020 to 2030 and 2050, and the step-wise plan to year-by-year fulfilment of such goals needs to be tightly integrated to policies and strategies in energy sector and certain fields of manufacturing industries. This will promote the planning security for investments by fuel producers, suppliers and transport industry (e.g. shipping industry) since they require long-term stable market conditions in terms of volume demand as well as prices to enable long-term investment. The European Union's Energy Union⁸⁹ shows great promise as a framework strategy, where alternative fuels for transport are addressed as one part of European energy and climate policies, and overall as well as sectoral step-wise targets for emissions reduction for example, use of renewables and energy efficiency improvements are laid out. One of these sectoral branches is the European Strategy for Low-Emission Mobility⁹⁰. The Energy Union is also a framework for Member States in their respective detailed strategies. The most recent publications, the so-called European Union winter package⁹¹, pave the way for continuation on energy topics, for example by showing support for transport biofuels using blending quota beyond the current decade (Proposal for a revised Renewable Energy Directive). In future activities, it is important also to ensure the consistency of energy policies with land use policies.

The European level is the forum to address fragmentation among Member States (MS) and decide on where and how much variation across Europe is appropriate and where harmonisation is essential. Considerations on cross-country biofuel incorporation targets provide an example of such actions where the effectiveness of the actions depends on the level of deployment. Coverage and consistency on acknowledging all transport modes and all viable alternative fuels is important here and should be planned in detail.

At European level, **incentive and disincentive schemes (A2)** should be drafted now to provide the overall framework for MS that actually implement them (diversity across Member State was perceived in early SINTRAS activities, including country studies and expert views expressed in the stakeholder consultation workshops). This would involve minimum requirements, guidance and directions, but leaving the details of implementations to the Member State. For example, subsidies are most importantly introduced at Member State level but a European-scale master approach could be beneficial. This applies to schemes for (1) alternative fuels: incentives for purchase, tax incentives, etc. and (2) use /acquisition of vehicles: incentives for purchase, tax incentives, benefits for use, CO₂ value limits for heavy duty vehicles, etc.

⁸⁹ European Commission, Energy Union and Climate: https://ec.europa.eu/priorities/energy-union-and-climate_en (Accessed 30.11.2016)

⁹⁰ A European Strategy for Low-Emission Mobility COM(2016) 501 final

⁹¹ European Commission – Press release: Clean Energy for All Europeans – unlocking Europe's growth potential, Brussels, 30 November 2016 http://europa.eu/rapid/press-release_IP-16-4009_en.htm

Regarding subsidies for alternative fuel investments (relevant at both the European Union and national levels) on biofuels (e.g. process development, support for first-of-a-kind installations), the focus should be on short-term subsidies for second generation biofuel suppliers in order not to support production of first generation biofuels but advanced RDI. Simultaneously, vehicle manufacturers need incentives to produce alternative fuel vehicles to the market. Currently, there are no real incentives for the auto manufacturers to produce flexi-fuel vehicles (FFVs) since their tailpipe CO₂ emissions are considered almost equal to the ones from conventional combustion engine cars even when running on renewable fuel. This does not provide any benefits for manufacturers in average manufacturer CO₂ emission calculations. A general recommendation is that external costs need to be fully assessed and allocated to all fuels (especially conventional fuels with high negative environmental impacts) so that they show in retail prices. Carbon dioxide-based taxation across Europe is an example of one such measure.

An example of a malfunction in previous subsidy policies is that lack of capital investment has hampered development of advanced biofuels that involve high capital expenditure. Traditional biofuels (e.g. food feedstock) production is by comparison low capex activity, and has therefore appeared as a more attractive industrial venture.

Another problematic example comes from fuel taxation, where different calculation choices may result in very different outcomes: i.e. taxation based on fuel volumes versus taxation based on fuel energy content. The latter would be preferable to ensure that fuels and energy carriers of different types are more comparable with one another.

Regulation and standards (A3) are essentially a topic on the European level at least in the short and medium terms. The aspects of harmonised action include: fuel quality standards and related analysis procedures (specification, blending, performance, life cycle impacts, etc.), market minimum quota, engine emissions, land use and feedstock use, certification and labelling, etc. Both voluntary, industry-driven initiatives and public sector driven measures are needed, and the co-development of the two would be ideal. Regulations and standards can be advocated by the European Union to create Pan-European availability and quality assurance of alternative fuels. In fact, Europe could even decide to take the global leadership in these matters, rather than adjust to or follow up on progress in the US or Asia. The current level of and need for standardisation varies between transport modes and hence different aspects should be considered respectively.

For example, in road transport speeding up standardisation of E20/E25-fuels and modification of Directive 2009/30/EC (fuel quality) to encompass higher ethanol concentrations in petrol are important issues. A new European standard on paraffinic diesel fuel (EN 15940, May 2016), will facilitate the use of high concentration renewable paraffinic diesel fuels. As regards maritime fuels, there is a need for technology qualification and safety standardisation techniques at ports.

Currently-used instruments by the EC include directives on fuel quality⁹², renewable energy share⁹³ and vehicle engine emissions⁹⁴. The positive effects of these should be guaranteed by ensuring that implementation and evaluation of the achievements takes place and that target setting in the directives is binding, ambitious enough and predictable in the long-term (e.g. step-wise). Also constant evaluation and

⁹² 2009/30/EC on fuel quality (amending Directive 98/70/EC) and 2015/1513/EU on sustainability of biofuels (amending Directives 98/70/EC and 2009/28/EC)

⁹³ 2009/28/EC on the promotion of renewable energy

⁹⁴ Regulations (EC) No 443/2009 and (EU) No 333/2014 on CO₂ emissions

development of compliance is needed to cope with technology development and increasing environmental demands.

Examples of topical issues at the European alternative fuels agenda and markets, which still lack legally binding European Union-level mandates or need to be further elaborated, are: (1) national deployment of alternative fuels infrastructure (also covering high-level ethanol), (2) common European Union-level carbon dioxide based fuel taxation and (3) carbon pricing and pricing in general to take into account externalities. These suggestions have been debated in the literature and were also raised by the experts in the SINTRAS workshops.

For the maritime sector, implementation of a specific renewable fuel mandate, to create synergy with the mandate for road transport could be an option, which might create complementarities in technology development, implementation, government support and deployment.

For aviation, the future within the European Union ETS (European Union Emissions Trading System) is currently under discussion and advancing in the right direction, as are other promising complementary and alternative measures on a global scale.⁹⁵

As for hydrogen, tight emissions regulations are an important driver for hydrogen vehicle supply and demand as are the regulatory instruments related to e.g. safety standards⁹⁶. Consequently, these should be promoted at the European Union level.

Funding for research, development and innovation (A4) in the short and medium terms should address alternative fuels, taking into account their maturity level and ensuring all modes are covered and that different time scales are considered. Funding for joint fuel-vehicle-infra RDI (e.g. heavy goods vehicles in road transport), as well as funding for infrastructure and questions related to sustainable alternative feedstock production should be even more in line with the policy frameworks than at present, allocating funds in full support for projects promoting policy objectives and refusing support for projects with conflicting outcomes. Currently perceived examples of such conflicts were brought up by experts in the SINTRAS workshops, pointing out, for example, European funding being allocated to transport infrastructure projects that rather strengthening reliance on private transport, road transport and use of conventional fuels.

For longer term options like hydrogen, international cooperation in the development of pioneer regions or pilot areas, which ensure large enough fleet roll-out and provide supporting fuel infrastructure for vehicles of various modes (road, maritime and in specific cases even for rail) is essential. In fact, the long-term vision and infrastructure preparedness in the topic of hydrogen was mentioned in the SINTRAS stakeholder interaction as one good example of European initiatives: actions are introduced even though the time horizon is lengthy and hydrogen infrastructure corridors are being advocated via measures ranging from RDI to implementation at the Member State level.

6.3.2 National level

The national level is largely where implementation of European level action takes place in practice. Ideally **long-term policies (A1)** as well as **incentive and disincentive**

⁹⁵ European Commission – Fact Sheet MEMO: 39th Assembly of the International Civil Aviation Organisation, Brussels, 7 October 2016 http://europa.eu/rapid/press-release_MEMO-16-3332_en.htm (Accessed 26.10.2016)

⁹⁶ E4tech for CCC: Scenarios for deployment of hydrogen in meeting carbon budgets <https://www.theccc.org.uk/publication/e4tech-for-ccc-scenarios-for-deployment-of-hydrogen-in-contributing-to-meeting-carbon-budgets/> (Accessed 18.10.2016)

schemes (A2) follow European frameworks but are tailored to national and local contexts and needs after the European Union-level decisions have taken place. This enables, for example, directing support measures to those alternative fuels supply sectors that are relevant in the country as well as crafting demand side schemes addressing local barriers and opportunities. Strengths and specific characteristics of national and regional industries and energy security are therefore relevant issues to be considered similarly in the context of transport strategies at regional, national and European Union levels. Nevertheless, alignment and collaboration not only with neighbouring countries but also with other Europe and global countries is important and should be promoted from the top level. The SINTRAS country studies proved that currently the practices in Member States vary widely, ranging from large investments to very narrow technological focus to largely lacking implementation of any measures at all to support alternative fuels.

Examples of national and regional level items connected to the European level, include national targets and quota for alternative fuels (e.g. renewables), deployment and manufacturing support and actions to secure long-term security for investments.

The type of support on alternatives depends on the maturity of technology and the national fuel preferences. Advanced biofuels, hydrogen, etc. still need support and development while some others, such as methane, gasoline-ethanol blends or diesel-biodiesel blends, are already mature enough and require actions rather on the final implementation side.

One effective means of incentive is taxation of fuels, energy carriers and vehicles. National and European Union legislation should ensure that alternative fuels and vehicles capable of using them have a fair standing in the markets, and tax schemes should fully acknowledge e.g. environmental impacts of conventional and alternative options (e.g. well-to-wheel CO₂ emissions). In contrast, an example of a measure that has been under discussion lately and raised serious criticism is a ban on diesel cars. Such a measure could be a powerful discouragement for fossil fuels and encouragement for electrification, but on the other hand it would backfire on biofuels (compatible to use in diesel engines) as well as being costly and difficult to get public acceptance.

Subsidies and other such incentives should be carefully planned, especially to ensure alignment with energy policies. The energy sector may furthermore provide examples of more or less successful schemes, the learnings of which should be taken on board to the transport sector in order to avoid similar mistakes (e.g. in the topic of solar energy, photovoltaics and related industries). Experts involved in SINTRAS interviews and workshops emphasised that subsidising during the early phases of the innovation chain (RDI) may prove more important and effective rather than at the market stage (e.g. production). Similarly, it should be carefully assessed that measures do not, as an unintended effect, encourage private car use but rather support active and collective transport modes.

Close dialogue between national decision-making and transport industries of national importance should be encouraged immediately, and the pros and cons of this relationship should be acknowledged (e.g. pressures from national vehicle or fuel industries in possible conflicts of interests in relation to environmental transport policies).

At national and local level, **RDI funding (A4)** has the opportunity to focus on alternatives, technologies, or uptake issues of national interest and to complement European⁹⁷ and industrial funding. Examples of these are the Bioresources, Industries and Performance (BIP)⁹⁸ Programme in France (2008-2014) and Smart Mobility Integrated with Low-carbon Energy (TransSmart)⁹⁹ programme in Finland (2013-2016).

Public procurement (A5) is an important tool in the national and local perspective, especially in the pre-commercial and early market phases. It can help create momentum and balance out small supply and demand discrepancies. Examples of such actions already taking place at city level are innovative procurements of public transport services, fleets, fuel supply, etc. supporting the transition to low-carbon mobility. Activities supporting public procurement should be strengthened systematically taking into account both national and local level perspectives.

The set-up of alternative fuels **infrastructure (A6)** is an urgent national and local action that again falls under a common European frame¹⁰⁰ but currently lacks the legally binding mandate from the European level, which makes the national implementation unsure.

6.3.3 Transport sector

The transport sector, including for example private sector stakeholders in business of transport services, vehicle manufacturing and sales, fuel manufacturing and sales, etc. are oftentimes the “practising” actors. These stakeholders may have the key role in implementing actions stemming from European, national or local levels but they could also be initiators for actions. Common goals between levels is essential, and wider use of alternative fuels in Europe requires joint decisions, actions and **partnerships by multiple, public and private, stakeholders (A7)** at European and national levels. From the industrial side, this means sustainable fuel supply and compatible vehicles. Availability of infrastructures is a joint effort of public and private parties. There already exist high-level public-private discussion forums, which should be strengthened and transformed immediately also to facilitate practical hands-on implementation of actions.

An example of partnerships between public and private stakeholders to promote alternative fuels uptake is that between the airport operator and fuels supplier that has resulted in Oslo airport being the first airport providing drop-in biofuels for airlines. The partnership extends over to fuel producers as well as end users (airlines), and has been well received as a forerunner initiative in demonstrating how steps towards alternative fuels can be taken in the aviation sectors with blend-in fuels requiring no changes to infrastructure. The role of hubs such as airports, ports, stations and terminals could in fact be central in promoting implementation of alternative fuels and vehicles.

An example from the maritime industry highlights the complexity of multiple transport sector stakeholders who are involved in the fuel choice decisions. In maritime transport, fuels are typically procured by shipping agents (charterers), not the vessel

⁹⁷ e.g. Horizon 2020, The EU Framework Programme for Research and Innovation: Smart, Green and Integrated Transport <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/smart-green-and-integrated-transport> and Smart Cities and Communities, The European Innovation Partnership on Smart Cities and Communities <http://ec.europa.eu/eip/smartcities/> (Accessed 30.11.2016)

⁹⁸ ADEME, BIP Bioresources industries performances <http://www.ademe.fr/bip-bioresources-industries-performances> (Accessed 19.01.2017)

⁹⁹ VTT Technical Research Centre of Finland Ltd, Smart Mobility Integrated with Low-carbon Energy (TransSmart) http://transsmart.fi/transsmart/in_english (Accessed 19.01.2017)

¹⁰⁰ Directive 2014/94/EU on the on the deployment of alternative fuels infrastructure

owner, which means that stakeholder involvement is very important to make changes in fuel choices and should not be taken for granted but consolidated.

The different timelines for different alternative fuels should also be taken more thoroughly into account so that both the short-term fixes as well as long-term opportunities are made use of in an optimised way. For example, while preparedness for hydrogen for most applications is a long-term consideration, the near-term efforts to support, e.g. blend-in alternative fuels that are already available in the markets, should be simultaneous. Besides availability, blend-in fuels are also an easy change, as they require little or no changes in current consumer behaviour. Currently, drop-in fuels seem to be the easiest and fastest route to low-carbon transport fuels and vehicles, but on the other hand they may enhance standing of combustion engine transport at the expense of long-term alternative fuel/vehicle options like hydrogen (fuel cell) vehicles.

Public and private sector funding have complementary roles in **RDI (A4)** and research in all regional levels presents already now examples of successful collaboration, e.g. in the form of RDI programmes where private funding and participation of companies in RDI projects are emphasised. Similarly to the public sector, to be fit for purpose, private sector RDI funding needs to acknowledge the linkages between fuel, vehicle, and infrastructure research.

Along with public actors, transport sector industries and private service and infrastructure providers have a central role in implementing the plans and setting up the transport **infrastructure (A6)**. Collaboration of public and private entities is essential especially in order to ensure trans-border continuity of infrastructure availability. Complementary actions targeting infrastructure and supply of alternative fuels could be used as effective bundled actions.

Transnational market creation (A8) could be promoted by intensified cross-border collaboration and exchange of experiences (e.g. benchmarking of best practice and performance of countries and cities) at national and regional levels. Timing of such market-shaping actions is linked to the maturity of various alternative fuels, and actions should be launched proactively when approaching the close-to market phase. An example of transnational market creation action is joint supply quotas for neighbouring countries or regional suppliers, which could enlarge markets for produce and higher stability of the regional biofuel market.

A good example of market-based measures initiated by industries comes from aviation, where the International Civil Aviation Organisation recently facilitated the Carbon Offset and Reduction Scheme for International Aviation (CORSA)¹⁰¹ in which 66 countries have voluntarily agreed to participate. Although not exclusively promoting alternative fuels, this scheme strengthens the commitment of aviation industries to climate actions and environmental protection in the long-term according to the goal of carbon-neutral growth from 2020 onwards.

6.3.4 Other stakeholders

Cities and municipalities (A9) have an important role in national implementation of actions towards alternative fuels. Even though European Union would present a legally binding mandate to the MS on some aspects of the alternatives, the states often have limited opportunities to influence local or regional level decisions on, for example, transport or land use planning and infrastructures, public transport services or fleets, park & ride issues, etc. However, cities can sometimes go well beyond national

¹⁰¹ ICAO, 2016. Carbon Offsetting and Reduction Scheme for International Aviation (CORSA). <http://www.icao.int/environmental-protection/Pages/market-based-measures.aspx> (Accessed 17.10.2016)

ambitions on their own initiative, and one such positive example is the covenant of Mayors for Climate & Energy¹⁰², which acts as a platform for local energy policy actions including those related to alternative fuels.

Fortunately, it seems that many cities have recently found an ambition to take an active role in promoting sustainable mobility and innovations at the local level instead of just following national plans and strategies. Consequently, new practices and mechanisms are needed to better connect European Union, national and local level targets and actions to find a win-win solutions (e.g. via linkages to Sustainable Urban Mobility Plans). Cities also have a key role in piloting the applicability and usability of the alternative fuels in vehicle fleets in **RDI (A4)**. Citizen participation in RDI pilots and demonstrations¹⁰³ can be effective in giving first experiences of new technologies and solutions and also in sparking interest and awareness through visibility and positive images.

To achieve wider usage of alternative fuels, broad customer awareness and acceptance of these fuel types is required. This can be supported by various channels of **information and awareness raising (A10)**, tailored to address topical issues in a timely manner. The purchasing price of alternative fuels (or alternative fuels vehicles) compared to conventional fuels (or vehicles with conventional powertrains) should not be seen as a significant disadvantage by the majority of the customers. They need to perceive the technological advantages of the alternative fuels and logistical infrastructure such as fuel supply or charging stations need to be available for them. One part of information and awareness raising is for the public sector to clearly articulate the end-user benefits and wider societal benefits from alternative fuels uptake to different stakeholders (private end-users, commercial (end-)users, operators, manufacturers, etc.) in a way to which they can relate.

Provision of accurate and palatable information for end users is important, and the information needs of different user groups such as citizens and fleet owners should be understood. New practical research knowledge is needed on this topic. Information alone will not change attitudes and preferences, but the positive image of alternative fuels could be strengthened with appropriate tools, for example by advertising agencies and the involvement of celebrities.

As suggested by experts in the SINTRAS stakeholder meetings, vehicle renting, leasing and sharing may also be used as the means to introduce alternative fuels and vehicles capable of using them to the public. To gain the first experience of these new products or technologies without having to make long-term commitment or investments could help the end-user to acknowledge alternatives as a functioning and reliable option. Special incentive schemes could actually be designed to support adoption of alternatives by renting and leasing firms or companies providing company cars.

One possibility to raise customer awareness could be the introduction of CO₂ labelling for fuels and more transparent fuel taxation at the point of sale (e.g. gas stations). From the perspective of transport companies using fuels containing biocomponents can be excellent PR and provide a basis for growing business.

Drop-in fuels are a different case from those alternatives that require new type of vehicles, infrastructure or transport behaviour. For drop-in fuels, the consumer may not even notice the difference at the service station if not advertised by the seller.

¹⁰² Covenant of Mayors for Climate & Energy http://www.covenantofmayors.eu/index_en.html (Accessed 20.01.2017)

¹⁰³ e.g. Smart Cities and Communities, The European Innovation Partnership on Smart Cities and Communities <http://ec.europa.eu/eip/smartcities/> (Accessed 30.11.2016)

Promotion of the new fuels by various stakeholders also requires focusing on the production of shared information and knowledge on the various aspects and life-cycle impacts of energy production (well to wheel) of the fuels with socio-economic assessment practices. For example, current negative public perception of hydrogen safety might become an issue in the future if informing the customers on the latest developments is not taken seriously.

Unlike other alternative fuels, hydrogen system deployment requires more training for safety and service personnel and also increasing the knowledge level of authorities and number of skilful hydrogen experts in general. Currently, there are not enough educated people for companies, and hence there are only few stakeholders on the market.

Roll-out of fleets of hydrogen cars, buses, light goods vehicles and even heavy goods vehicles requires support and coordination. This could start from 'Pioneer regions', which have favourable characteristics for early hydrogen introduction, such as large and coherent areas of demand, availability of wind and solar energy or proximity to potential Carbon Capture and Storage sites allowing the production of hydrogen from natural gas while meeting emissions constraints. In addition, vehicle grants will be probably needed to support the first cars and other vehicles.

6.4 Cost-benefit analysis

Table 17. **Summary table on costs and benefits of Focus Area 5 actions.**

sums up the cost-benefit analysis (CBA) for Focus Area 5, based on expert evaluation. The results of this analysis have been validated through extensive stakeholder consultation. In the following paragraphs we discuss shortly key implications on each Focus Area 5 action¹⁰⁴.

¹⁰⁴ Refer to Table 1 and Table 2 in Chapter 1 for the elaboration of the guidelines on assessing the costs and benefits for each action

Table 17. Summary table on costs and benefits of Focus Area 5 actions.

Benefit	High	-	A2 Incentive and disincentive schemes A3 Regulation and standards A4 Research, development and innovation	A1 Long-term, aligned policies A6 Infrastructure
	Medium	A10 Information and awareness raising	A8 Transnational market creation A9 Active cities and municipalities	-
	Low	A7 Public-private collaboration A5 Public procurement	-	-
		Low	Medium	High
Cost				

(A1) Long-term, aligned policies for energy, climate, natural resources, agriculture, land use and transport: This is a group of actions that is costly in terms of resources that are required to formulate and execute long-term, aligned policies at European and national levels. Policy making is time-consuming and major efforts are required in order to commit and find agreements and consensus, especially when decisions face resistance. This applies particularly to considerations across policy fields. Nevertheless, the impacts of suchlike actions are high; they spread across domains as well as region and enable steady long-term progress providing that the policies are also followed through.

(A2) Incentive and disincentive schemes: This group of actions enfolds numerous sub-measures, whose costs and impacts vary significantly when compared to one another or when combined in different ways. However, in general incentive and disincentive schemes can be considered medium-cost measures with potential to high positive impact in terms of alternative fuels take-up. Careful planning is necessitated to find the most appropriate implementation, including timing, sequencing of measures and intensity of action.

(A3) Regulation and standards: Regulation and standardisation bears some costs and requires collaboration and strong involvement of various stakeholders. Finding appropriate level of consensus may in some cases be difficult and time-consuming. Expected impacts are high, as such measures may accelerate up-take and growth of markets for alternative fuels. Ideally regulation and standardisation would secure a strong and efficient European alternative fuels markets (supply and demand), as well

as position Europe as competitive on global scale. It should be acknowledged though that the maturity of different alternative fuels varies greatly, and while others may be lacking in standards and regulation, others have already made it to the market.

(A4) Research, development and innovation (incl. funding and piloting): RDI on different levels, including piloting and demonstrations, is medium-cost and also delivers medium-high benefits. This is, however, the type of action that acts as a prerequisite for further, continuous progress on technological and other innovations, breakthroughs and improvements. Therefore investments in RDI actions are of great importance even if their direct impacts would be less impressive. European funding programmes for RDI are of utmost importance, complemented by national funding that can further address topics of local nature or relating to regional specialisation.

(A5) Public procurement: While public procurement, including international, national and municipal levels, is categorised as a low-impact yet low-cost type of action, it can be an important trigger for indirect positive developments. Public procurement supporting alternative fuels can affect attitudes and awareness of end-users and provide them experience on new technologies and solutions. It can also facilitate early markets (supply side) to develop, an example of which is how bus fleets in Finland have opened up markets for gas buses and electric buses. Although not very costly, know-how and willingness to adjust procurement processes are important.

(A6) Infrastructure: Set-up of alternative fuels infrastructure at national and local levels, as well as ensuring transnational continuity of infrastructure is costly to implement, but it is also a straightforward prerequisite for high-impact take-up of alternative fuels. Involvement, investments and efforts from public and private sector are required on all levels.

(A7) Public-private collaboration: This action is low-cost and low-impact in direct terms, but again it is an important enabler that triggers wider positive impacts when coming to fruition through subsequent actions such as infrastructure build-up (A6), standards (A3), policies (A1), production agreements, etc. On the other hand, neglecting this action, i.e. letting public-private collaboration deteriorate or even the estrangement of stakeholders, could lead to highly negative impacts (lock-in with conventional fuels).

(A8) Transnational market creation: Whether bilateral, regional or cross-European, this action is perceived medium-cost and would be ideally combined to efforts such as (A1). Transnational market creation is an important intermediate step towards European and even global alternative fuels markets, and the role of various stakeholders from public and private sectors is central (A7).

(A9) Active cities and municipalities: Locally implemented actions are fairly costly but have the potential to have high positive impacts. Cities have in many ways the opportunity to be the arena for alternative fuels transition in practice and actions (A1), (A2), (A4), (A5), (A6), (A7) and (A10) all entwine at the city level. Indeed, the cost-efficiency and impact of local actions depend largely on how well high-level policies as well as other measures connect and flow down to city-level. Relevant funding channels include, for example, European funds directed to cities and regions.

(A10) Information and awareness raising: As a low-cost, medium-impact action, information and awareness raising facilitates establishing alternative fuels as acknowledged option for end-users. Efficient implementation can take place as part of other local activity around the topic (A9).

6.5 Prioritisation

Amongst the actions described above, the highest priority should be given to those which offer an attractive benefit-to-cost ratio (in particular, those which impact the entire European transport system) and which are urgent or will yield results in the relatively short term. Urgent actions are especially important if they will unlock a series of positive changes. Short-term results are important as they will quickly demonstrate that the efforts to transform the European transport system are paying off. This will help to build momentum and continued support for change.

The second priority should go to actions which still offer an attractive benefit-to cost ratio but which will yield results in the medium to long term. These actions are important because they yield valuable results; but, as they need to persist for some time before the results become visible, they will be less effective in building momentum and support.

The third priority actions are those which yield less attractive benefit-to-cost ratios. For example, the benefit of such actions, while still substantial, may be limited to an individual issue or a narrow group of stakeholders. The results of such actions, whether short- or long-term, will have less impact on the functioning of the European transport system as a whole.

Based on the discussions of timing and cost-benefit in the previous sections, we propose the following prioritisation of actions. Within each group, we list actions in decreasing order of priority:

Table 18. Action prioritisation.

Priority 1: Attractive benefit-to cost ratio and urgent or short term results
A1 Long-term, aligned policies
A6 Infrastructure
A4 Research, development and innovation
A2 Incentive and disincentive schemes
Priority 2: Attractive benefit-to-cost ratio and medium- to long-term results
A3 Regulation and standards
A10 Information and awareness raising
A8 Transnational market creation
A9 Active cities and municipalities
Priority 3: Less attractive benefit-to-cost ratio
A7 Public-private collaboration
A5 Public procurement

In terms of importance, we evaluate the actions for long-term, aligned policy (A1) and infrastructure set-up (A6) as top priorities. Although costly, they are a high-benefit necessity for long-term progress in this Focus Area, ensuring that prerequisites for alternative fuels to succeed exist. Research, development and innovation (A4) as a group of actions is important for continuity and long-term assurance for emerging alternative fuels to mature as well as for those already close to market to make their entry. In terms of urgency of action, we raise incentive and disincentive schemes (A2) to the front as a medium-cost, high-benefit action with great potential to accelerate

uptake of alternative fuels in the short- to medium-term by supporting prompt, positive developments in both the supply and demand side.

The second priority actions for regulation and standards (A3), information and awareness raising (A10) and transnational market creation (A8) facilitate deployment of alternative fuels in different ways, and these actions complement the first priority actions. Active cities and municipalities (A9) emphasizes locally tailored action to accelerate and stimulate practical progress in supply as well as demand.

The third priority actions, promoting public-private collaboration (A7) and public procurement (A5), target very specific stakeholders and interactions in the alternative fuels scene, and the impact of these actions when compared to the others is lesser. On the other hand, they may act as activators for positive bottom-up developments.

6.6 Key performance indicators

To measure impacts of the Focus Area 5 Actions (A1) to (A10), key performance indicators (KPIs) along the four impact pathway steps (Effort-Action-Outcome-Impact) are shown in the following Table¹⁰⁵. These KPIs measure the success of implementation of the proposed actions and evaluate the achievements during the whole innovation path from R&D (idea) to diffusion. This process approach results in a large number of KPIs (3-5 for each action), but in doing so, provides a comprehensive picture on the inputs and outputs required by the actions.

¹⁰⁵ See elaboration of assessment framework for monitoring and evaluation in Chapter 1, Figure 4

Table 19. Focus Area 5 key performance indicators.

Effort-KPIs	Action-KPIs	Outcome-KPIs	Impact-KPIs
(A1) Investments/resources for integrated policy processes in the fields [PM, €]	(A1) On-going integrated policy processes and strategy evaluation actions [yes/no or number]	(A1) Completed integrated policies [yes/no or number]	(A1) New integrated knowledge, strategic agreements/decisions, co-operation and partnerships created by the process [yes/no or number]
(A2a) Resources for IDS framework design [PM, €]	(A2a) On-going IDS design actions or their evaluation [yes/no or number]	(A2a) Completed IDS design actions [yes/no or number]	(A2a) New knowledge, strategic agreements/decisions, guidelines, co-operation and partnerships created by the IDS design [yes/no or number]
(A4a) EC, national and business funding for f-v-iRDI [€]	(A4a) On-going f-v-i RDI activities [number]	(A4a) Completed f-v-i RDI activities, new concepts/solutions/processes [number]	(A4a) New knowledge, strategic agreements/decisions, guidelines, co-operation and partnerships created by the f-v-i RDI activities [number]
(A7) Establishment of pp-forums to interact and collaborate [yes/no]		(A7) High-level strategies promoting pp-collaboration initiated and supported [yes/no]	(A7) New integrated knowledge, strategic agreements/decisions, co-operation and pp-partnerships created [yes/no or number]
(A4b) Joint EC, national and business funding for piloting and demonstrations [€]	(A4b) Joint piloting and demonstration actions [number]	(A4b) Validated solutions, applications (by users in real operational environment) [yes/no, number]	(A4b) New value chains, processes, consideration of new solutions in procurements, planning, standardisation, regulation [yes/no, number]
(A10) Resources used in information and awareness raising [€, PM]	(A10) Information and awareness raising campaigns [number]	(A10) Outreach of information and awareness raising campaigns [% of population]	(A10) Behavioral change achieved: Impact on uptake of alternative fuels [qualitative assessment, yes/no]
(A2b) Monetary and resource investments on IDS schemes [€, PM]	(A2b) IDS Schemes under preparation by type [yes/no or number]	(A2b) Implemented IDS schemes by type [yes/no or number]	(A2b) Impacts on production and purchase volumes, vehicle sales, long-term impacts on economy, environment, etc. [yes/no or m3, number, €]
(A3a) FQ standardisation activities initiated and supported [yes/no or number]		(A3a) FQ standards established [yes/no or number] (A3b) Minimum quota set and enforced nationally [yes/no]	(A3a) Uptake of FQ standards nationally/European-wide/globally [yes/no or number]
(A5) Framework and resources to consider/prioritise alternative fuels in public procurements [yes/no]	(A5) Share of public procurements in MS supporting alternative fuel uptake [%]	(A5) Number of “accepted” public procurement processes taken into use (as a continuous action)	(A5) National and local impacts on alternative fuel demand and supply (volumes), local impacts on energy consumption, emissions
(A6) Resources to construct the alternative fuels infrastructure	(A6) The readiness (%) of the planned infrastructure	(A6) Take up of alternatives: Share of alternative fuels used in fleets under public procurement [%]	
(A9) Investments in cities to promote alternative fuels [€, number]		(A9) Coverage of the completed infrastructure in municipality [fuel stations, charging points/vehicle/km3] (A9) The share of alternative and flexi fuel vehicles on annual vehicle sales in municipality [%]	(A9) Take up of alternatives: Share of alternative fuels used/sold in municipality [% of total fuel sales] (A9) Environmental impacts [e.g. emission reductions achieved by using alternative fuels in municipality, CO2]
(A8) Establishment of international/European/global forums to agree on market frameworks [yes/no]	(A8) Technical and other preparedness/compatibility for transnational market [yes/no], [%]	(A8) Stage of transnational market for each alternative fuel [qualitative assessment of the stage and geographical outreach, %] (A3b) Minimum quotas set and enforced aligned in Europe/globally [yes/no]	(A3b) Take up of alternatives: impacts on production and purchase volumes, vehicle sales, long-term impacts on economy, environment, etc. [yes/no or m3, number, €]

Next, we list all KPIs per action, some of which are broken down to sub-actions in order to give more concrete examples within action groups. The potential units of measurement are shown in brackets after each indicator. The time period for

definition, measuring and tracking of KPIs can be, for example, one year or covering the length of a specific measure.

- **(A1) Long-term, aligned policies** for energy, climate, natural resources, agriculture, land use and transport
 - Investments/resources for integrated policy/strategy processes in the fields [PM (person-months), €]
 - On-going integrated policy processes and strategy evaluation actions [yes/no or number]
 - Completed integrated policies/strategies [yes/no or number]
 - New integrated knowledge, strategic agreements/decisions, co-operation and partnerships created by the process [yes/no or number]
- **(A2) Incentive and disincentive schemes**
 - **(A2a) Framework for incentive and disincentive schemes for MS** on (1) alternative fuels: incentives for production, purchase, tax incentives, etc. and (2) use /acquisition of vehicles
 - Resources for incentive and disincentive schemes framework design [PM, €]
 - On-going incentive and disincentive schemes design actions or their evaluation [yes/no or number]
 - Completed incentive and disincentive schemes design actions [yes/no or number]
 - New knowledge, strategic agreements/decisions, guidelines, co-operation and partnerships created by the incentive and disincentive schemes design [yes/no or number]
 - **(A2b) Implementation of the incentive and disincentive schemes by MS**
 - Monetary and resource investments on incentive and disincentive schemes [€, PM]
 - Incentive and disincentive schemes under preparation by type [yes/no or number]
 - Implemented incentive and disincentive schemes by type [yes/no or number]
 - Impacts on production and purchase volumes, vehicle sales, long-term impacts on economy, environment, etc. [yes/no or m3, number, €,]
- **(A3) Regulation and standards**
 - **(A3a) Fuel quality standards**
 - New fuel quality standardisation activities initiated and supported [yes/no or number]
 - New fuel quality standards established [yes/no or number]
 - Uptake of new fuel quality standards nationally/European-wide/globally [yes/no or number]
 - **(A3b) Market minimum quota for suppliers**

- Minimum quota set and enforced nationally [yes/no]
Minimum quotas set and enforced aligned in Europe/globally [yes/no]
 - Take up of alternatives: impacts on production and purchase volumes, vehicle sales, long-term impacts on economy, environment, etc. [yes/no or m3, number, €,]
- **(A4) Research, development and innovation (RDI)**
 - **(A4a) Funding for joint fuel-vehicle-infra (f-v-i) RDI on different time scales**
 - European Union, national and business funding for f-v-i RDI [€]
 - On-going f-v-i RDI activities [number]
 - Completed f-v-i RDI activities, new concepts/solutions/processes [number]
 - New knowledge, strategic agreements/decisions, guidelines, co-operation and partnerships created by the f-v-i RDI activities [number]
 - **(A4b) International cooperation in the development of pioneer regions and pilot areas**
 - Joint European Union, national and business funding for piloting and demonstrations [€]
 - Joint piloting and demonstration actions [number]
 - Validated solutions, applications (by users in real operational environment) [yes/no, number]
 - New value chains, processes, consideration of new solutions in procurements, planning, standardisation, regulation [yes/no, number]
- **(A5) Public procurement**
 - Framework and resources to consider/prioritise alternative fuels in public procurements [yes/no]
 - Share of public procurements in Member States supporting alternative fuel uptake [%]
 - Take up of alternatives: Share of alternative fuels used in fleets under public procurement [%]
- **(A6) Infrastructure**
 - Resources to construct the alternative fuels infrastructure [€]
 - The completion of the planned alternative fuel infrastructure [% ready compared to goal]
 - Coverage of the completed alternative fuel infrastructure [fuel stations, charging points/vehicle]
 - National and local impacts on alternative fuel demand and supply [m3]; (impacts on energy consumption, emissions [CO₂])
- **(A7) Public-private collaboration**

- High-level strategies promoting pp-collaboration initiated and supported [yes/no]
- Establishment of pp-forums to interact and collaborate [yes/no]
- New integrated knowledge, strategic agreements/decisions, co-operation and pp-partnerships created [yes/no or number]

- **(A8) Transnational market creation**
 - Establishment of international/European/global forums to agree on market frameworks [yes/no]
 - Technical and other preparedness/compatibility for transnational market [yes/no], [%]
 - Stage of transnational market for each alternative fuel [qualitative assessment of the stage and geographical outreach, %]

- **(A9) Active cities and municipalities**
 - Investments in cities to promote alternative fuels [€, number]
 - The share of alternative and flexi fuel vehicles on annual vehicle sales [%]
 - Coverage of the completed infrastructure [fuel stations, charging points/vehicle/km³]
 - Take up of alternatives: Share of alternative fuels used/sold in municipality [% of total fuel sales]
 - Environmental impacts [e.g. emission reductions achieved by using alternative fuels in municipality, CO₂]

- **(A10) Information and awareness raising**
 - Resources used in information and awareness raising [€, PM]
 - Information and awareness raising campaigns [number]
 - Outreach of information and awareness raising campaigns [% of population]
 - Behavioral change achieved: Impact on uptake of alternative fuels [qualitative assessment, yes/no]

7 Beyond Focus Areas

7.1 System-level transformation

Figure 18. System-level transformation across Focus Areas.

lays out the overall view of the European landscape in the short, medium and long term, as reaching towards the vision of a single and innovative European transport system. This transformation graph sums up the key aspects of developments that are necessary to overcome the barriers identified in the present situation but also acknowledges various drivers of change that support or facilitate the desired progress.

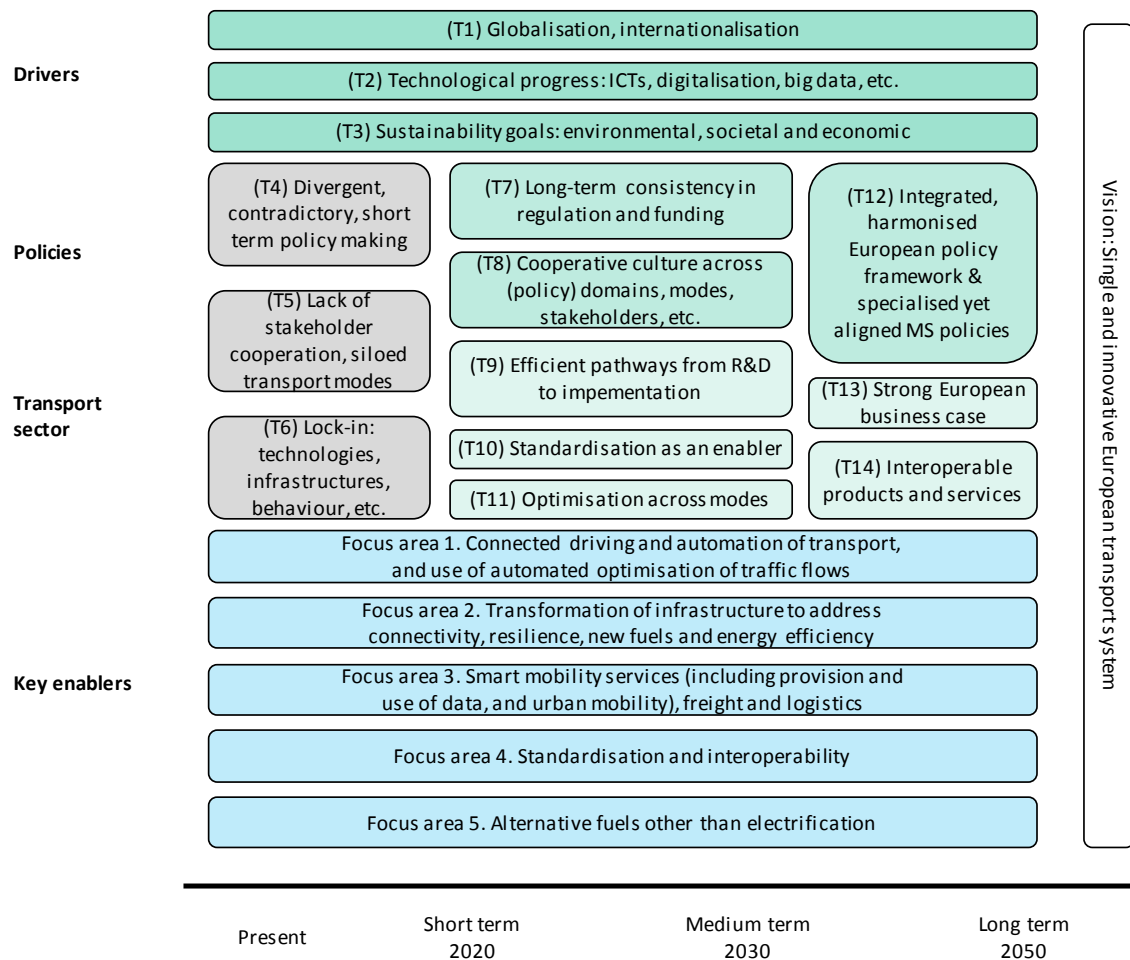


Figure 18. System-level transformation across Focus Areas.

There are three key groups of drivers in the transformation. Globalisation and internalisation (T1) highlight the growing importance of interactions across countries and continents, for example, which imply growth of mobility and growingly international transport systems and value chains. Technological progress (T2) is a diverse group of drivers, many of which are also enablers in improving our current transport systems as well as new innovations. Sustainability goals (T3) in turn put pressure on making changes in currently inefficient, harmful or lacking systems, examples of which include reduction goals on emissions, safety goals on human health or economic goals to make transport equally affordable.

The present state of European transport policy (T4) can be characterised as divergent, and it would benefit from aligned, longer-term strategies. Divergence shows, firstly, to some extent at the European Union level, where the multitude of transport policy topics do not always align, e.g. transport policy and funding for transport infrastructure in comparison to transport policy objectives on alternative fuels and modal shift. Secondly, divergence shows between the Member States, whose policies may radically differ from one to another, and compliance to the European Union-level policies remains sometimes superficial. Public and private sector stakeholders, as well as the two together, do not always collaborate efficiently, and silos are still strong, for example, in terms of different transport modes and different geographical levels of action deployment (T5). Many of the complications of the present state could be solved, meaning that new technical solutions are available, for example, but cannot catch on because of the complex lock-in situation (T6) that characterises the political level as well as transport sector businesses, long-life transport investments and end-user transport behaviour.

To make progress from the present towards the vision, the five Focus Areas are some of the most important 'enabler themes', although not the only ones. Topics dedicated to public transport, vulnerable groups and behavioural change, etc. are also important. In the short to medium term, the policy level needs more consistent, long-term decision-making, which should show in regulation as well as funding (T7). Cooperative culture across different domains, modes and stakeholders (T8) should be adopted, as the analyses of all Focus Areas have highlighted collaboration needs. The efficient and accelerated pathway from R&D all the way to implementation (T9) is something that needs to be addressed by various mechanisms and support channels, for example tailored to each Focus Area. Along with incentive schemes, standardisation (T10) is an important enabler and measure, and could be used more strongly to accelerate progress as well as to push European leadership. System-level optimisation across modes (T11) is another example of approaches that need to be adopted in the transport sector, contributing to efficiency and reduction of negative impacts and externalities.

The medium- to long-term considerations paving the way for the vision include establishing an integrated and harmonised European policy framework (T12) that promotes European causes while balancing out the Member State level and allowing specialisation and positive diversity. Instead of targeting a fully identical policy environment across Member States, it will be important to align certain transport policy topic at the European Union level and define the appropriate degree of compliance for Member States. Progress needs to build on a strong European business case (T13), i.e. make use of European strengths and further promote European competitiveness, which not only signifies promotion of European causes and industries but global collaboration. This is strongly linked to the issue of interoperability of products, services and other solutions (T14), most importantly inside Europe but increasingly also at a global scale.

7.2 Cross-effects and synergies among action plans across Focus Areas

Our analysis started from the aggregate-level objective of a single and innovative European transport system and then branched out into five specific Focus Areas. Although system-level considerations were acknowledged throughout the action planning for each Focus Area, it is important to glance once more at the proposed actions from the European transport system aspects in order to identify and understand possible cross-effects and synergies. In the next paragraphs, we raise cross-cutting issues where several or even all Focus Areas coincide, and synergies or contradictions in proposed support measures have been identified.

The most important cross-cutting theme over all Focus Areas is the need for a stronger long-term policy frame that spans over short-, medium- and long-term policy landscapes and addresses different Focus Areas as well as any other technological or other domains relevant for the single European transport system. The long-term policy framework should provide a vision, step-wise strategic goals, implementation as well as evaluation, monitoring (for example, Key Performance Indicators) and means for corrective actions to ensure follow-up. Some of these items are already present in the current European scheme, but what the Focus Areas suggest is that not all high-level policy goals currently move down to the level of practical implementation and progress towards the fulfilment of these policies, which is monitored neither sufficiently nor in a cross-sectoral manner. In some cases, an unstable policy environment has even been seen as a barrier to industrial investment.

All five Focus Areas also indicate that very specific support measures to incentivise progress within the Focus Area towards European goals are needed, e.g. specifically targeted regulation, training and infrastructure. Efficient planning and implementation of these necessitates the abovementioned long-term policy framework, which provides the starting point and reference for the practical, root-level measures.

In Focus Areas 1, 3 and 5 the proposed incentive schemes support the business cases, as actions address market development of new technologies and services. These three Focus Areas share the chicken and egg problem, meaning that neither supply nor demand as such is strongly incentivising the other. Actions facilitating progress in these Focus Areas should be compared, and applicability of approaches adopted in one domain should be assessed for the others. Cross-analysis is also important when actions have been implemented and monitored to find out what types of approaches and support mechanisms work or do not work and if they could be applied in other Focus Areas. Yet another aspect common to Focus Areas 1, 3 and 5, and their proposed actions addressing market and business development, is that there is a risk of negative impacts on the transport system level (e.g. unintended harmful impacts to public transport, environment, equality or safety). This brings us back to the importance of the long-term policy framework from which the root-level actions should stem and against which all root-level actions should be assessed to ensure that practical measures all contribute to the right direction.

Research, development and innovation (RDI) across the entire innovation chain was a common topic across Focus Areas. RDI measures are already an important and effective group of support actions implemented on European as well as national levels. Across Focus Areas certain aspects to be strengthened in RDI were raised: wider involvement and commitment of stakeholders and interest groups, more emphasis on business case and ecosystem building to facilitate take up of results and closer attention to societal and individual user needs and matters of acceptance.

The vastly untapped potential of regions, cities and municipalities was yet another theme that presented itself across Focus Areas. Local levels could be better connected to the European policy objectives under the long-term policy framework, as in many cases the region, city or municipality is the entity linked to practicalities of the transport system. Policy goals as well as funding (especially funding of infrastructure) could be better integrated from European to local levels. Focus Areas could learn much from one another, e.g. in smart city RDI and pilots (Focus Area 3) or innovative public procurement (Focus Area 5), and local-level actions could address multiple Focus Areas jointly.

The development and funding for ICT (information and communications technology) infrastructure connected with physical infrastructure upgrading is present in key actions in Focus Areas 1, 2, 3 and 5. Under the long-term policy framework this topic is of major importance, and although the Focus Area-specific perspectives to

infrastructure development differ, the big picture of infrastructure development and the interlinkages between requirements from different Focus Areas, technologies or services should be acknowledged.

8 Conclusions

The SINTRAS study has identified an extensive range of barriers hindering the use of innovation and new technology across Europe's transport system and has proposed actions to address them. Previous SINTRAS reports have described the barriers and their root causes in some detail, discussed the evidence for them and prioritised them based on stakeholder consultation. Earlier chapters in this report summarise these barriers and propose actions.

8.1 Barriers and root causes

In the main, our findings regarding the barriers are consistent with the results of previous work, chiefly under the Framework Programme, on collaboration and new technology in transport. The *ETNA Plus* project, for example, examined transnational collaboration in transport research and innovation¹⁰⁶. It found successes and examples of good practice – but also pointed to systemic barriers. It is noteworthy that these systemic barriers vary greatly, ranging from relatively 'hard' issues such as budgets and funding rules to very 'soft' issues to do with culture; our findings show a similar variety of barriers and root causes.

Consultations during our work have shown that some of these barriers are widely recognised; it has been noticeable, however, that opinions are often sharply divided on many others, with some consultees regarding a barrier as strongly present and important while other consultees dismissing the same barrier as not a real issue.

The previous chapters on individual Focus Areas, and the Annex below, provide more detail on all of the barriers identified and their root causes.

Finding 1: Technology is not the problem

There is widespread agreement amongst all stakeholders that difficulties in exploiting innovation and new technology to strengthen Europe's transport system have little to do with the technology itself. Other economic, political and societal factors are much more significant. This is not to underestimate the substantial technology challenges still present in, for example, automated driving or alternative fuels. But there is confidence that these challenges can be met and that research and development around the world, including in Europe through, for example, Horizon 2020 and its Joint Technology Initiatives and public-private partnerships, will deliver solutions. There is less confidence that Europe will be able to use those solutions to the full. In some cases, there is even scepticism whether certain solutions should be utilised at all or, at least, there should be words of caution to pay extreme attention to possible unintended side-effects and rebound effects. This refers mainly to fully automated vehicles, biofuels and large infrastructure projects. A recurring theme across the stakeholder consultation events was also the sentiment that some problems do not require technical solutions at all but simply more active mobility and better spatial planning, especially in urban contexts.

This Finding echoes the conclusions from previous studies such as *ETNA Plus*, mentioned above, and the recent *RACE2050* project, which used foresight methods to identify key success factors for the sustainable growth of the European transport industry.

¹⁰⁶ <http://www.transport-ncps.net/etna-plus/project-description.html>

Finding 2: Investors are reluctant to commit to new technology

The large-scale implementation of new technology does not always require massive investments but in very many cases it does. Public authorities and transport operators hesitate to make such commitments, not least due to budget restrictions in a time of financial crisis. Beyond the crisis, however, two other issues arise, which are familiar from experience of technology commercialisation in general. First, building a convincing business case is difficult when the benefits and the costs of the new technology are uncertain; this is especially challenging when the benefits are also hard to quantify, such as improvements in safety or quality of life. In particular, doubts about the business case are a strong feature of the implementation of C-ITS. Second, there is fear of 'first mover disadvantage': no-one wants to be first to invest (possibly very large amounts) in infrastructure based on a new and unproven technology because of the risk that the long-term performance of the technology turns out to be inadequate, a rival technology later emerges as a better choice, or subsequent legislation changes the situation (relevant barriers are FA1-01, FA1-03, FA1-04, FA1-05, FA1-07, FA1-12, FA2-01, FA2-02, FA2-03, FA2-07, FA2-09, FA4-03, FA5-01).

Similar conclusions emerged from the *TRANSFORuM* project, which provided a platform for stakeholders of all areas of the European transport sector to develop a common view and strategies of how four key goals of the European Commission's 2011 White Paper on Transport could be achieved¹⁰⁷. One clear message from this work was that investments in new infrastructure can form part of the necessary interventions but are not a sufficient condition; what matters more is better coordination and increasing the efficiency of the existing infrastructure. This implies a view that making the most of current assets is less costly and risky and is therefore preferable to building new assets.

Finding 3: Commercial interests get in the way of collaboration

Collaboration between modes or across local or national borders requires the various operators involved to work together to introduce new technology, share data, harmonise operational practices and perhaps invest jointly in infrastructure. We have seen examples where this works well; but there are also many instances where operators see no commercial benefit in such sharing and, indeed, regard other operators as competitors with whom to share commercially confidential data on, for example, passenger travel patterns would be seen as commercially damaging (relevant barriers are FA2-05, FA2-06, FA3-A1, FA3-A2, FA3-B1, FA3-C1, FA3-C2, FA4-01, FA4-02, FA4-04, FA5-01).

A particular case where commercial interests get in the way concerns liabilities arising from cooperative services. If a transport activity involves several operators, who is liable if something goes wrong? We see this in freight, where goods pass through the hands of a sequence of operators between origin and destination. We also see this in passenger transport, where the liability issue is currently a major barrier to progress towards multi-modal ticketing, along with lack of common standards for data bases and data exchange¹⁰⁸ (relevant barriers are FA1-11, FA3-B3, FA3-C1).

Finding 4: Users do not always directly feel the benefits

The benefits of some new technologies, for example in automated driving and alternative fuels, are mainly in societal terms – improved road safety, decarbonisation and so on. While citizens may support these as worthy goals, many seem reluctant to

¹⁰⁷ www.transforum-project.eu

¹⁰⁸ Identified during our work and also by the earlier ORIGAMI project (<http://www.origami-project.eu/>) which was concerned with improvements in long-distance door-to-door passenger transport chains through improved co- and inter-modality.

adopt such technologies themselves unless and until they see a direct financial or otherwise direct personal advantage in doing so. This is a normal feature in new technology adoption: early adopters will use the new technology, even at a higher price, but mass adoption follows only when individual users believe they will obtain a personal advantage (in terms of price, performance, convenience, travel time or social status) or if there is a regulatory intervention (relevant barriers are FA1-01, FA1-04, FA1-05, FA1-07, FA2-09, FA3-C2, FA4-09, FA5-02, FA5-05, FA5-07).

Finding 5: Transitions are treacherous

Many innovations and new technologies displace or supersede an existing way of operating or an old technology. Making the transition from the old to the new requires users to see a clear benefit, as described in Finding 4 above; it also requires careful handling of issues of risk and conservatism. The risk is that the new technology will turn out not to be as good as expected or will have unexpected negative side effects. Conservatism arises when the old is so well established that switching costs and efforts are perceived to be uncomfortably high and imply the cannibalisation of previous investments, skills, contacts, routines, etc.; and when the new technology will require those involved to work in different ways which are not yet clear. Both issues impede the adoption of new technologies, particularly in automated driving and alternative fuels (relevant barriers are FA1-01, FA1-06, FA1-07, FA1-12, FA2-02, FA2-03, FA4-07, FA5-07, FA5-08).

Finding 6: National and local interests work against European solutions

Member States sometimes face conflicting objectives. Developing an integrated Europe and supporting cross-border transport may be stated aims. Yet, at the same time, protecting national industry may be seen as necessary in order to defend and create jobs. This may lead to setting national standards or support policies which favour domestic solutions at the expense of European harmonisation. Similar defensive behaviours may also be seen at local levels (relevant barriers are FA2-06, FA3-A4, FA5-04, FA4-05).

The fact that national and local authorities can favour local interests over European-level solutions stems from principles of subsidiarity and the 'room for manoeuvre' built into much European-level transport policy and instruments. The aforementioned *RACE2050* project described transport as "*one of the weakest and the most fragmented policy areas as regards the national implementation*"¹⁰⁹. However, as that project also points out, allowing national and local authorities some room to favour local interests is not necessarily wholly positive or wholly negative for innovation and new technology uptake. While enforcing a common European approach may encourage innovation in some topics, in others some local support may be essential to give industry the confidence to invest. Here, we note that the majority of stakeholders in our consultation workshops favoured strong top-down European Union coordination.

Finding 7: Stakeholders have differing aims

Different regions have different needs and priorities. Policies which respond to these local needs in one region may therefore be inconsistent with policies developed for an adjoining region. Different national and local policymakers may support different solutions, or no solutions at all, not in order to defend national interests (Finding 6, above) but simply in response to different needs, priorities and availability of resources. Variations in support for C-ITS (relevant barriers are FA1-03, FA1-08) and choices of alternative fuels (relevant barriers are FA5-04, FA5-08) are examples.

¹⁰⁹ RACE2050 Impacts of European Policies on Global Competitiveness of the European Transport Industry (September 2013) (http://www.race2050.org/fileadmin/files_race2050/Reports/RACE2050D3.1FINAL.pdf)

One consequence of policymakers pursuing differing aims is that the resulting inconsistencies in policy across regions create uncertainty and confusion for technology developers and investors (relevant barriers are FA2-05, FA2-06, FA3-A4). It also appears to make political interventions to encourage cross-border collaboration less effective (a relevant barrier is FA3-A1). This uncertainty and confusion does not help the supply chain, which is not always aligned with any overall European Union or national transport agenda and so is sometimes not able or willing to provide full support. This is particularly apparent in infrastructure (a relevant barrier is FA2-05); it is less of an issue in the other Focus Areas.

Similar issues were raised by the FUTRE project, which investigated the challenges for the European transport sector in the long term and developed strategic options for European transport research policy¹¹⁰. Among many constraints to the adoption of innovation, the project drew attention to the lack of coordination amongst policymakers (and with other stakeholders) regarding transnational infrastructures and regulatory regimes.

Finding 8: Pricing is a problem

It is often said that there is not enough money available to fund the implementation of new technology in transport. Yet a wide range of funding instruments is available and there are many examples of major investments which do get funded. Clearly good business cases are key; previous Findings have pointed to some of the challenges of building good business cases around technology which is, as yet, far from proven. Even without technological uncertainty, business cases need to show adequate returns; here, we see issues with ineffective or inadequate pricing models (relevant barriers are FA1-09, FA2-01, FA2-09).

Finding 9: Data are missing or not well used

Effective developments in transport provision depend on good spatial planning and good understanding of passenger travel patterns and preferences and of how the existing physical infrastructure needs to be adapted. There are good examples of transport operators who use smart ticketing technologies to gather large amounts of passenger travel data. There are many others who do not, either through a lack of awareness of the potential value of such data or because they prefer to invest limited funds in physical infrastructure. However, insufficient data or knowledge of future needs may affect the ability to develop the infrastructure, for example in response to climate change or to implement C-ITS (relevant barriers are FA1-02, FA2-08, FA3-A3, FA3-A2, FA3-B2, FA3-C3).

Finding 10: Standards are still insufficient

Despite great efforts and progress to build effective and harmonised standards, there is still room for improvement. In some cases, standards are missing, incomplete or allow room for differing interpretations (relevant barriers are FA1-10, FA2-07, FA3-A5, FA4-06, FA4-07, FA4-08). In others, the timing of the introduction of new standards does not fully support the introduction of new technology (a relevant barrier is FA2-04).

¹¹⁰ FUTRE Options for the EU research policy (September 2014)
(http://www.futre.eu/Portals/0/Documents/Deliverables/FUTRE_D6_2.pdf)

8.2 Actions

Policy

A major theme emerging from the analysis and stakeholder consultation has been the need for Europe to act in a more coherent way regarding transport, to counter the tendency to work in silos. This requires actions in many domains, including policy. Here, the European Union should provide a stronger long-term unifying vision to guide policy development in Member States. It should then ensure that Member States' strategic policies are appropriately aligned with this overarching vision and themselves provide long-term vision and predictability. This, backed up by binding commitments, will stimulate innovation and technology adoption by providing innovators, investors and operators with a single market and long-term security. This is seen by stakeholders as especially necessary for the adoption of connected driving (Focus Area 1 Action A1) and alternative fuels (Focus Area 5 Action A1) and for the improvement of infrastructure (Focus Area 2 Action A1a).

Specific measures to support the development of better transport policy include actions to develop improved KPIs (Focus Area 4 Action A7) and traffic simulation tools (Focus Area 4 Action A8). In some policy areas, action is needed to build capacity in public authorities in order to be able to deal effectively with rapidly developing new technology and its policy consequences, for example in C-ITS (Focus Area 1 Action A9).

Funding

There are opportunities to develop the use of existing European Union funding instruments and budgets. This was a more common result of our stakeholder consultations than proposals to increase budgets or launch new funding mechanisms. While requests for increased funding are to be expected, it is also important to make the most of the existing funding. For example, it would be valuable to continue and to some extent re-target Framework Programme funding to support more vigorously the introduction of connected driving and automation of transport (Focus Area 1 Action A4). Action is also needed to ensure that funding is only provided where projects clearly support policy objectives. Stakeholder consultation identified occasions where this has not been fully achieved, for example in infrastructure (Focus Area 2 Actions A3a and A3b), smart mobility (Focus Area 3 Action A4) and alternative fuels (Focus Area 5 Action A4).

Additional funding is needed in some areas, for example for the improvement of transport infrastructure (Focus Area 2 Action A2a). The timing of the funding may be critical: for example, C-ITS roadside infrastructure needs to be deployed as early as possible to reduce the hesitation end-users might have in purchasing connected and automated vehicles (Focus Area 1 Actions A5 and A11). Member States need to support development and deployment by funding work on regulatory and operational issues, as well as the technology itself, for example the deployment of connected driving (Focus Area 1 Action A10).

Transport infrastructure in general requires substantial long-term investment and therefore those responsible tend to be risk-averse and cautious about the adoption of new technologies. There is a need to develop new life-cycle management tools to support confident investment in new infrastructure technologies (Focus Area 2 Actions A4a, A4b and A4c). This is also a topic where Member States should introduce new funding mechanisms to help attract greater funding, especially from the private sector (Focus Area 2 Action A2b).

Reducing risks and increasing stakeholder (especially end-user) acceptance of new technology could be improved by an initiative to set up large-scale pilot facilities, for example in infrastructure (Focus Area 2 Actions A7a and A7b).

Incentives

Incentive schemes to encourage the adoption of new technology – and disincentives for the continued use of older technology – have often been identified during our consultations as needing further development.

Often what is needed is to extend or adjust the focus of existing European Union incentive schemes, for example to foster connected driving and digital road infrastructure through the TEN-T programme and the Connecting Europe Facility (FA1 Action A2) and to encourage greater collaboration along the freight chain (Focus Area 3 Action A2). There is also a need for additional efforts at national and local levels to support the deployment of new technology, for example connected driving and automation of transport (Focus Area 1 Action A7). One way to do this is to use public procurement more effectively, for example to drive the deployment of connected driving (Focus Area 1 Action A8) and alternative fuels (Focus Area 5 Action A5).

Harmonisation

Another frequently discussed issue during the consultations was the need for more European Union action to set and enforce common frameworks and standards across Europe, to counter the tendency for multiple and incompatible schemes and systems to develop (Focus Area 2 Action A6).

A case in point is incentives, where there is a need to provide stronger European Union-level frameworks to ensure greater coherence between the various incentive schemes introduced by Member States, for example to support the introduction of alternative fuels (Focus Area 5 Actions A2 and A6).

A further example concerns regulation and standards. Action is needed to establish a common regulatory approach for C-ITS across Europe. This requires action at European Union level to set common frameworks (Focus Area 1 Action A3) and at Member State level to pay more attention to matching national regulatory approaches with those in the rest of Europe (Focus Area 1 Action A6). Here, as for regulatory measures in general, the emphasis should be on smarter regulation rather than simply more regulation.

Standards

Standards can have a powerful effect on innovation and the introduction of new technology, by helping to provide the business opportunities of a single, large market. In some cases, such as transport infrastructure, many standards exist but more should be done to update, maintain and implement existing standards (Focus Area 2 Actions A5a, A5b and A5c). Elsewhere, there is a need to extend European Union-level standardisation to cover topics currently not standardised and to enforce current standards in all Member States. This will, for example, support greater collaboration and interoperability (Focus Area 4 Action A1) and encourage the adoption of alternative fuels (Focus Area 5 Action A3). In some cases it will involve replacing current sets of incompatible local or industry sector standards (Focus Area 4 Action A2).

Stakeholder partnerships

Stronger partnerships by multiple, public and private, stakeholders will help the adoption of connected driving (Focus Area 1 Action A12) and alternative fuels (Focus Area 5 Action A7). This is partly a matter of the private sector working more closely together and taking collective responsibility for finding ways to deploy new technology

effectively. In some cases, this should be supported by action to raise awareness amongst all stakeholders of new service possibilities, looking at framework conditions, regulatory and cost-benefit issues as well as at the new technology itself. An example of this is Mobility-as-a-Service (Focus Area 3 Action A9). Similarly, it would be helpful to promote the wider adoption of open innovation throughout the supply chain (Focus Area 2 Action A1b) and to encourage the exchange of best practices (Focus Area 2 Action A8b).

Stronger partnering is also partly a matter of the public sector, at European Union and Member State levels, doing more to encourage this to happen. One step forward should be for the European Union to explore the use of trusted third parties or brokers to facilitate stronger partnering (Focus Area 3 Action A1). At Member State level, more should be done to stimulate partnerships between existing operators and new entrants bringing innovation to deploy new services, for example in smart mobility (Focus Area 3 Actions A5, A6 and A11).

Freight transport has much potential to improve capacity and efficiency through the use of better multi-modal services, connected driving and the 'physical internet'. To realise this potential, actions are needed to develop new business models (Focus Area 1 Actions A13, A14 and A15; Focus Area 4 Actions A6, A11, A13, A14, A15 and A16), build better ICT platforms to support multi-modal route planning and execution (Focus Area 4 Action A9), and improve data access (Focus Area 4 Action A4) and cooperation and connections between freight transport operators (Focus Area 4 Actions A5 and A10). All this should be supported by better availability of Key Performance Indicators to monitor freight transport in cities (Focus Area 3 Action A8).

Transnational collaboration

Better provision of cross-border transport services has long been a European ambition. Our work suggests that direct European Union support for such services is unlikely to be the most effective way forward, except on the major corridors such as the TEN-T network. It indicates that the smarter way to encourage such provision is by helping local authorities and operators to recognise for themselves where it is in their own interest to work together to create cross-border services.

This can be done, for example, by introducing a range of diffusion initiatives to help Member States and regions to appreciate the strategic and economic value *to them* of cross-border transport infrastructure (Focus Area 2 Action A8a). This would complement the unifying policy vision discussed above. More generally, the European Union should support more exchange of experience and performance benchmarking amongst Member States, regions and cities (Focus Area 5 Action A8).

Direct support for cross-border service development is still appropriate in certain instances. For example, the European Union should provide more support for testing and demonstration of cross-border data integration, to help the deployment of MMITS which will, in turn, enable greater multi-modal cross-border travel (Focus Area 3 Action A12).

Cities

Cities make important decisions on transport and land use planning, infrastructures, public transport services and fleets, park & ride schemes, and so on. Fortunately, some cities now take an active role in promoting sustainable mobility and innovations at local level. However, many others remain risk averse or simply continue outdated routines. Particularly in some areas of new technology, such as connected driving and automation of transport, technology deployment in urban areas is especially difficult. Cities need to get involved early in planning deployment so that they can reap the benefits the technology offers (Focus Area 1 Action A16).

More generally, new practices and mechanisms are needed to better connect European Union, national and local level targets and actions to find win-win solutions (e.g. via linkages to Sustainable Urban Mobility Plans). One example where this is important is the introduction of alternative fuels (Focus Area 5 Action A9).

Data access

The key to better transport provision is often the open availability of good quality data. At the development stage, it is important to make the results and data from European Union-funded projects more widely available (Focus Area 3 Action A3). At the operational stage, more effort is needed, at both European Union and Member State levels, to stimulate the development of publicly-available databases of transport providers and services, to enable wider access to good quality data and optimum multi-modal transport choices (Focus Area 3 Action A7 and Focus Area 4 Action A3). This includes building better links between databases, to improve efficiency and cut costs, in particular for freight and logistics where data availability is being strongly affected by the growth of the Internet of Things (Focus Area 4 Action A4). In all cases, it is of course also necessary to encourage greater awareness and use of the data that do exist (Focus Area 3 Action A10).

Awareness

To achieve wider adoption of new technology, broad end-user awareness and acceptance is required. This should be supported by more action to provide information and raise awareness. Examples of where this is important include connected driving (Focus Area 1 Actions A17 and A18), the diffusion of new mobility patterns amongst citizens in order to increase the demand of connected, efficient and intelligent transport infrastructures at the European level (Focus Area 2 Action A8c), smart mobility services (Focus Area 3 Action A13) and alternative fuels (Focus Area 5 Action A10).

Annex: Barrier profile tables

The following tables summarise identified barriers, their root causes and proposed actions to overcome them in each of the five Focus Areas.

Focus Area 1

Connected driving and automation of transport, and use of automated optimisation of traffic flows

Barrier FA1-01 (Not so important)	Low acceptance of the technology that exists for C-ITS and hesitation to invest from diverse stakeholder groups
Short description	The technology is ready for the market, but a major obstacle for C-ITS deployment is that significant upfront investments are required both on the vehicle and the infrastructure level and that enhanced co-operation needs to be established before any benefits will occur. Currently, however, we are stuck in a valley of death: there is no roll-out because of a lack of funding. There is also no experience with evaluation (e.g. 5,000 € costs per junction but potentially 10,000 € benefits) This situation is particularly pronounced because benefits will only accrue beyond a relatively high penetration rate; in other words, wide-spread acceptance is crucial. But wide-spread acceptance means that very many and very diverse stakeholders have to be involved. Almost everyone must participate in C-ITS for it to “work”. Put bluntly, how would I get my grandmother to invest in a C-ITS ready car?
Focus area(s) affected	FA1
Impact	Investments in C-ITS are limited due to fear of first-mover disadvantage.
Root causes, including justification and trends	(a) Uncertain business case for C-ITS (b) Many actors involved that initially won’t benefit from C-ITS (c) Unclear funding sources.
Benefit of removal	More investment in C-ITS infrastructure and C-ITS ready vehicles.
Actions	More frontrunners are required to highlight the benefits of C-ITS, that need to be evaluated more clearly. Identify the minimum penetration rate that needs to be achieved to create benefits. (A1) Aligned policies among wide group of stakeholders (A12) Private Public collaboration
Cost-benefit of priority actions	A1 and A12 are both low cost actions as they do not require any direct infrastructure investments. The main costs are coordination activities with various stakeholder groups from the public and private sector. A12 is classified as a high benefit as it encourages the involvement of the private sector that can result in a large leverage in the investment into connected driving.
Barrier FA1-02	Insufficient knowledge in public authorities about type and scale of

changes required to physical road infrastructure	
Short description	<p>The impact of connected and automated driving on the physical infrastructure includes new requirements imposed on road construction to help unlock maximum benefits from this new technology but also that old practices may no longer be necessary (e.g. removal of physical road signs and their maintenance) or that current practices (e.g. shared space) might raise safety concerns. Example: Should zebra-crossings be different in the future? In urban areas, particularly, more infrastructures cannot easily be fitted due to space constraints.</p> <p>This is particularly problematic because of the lifecycle of any infrastructure. Any investment in physical infrastructure made today will be with us for the next 20+ years. There is uncertainty about when is the time right to invest in what? Is it still worthwhile to refurbish infrastructure even if it can't be made 100% C-ITS ready? The public authorities have little knowledge about the requirements of connected and automated driving and are currently not dealing with possible adjustments since they are, by and large, still used to hardware and not to software, data, IT, algorithms. How can knowledge and awareness in public authorities be raised?</p>
Focus area(s) affected	FA1
Impact	Due to the long lifetime of physical road infrastructure changes might only occur heavily delayed.
Root causes, including justification and trends	<p>(a) Uncertainties about changes to physical road infrastructure</p> <p>(b) Lack of use cases that could influence the adaptation of highway codes</p> <p>(c) Interaction with cyclists and pedestrians – will it require more physical separation?</p>
Benefit of removal	More investment in C-ITS infrastructure and C-ITS ready vehicles
Actions	<p>Understanding and capacity of public authorities need to be increased, so that public authorities understand their roles in the deployment of C-ITS. Public authorities need to understand how they can invest into C-ITS. Public authorities expertise is mainly with “concrete”, they need to move from “bitumen” to “bytes”.</p> <p>Guidance on innovative public procurement for public authorities should be elaborated.</p> <p>(A6) Aligned policies among wide group of stakeholders</p> <p>(A16) Involvement of cities and municipalities</p>
Cost-benefit of priority actions	A6 and A16 are both low cost actions as they do not require any direct infrastructure investments. The main costs are coordination activities with various stakeholder groups and capacity building for cities and municipalities. The benefits of A16 are especially high due to the important role cities and municipalities play in the deployment of connected driving (C-ITS) infrastructure.

Barrier FA1-03 Unclear business case and “sensibility case” for C-ITS deployment in urban areas	
Short description	There is a poor understanding of the urban C-ITS policy framework and factors driving procurement decisions: cities are comparatively more complex than corridors, strongly policy driven and risk-averse when it comes to new

	<p>technologies.</p> <p>Furthermore, there is often inappropriate communication of C-ITS: excessively focussed on car driver benefits, while cities are not especially interested in this issue but on solutions for their transport problems, addressing sustainability, modal shift, quality of life, etc. The interest of cities in related issues is mainly targeted to the automation of public transport vehicles because of the possible savings in driver staff costs.</p> <p>Besides, a growing number of cities want to reduce the absolute number of cars – not simply make them smarter. In fact, traffic by very smart cars still impacts negatively on quality of life and poses high risks for public health (e.g. obesity, diabetes, etc.)</p>
Focus area(s) affected	FA1
Impact	Investment in C-ITS is limited due to fear of first-mover disadvantage.
Root causes, including justification and trends	<p>(a) Uncertain benefits for cities.</p> <p>(b) Many cities want to reduce the number of vehicles on their network. Focus is on public transport and non-motorised transport.</p> <p>(c) Interaction with pedestrian and cyclists.</p>
Benefit of removal	More investment in C-ITS infrastructure and C-ITS ready vehicles in urban areas.
Actions	<p>Trials and experimentation may help overcome many of the barriers, including acceptance, evidence for decision making, etc.</p> <p>(A9) Develop C-ITS training for public authorities (A16) Involvement of cities and municipalities</p>
Cost-benefit of priority actions	A6 and A16 are both low cost actions as they do not require any direct infrastructure investments. The benefits of A6 and A16 are especially high due to the important role cities and municipalities play in the deployment of connected driving (C-ITS) infrastructure.

Barrier FA1-04	Unclear user acceptance, willingness to pay and business case for C-ITS day 1 and 1.5 services
Short description	<p>What are the resulting applications? How can the benefits be sold to the large number of stakeholder? Day 1: All services, which can be used immediately with a C-IST equipped vehicle:</p> <ul style="list-style-type: none"> - eCall System: An emergency call will be made automatically in case of accident - Unclear who will pay for such services? Will this be part of the purchase price? - Buyers of non-equipped cars might be unwilling to participate in the financial burden sharing. Potential opposition.
Focus area(s) affected	FA1
Impact	Investment in C-ITS is limited due to unclear benefits to different stakeholders.
Root causes, including justification and trends	<p>(a) Unclear division between personal and societal benefits of services and applications</p> <p>(b) Business model (i.e. willingness to pay) for services and applications</p>

	(c) User acceptance of services and applications (i.e. effect on penetration levels)
Benefit of removal	More investment in C-ITS infrastructure and C-ITS ready vehicles
Actions	(A2) Incentive and disincentive schemes (A7) Incentive and disincentive schemes (A13) New Business models and additional services to increase willingness to pay (A17) Information and awareness raising
Cost-benefit of priority actions	A2, A7, A13 and A17 are all low cost actions as they do not require any direct infrastructure investments. All benefits from these actions are either high or medium as can have a big impact on the willingness pay and invest in C-ITS.

Barrier FA1-05 (Important)	Long waiting period and sufficient penetration rates (approximately 30%) are required until benefits such as optimisation of traffic flow materialises
Short description	Significant benefits will only start to accumulate 5 to 10 years after initial investments, depending on deployment scenario and uptake rates. At what penetration level do traffic flow benefits emerge? The selling argument should not be fully automated traffic. Rather, benefits from early applications should also be acknowledged (instant benefits).
Focus area(s) affected	FA1
Impact	Investment in C-ITS is limited due to unclear benefits to different stakeholders.
Root causes, including justification and trends	(a) In urban areas optimisation of traffic flow might not be as high as on corridor level. (b) Benefits from the optimisation of traffic flow could be reduced due to induced demand from improved journey times. Is there an argument for restrictive measures (e.g. road pricing) (c) There is clear difference in the nature of Costs and Benefits of C-ITS services. The majority of costs are essentially service independent. High investments are required even to enable small benefits.
Benefit of removal	
Actions	Focus should be on the benefits that can be felt instantly by the users. (A2) Incentive and disincentive schemes (A17) Information and awareness raising
Cost-benefit of priority actions	A2 and A17 are both low cost actions as they do not require any direct infrastructure investments. The benefits of both actions are both medium as they only provide incentives and information about C-ITS.

Barrier FA1-06 (Important)	Unclear role for operational stakeholders for enhanced traffic management
Short description	Facing a transition period, from conventional driving to fully automated systems, will be challenging, as from setting up the right strategies to understanding the impact of automation on, and the resulting changes to, the roles and borders of the road authorities, traffic managers, service providers, vehicle manufacturers

	<p>and the physical infrastructure stakeholder groups, at operational level.</p> <p>Example: Along a certain highway corridor, the infrastructure could belong to x different companies and y different operators, maintenance companies, etc. This is particularly prevalent in countries with high PPP numbers (i.e. a colourful mix of private and public actors). The situation becomes even more complex with cross-border issues.</p> <p>In other words, there is no central body for horizontal coordinating. Should there be one champion agency?</p>
Focus area(s) affected	FA1
Impact	Investment in C-ITS is limited due to fear of first-mover disadvantage.
Root causes, including justification and trends	<p>(a) Uncertainties on operation level for numerous stakeholders</p> <p>(b) Lack of interest and/or awareness of expected changes</p> <p>(c) Lack of use case / best practice examples to refer to</p>
Benefit of removal	More investment in C-ITS infrastructure and C-ITS ready vehicles
Actions	<p>Clear roles for the industry and public authorities need to be defined.</p> <p>(A1) Aligned policies among wide group of stakeholders</p>
Cost-benefit of priority actions	<p>A1 is a low-cost action as it does not require any direct infrastructure investments.</p> <p>The main costs are coordination activities with various stakeholder groups from the public and private sector.</p>

Barrier FA1-07 (Very important)	Road Safety concerns about C-ITS and Automation can inhibit its deployment
Short description	All road users involved in traffic: including fully or partially automated motor vehicles, non-automated motor vehicles, motorcyclists (non-automated yet), cyclists and pedestrians will be affected. Safety improvements are a powerful argument for the deployment of C-ITS and Automation, but new types of road safety issues might arise especially during the transition phase.
Focus area(s) affected	FA1
Impact	Safety concerns can inhibit the deployment of C-ITS and Automation.
Root causes, including justification and trends	<p>(a) The role of cyclists and pedestrians in the deployment of C-ITS and Automation is not clear.</p> <p>(b) Unclear at which point safety benefits actually materialise.</p> <p>(c) Safety concerns can restrict C-ITS and Automation deployment to restricted areas only.</p>
Benefit of removal	
Actions	<p>Identify the new road safety challenges resulting needed for a safe deployment of partially or fully automated vehicles and/or C-ITS based solutions.</p> <p>Identify if and how the traffic rules (rules of behaviour) should be adapted to ensure that fully or partially automated vehicles are safely integrated into traffic.</p> <p>Contribute to the discussion and coordination between authorities dealing with rules of behavior and technical vehicles regulations on how to address these challenges and adaptations.</p> <p>(A4) Research, development and innovation</p>
Cost-benefit of	A4 is medium cost action due to high costs that are required for research

priority actions	activities. The benefits of successful research significantly resolve the issues with this barrier.
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Barrier FA1-08 (Important)	Uneven deployment of C-ITS across EU-28
Short description	Currently C-ITS are high on the policy agenda mainly in a few EU-members in north-western Europe. How can other Member States, where there is no industrial agenda (e.g. Slovakia, Romania) and more important aspects are on the agenda than digitisation, become more involved? The industry's plan is to make all C-ITS equipped vehicles "EU-ready". But when passing a border, the vehicle will have to adjust its "behaviour" to the specific national regulations (e.g. speed limit in inner cities 30 km/h versus 20 m/h; left-hand versus right-hand driving; etc.) Is the pre-defined path of less advanced countries simply one of "catching up" or is there the opportunity for "leap frogging"? When less advanced countries invest in new infrastructure can they deploy ready systems in one go (with small extra investments)? Can they build <i>digital roads</i> instead of <i>normal roads</i> right from the start?
Focus area(s) affected	FA1
Impact	Investment is limited across the EU
Root causes, including justification and trends	(a) High costs of investment (b) Lack of political support in many Member States (c) Expected low penetration levels connected vehicles
Benefit of removal	More investment in C-ITS infrastructure and C-ITS ready vehicles.
Actions	Common goals need to be defined that all countries can follow. C-ITS platform should also invite member countries that do not have industry that supports C-ITS. (A1) Aligned policies among wide group of stakeholders
Cost-benefit of priority actions	A1 is a medium cost action with a high benefit resulting from an EU-wide deployment of C-ITS.

Barrier FA1-09 (Not so important)	Unclear lending criteria by financial institutions to finance C-ITS measures
Short description	International, European or National Development Banks (e.g. EBRD, EIB, KfW) don't have lending criteria to assess the bankability of C-ITS measures.
Focus area(s) affected	FA1
Impact	Lack of finance for C-ITS measures
Root causes, including justification and trends	(a) Development banks lack examples of financed C-ITS measures. (b) Technical ability/capacity is missing to assess C-ITS. (c) Technological debate has not included the banking sector enough
Benefit of removal	
Actions	Difference between financing of physical and digital infrastructure need to be

	<p>understood in a better way.</p> <p>European and national development banks should be involved in the C-ITS platform.</p> <p>(A11) Infrastructure</p> <p>(A15) Infrastructure</p>
Cost-benefit of priority actions	<p>A11 and A15 are both high cost actions as they can result in significant C-ITS infrastructure investments. The impact is medium as the European or national development banks can only provide funding for parts of the European Union TEN-T network.</p>

Barrier FA1-10 (Important)	The “Hybrid” Issue: How to make with 802.11 p / mobile internet / 5G choices and still be able to create a workable system?
Short description	<p>Road infrastructure operators have uncertainties about the technology in which they should invest for C-ITS. For instance, technology progress in the medium-long-term (10, 20 or 30 years) is uncertain. It is not fully clear where to focus the investments: regions, locations, hot spots with a high level of accidents or traffic jams, end customer visibility; where is the break-even for these services? Who is the driver of a technology?</p> <p>Planners who have to make infrastructure related decisions <i>now</i> do not have the expertise or time to engage in such detailed technical discussions. Do they have to wait for highly specialised engineers to make up their mind first? Or can we go ahead and start building something that is flexible enough to serve various kinds of wireless networks?</p>
Focus area(s) affected	FA1
Impact	Investment in C-ITS is limited due to fear of first-mover disadvantage.
Root causes, including justification and trends	<p>(a) Technological uncertainties</p> <p>(b) Unclear standards</p> <p>(c) Lack of wide scale deployment</p>
Benefit of removal	More investment in C-ITS infrastructure and C-ITS ready vehicles
Actions	<p>Additional use cases are required to illustrate which solutions work best in which context (e.g. high density vs. low density areas).</p> <p>(A3) Regulation and standards</p>
Cost-benefit of priority actions	<p>A3 is an action with medium costs and high impact. The costs result mainly from the coordination efforts required to achieve EU-wide regulation for C-ITS infrastructure and vehicles.</p>

Barrier FA1-11	Liability, legislation and insurance related aspects
Short description	<p>The current degree of uncertainty around liability in the field of connected driving and the automation of transport is not surprising given the wide and rapidly developing range of (complex) applications and services and the highly-varied liability regimes across the European Union. The introduction of decisions being taken by artificial intelligences (AIs) will especially be problematic as it might be</p>

	<p>difficult to track at which point and for what reason the decision was taken by the AI.</p> <p>Although an important (potential) barrier it is likely to be tackled in time as more business models from insurance companies emerge over time.</p>
Focus area(s) affected	FA1
Impact	The insurance costs for end-users of connected and automated vehicles are still unclear.
Root causes, including justification and trends	(a) Lack of a business model for insurance companies.
Benefit of removal	
Actions	<p>Insurance companies need to be involved in the development of C-ITS and automation.</p> <p>Continued involvement in the C-ITS platform.</p> <p>(A3) Regulation and standards</p>
Cost-benefit of priority actions	A3 is a medium cost action with a high impact. The benefits of resolving the insurance-related uncertainties are high because they do not act as barriers anymore for technological developments.

Barrier FA1-12	Unclear risks between interaction with non-equipped and equipped vehicles
Short description	<p>New cars are gradually being equipped with driver assistance technologies which may assist the driver in some tasks or even take control of the vehicle in an emergency situation. The deployment of C-ITS will result in more advanced assistance systems made possible on the basis of communication between vehicles (V2V) or between vehicles and infrastructure (V2I). The deployment of such systems will be gradual, which means that cars with very different levels of equipment will inevitably circulate at the same time. The situation is likely to be prolonged for a very long time. The fact that vehicles equipped with these technologies and other vehicles or users not equipped will share the road may give rise to some new risks, mainly related to user behaviour.</p> <p>We simply don't know yet how the interaction between equipped and non-equipped vehicles will play out because we don't have any "cases" yet. We can only make assumptions.</p>
Focus area(s) affected	FA1
Impact	Due to high level and prolonged existence of non-equipped vehicles investment in C-ITS infrastructure might not be justifiable.
Root causes, including justification and trends	<p>(a) Lack of business case to retrofit non-equipped vehicles with on-board units</p> <p>(b) "Chicken and Egg" problem. First investment in vehicle technologies or in C-ITS infrastructure</p>
Benefit of removal	More investment in C-ITS infrastructure and C-ITS ready vehicles.
Actions	<p>Additional research is required on effect of the prolonged transition phase until high penetration rates have been reached.</p> <p>(A4) Research, development and innovation</p>

Cost-benefit of priority actions	A4 is a medium cost action with a high level of benefits.
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Focus Area 2

Transformation of infrastructure to address connectivity, resilience, new fuels and energy efficiency

Barrier FA2-01	Funding gap in the development or improvement of transport infrastructure
Short description	<p>Transport infrastructure is a capital-intensive sector that requires high level of investment to achieve safe, durable, connected, updated and innovative facilities with the capacity to satisfy the increasing freight and passengers transport demand. Moreover, according to some experts, the rate of adoption of new technology is limited by the sheer scale of the costs involved. The scarce and decreasing public resources in national level devoted to transport infrastructure, has made the EU funding subject of higher competition. Moreover, the difficulties faced to attract other complementary sources of resources require further development of innovative funding instruments.</p> <p>The problem seems not to be only related to the underinvestment, but also to the allocation of the funds. For example, the European funding is a tool that could and should be better aligned with (European) transport policies. As it is, funding decisions do not necessarily fully support the long-term objectives, such as modal shift, climate change mitigation, etc. Beyond the funding gap, the risk aversion of infrastructure owners in order to guarantee safety, and durability (based on a clearly establish regulatory framework) together with public procurement rules, which favour the most economic solutions, are a major barrier for the introduction of innovative alternatives for prevailing technologies. Lock in situation with existing technologies complicates justification of new technology investments.</p> <p>The capture of private sector funding is still difficult as long as the business and risk sharing models are still considered ill-defined and unattractive. Instability of transport policies and changing conditions of regulatory landscape also prevent private sector from joining public private partnerships or other means of joint investment.</p> <p>Thus, funding gap has emerged as paramount barrier to the adoption of innovation and technology within transport infrastructure, especially in situations where investment plans cannot represent proven cost-efficient solutions.</p> <p>Moreover, the trend towards utilisation of loans and mixed models of finance, instead of public grants, is considered by some stakeholders as a new emerging barrier for trans-national transport network, especially from the perspective of cohesion of EU. The increasing tendency of utilising combined finance is prone to attract investors for profitable projects only leading to unequal levels of investments within MSs and growing disparities of infrastructure development within EU. Transnational projects that foster cross-border interoperability are often unattractive for Member States to tackle due to unclear benefits and economic profitability. The projects financed by grants and by loans will have very different impacts, which should be taken into account in the future policy. More EU grants would be needed and the possible shift towards new finance mechanisms may be an important barrier creating a new type of gap in funding.</p>
Focus area(s) affected	FA2
Impact	The potential of research and innovation in contributing to European Union safe, durable and connected transport infrastructures has not been exploited to its full extent.

	Cross border transport infrastructure is not completed.
Root causes, including justification and trends	(a) Slow economic growth in Europe during recent years leading to austerity of public investments in transport infrastructure. (b) There is a lack of private funding sources. (c) Lack of innovative financing instruments for transport infrastructure. (d) Lack of business model (i.e. willingness to pay) for services and infrastructures.
Benefit of removal	New business models and financing instruments leading to enhanced investment levels in the long-run.
Actions	(A2a) To strengthen the use of new financing instruments already developed at EU level. (A2b) Countries need to attract additional public and private finance at national level to fund projects and optimise risk allocation amongst the respective stakeholders. (A2c) To monitor the impact of financial reforms on infrastructure financing to the risk sharing amongst all the stakeholders. (A3a,b) To improve the alignment of RDI funding allocation and instruments with related framework public policy priorities, but also with the interests and needs of the sector's stakeholders. (A4a,c) To promote the research and development of innovative tools for infrastructure life cycle management to enhance the adoption of innovative products and solutions. (A4b) Adaptation and promotion of innovative tools for infrastructure life cycle management action
Cost-benefit of priority actions	Low-to-high-cost actions with medium-to-high benefits. Complementary, grouped actions are required

Barrier FA2-02	Risk averse policies
Short description	<p>EU transport infrastructure policy could further address how innovation and new technology may contribute to a faster, more cost efficient, durable and sustainable development of the corridors and whole transport system.</p> <p>As for Member States, in general terms, the transport infrastructure policies do not provide sufficient support to the development and deployment of innovation and new technologies. Policy support on this issue is rather risk averse so far, as long as infrastructure assets have a very relevant impact on safety and security aspects for users, economic activities, etc.</p> <p>Thus, risk aversion is motivated by several factors, among others:</p> <ul style="list-style-type: none"> • Regulations of transport infrastructure construction projects, products and processes are focused on safety, security and the protection of user rights than on promotion and support of new technologies and innovation. There is a well-established normative and regulatory framework to guarantee the performance and quality of transport infrastructure construction, maintenance and operation industry. Moreover, these regulations are really embedded in the national systems and stakeholders are reluctant to change them. However, there is a lack of questioning old practices and specifications. There is a need for a new updated and flexible regulation. A goal driven policy is needed instead of measures driven policies. • The benefits of innovations in transport infrastructures come very often in the long-term (longer than the policy cycle). As the life-cycle of

	<p>transport infrastructure assets is much longer than the policy agendas, decision makers have limited motivation to assume risks related to the incorporation of not well proven technologies, both at creating new infrastructures or in terms of maintenance of the existing ones.</p> <p>Infrastructure assets have to be long lasting, even longer than estimated in design period (far beyond 50 years). It must be ensured that innovative transport infrastructure must provide the agreed functionalities to the end-users, with the same level of safety and security over its entire life cycle. In some cases, uncertainties about the performance of innovations or new technologies over time impede its market uptake during a long period of time. The management of whole life cycle aspects better considering concepts as durability, performance during service life and conservation would reduce risk perception and could enhance the research activity on this matter and the future adoption of innovations and new technologies.</p> <p>Innovation in transport infrastructure is highly capital intensive and therefore a risky activity in many cases. Risk perception increases when the understanding and research about the impacts of major innovations (and investments) in transport infrastructure are weak.</p> <p>Decision makers have to ensure (in general) the best economic alternative as promoted by public procurement regulation. This alternative is not usually the most innovative or technology based solution. Innovative procurement asking for outcomes rather than detailing technicalities is one potential remedy.</p> <p>Therefore, the decision-making situation to adopt new technologies or innovation into transport infrastructures is complex as far as it involves high levels of investment and uncertainty. Sometimes, this provokes that the adoption pace of new technologies and innovation in transport infrastructure is slower than in other industries.</p>
Focus area(s) affected	FA2
Impact	<p>Due to the long lifetime of physical transport infrastructure and to the lack of information about the performance and impact related to the adoption of innovations, changes only occur heavily delayed.</p> <p>Due to the well-established normative and regulatory framework oriented to preserve safety, security and protection of user's rights, bringing the technology to market may not be justifiable.</p> <p>Investment in innovation is limited to provide the agreed functionalities required.</p>
Root causes, including justification and trends	<p>(a) Transport infrastructure investments are highly capital-intensive.</p> <p>(b) Factors related to durability, performance, safety or security during infrastructure lifetime and conservation are not appropriately considered in the impact assessment regulation and involves uncertainty.</p> <p>(c) Lack of use cases/demonstrators that could enhance the adaptation and adoption of technology and innovation.</p> <p>(d) Current business and risk sharing models do not properly take into account complete transport infrastructure life-cycle and complicates the attraction of new funding agents.</p>
Benefit of removal	<p>Better appropriation of innovation in transport infrastructure.</p> <p>More factors to be considered in the environmental and socio-economic sustainability of the transport infrastructures.</p>
Actions	<p>(A1b) The adoption of open innovation dynamics by the transport sector including the final users.</p> <p>(A3a,b) To improve the alignment of RDI funding allocation and instruments with related framework public policy priorities, but also with the interests and needs of the sector's stakeholders.</p> <p>(A4a,c) To promote the research and development of innovative tools for</p>

	<p>infrastructure life cycle management to enhance the adoption of innovative products and solutions.</p> <p>(A4b) Adaptation and promotion of innovative tools for infrastructure life cycle management action</p> <p>(A5a) An improvement and continued adaptation of the regulation and standard frameworks to the new transport infrastructure demand to boost innovation and technology in the sector.</p> <p>(A5b) Implementation of European regulation/standards in national level, and enhancing the involvement of all relevant actors.</p> <p>(A5c) Industry initiated and led standardisation process (ahead of regulation).</p> <p>(A5d) Access of users to large research infrastructures enhancing the standardisation process.</p> <p>(A7a) To develop large-scale pilot infrastructures to test new technologies to know their performance in real environments according security and reliability requirements.</p> <p>(A7b) The introduction of pilot demonstrator in the transport infrastructure projects guaranteed by MSs to stimulate the adoption of technology and innovation.</p> <p>(A7c) To develop pilot projects at local level to deploy technologies.</p> <p>(A8b) To the exchange of good practices by Member States to learn best experiences to disseminate and adopt at national level.</p>
Cost-benefit of priority actions	Low-to-high-cost actions with medium-to-high benefits. Complementary, grouped actions are required

Barrier FA2-03	Challenges to incorporate new technologies and innovation into already existing infrastructure networks
Short description	<p>European transport infrastructure network is one of the densest and most developed in the world. However, most of these infrastructures have already been used over its intended working life and many of them no longer fulfill current functional requirements and today's safety and quality standards.</p> <p>To cope with the increasing mobility demand and current requirements, these infrastructures have to face continuous upgrading, refurbishing, strengthening and transformation processes along the time.</p> <p>However, the integration process of new technologies or innovation is more complex if they have to be embedded in an already existing and well-established infrastructure network, designed according to other past parameters.</p> <p>The same happens when new technologies developed replace others already deployed, especially if they have not reached the end of their life span.</p>
Focus area(s) affected	FA2
Impact	<p>Obsolete infrastructure network to tackle with current transport demand and safety and quality requirements.</p> <p>Less efficient technology and innovation adoption process.</p>
Root causes, including justification and trends	<p>(a) Long trajectory of infrastructure investment in Europe.</p> <p>(b) Legacy of existing ageing infrastructure.</p>
Benefit of removal	Already existing transport infrastructures adopt specific technologies and innovation in order to better comply with mobility demand and current relevant requirements in terms of safety, quality, energy efficiency, connectivity, etc.
Action	(A3a,b) To improve the alignment of RDI funding allocation and instruments with related framework public policy priorities, but also with the interests and needs of the sector's stakeholders.

	<p>(A4a,c) To promote the research and development of innovative tools for infrastructure life cycle management to enhance the adoption of innovative products and solutions.</p> <p>(A4b) Adaptation and promotion of innovative tools for infrastructure life cycle management action</p> <p>(A5a) An improvement and continued adaptation of the regulation and standard frameworks to the new transport infrastructure demand to boost innovation and technology in the sector.</p> <p>(A5b) Implementation of European regulation/standards in national level, and enhancing the involvement of all relevant actors.</p> <p>(A5c) Industry initiated and led standardisation process (ahead of regulation).</p> <p>(A5d) Access of users to large research infrastructures enhancing the standardisation process.</p> <p>(A7a) To develop large-scale pilot infrastructures to test new technologies to know their performance in real environments according security and reliability requirements.</p>
Cost-benefit of priority actions	Low-to-high-cost actions with medium-to-high benefits. Complementary, grouped actions are required

Barrier FA2-04	Timing of the standardisation process
Short description	<p>Even though this barrier was identified during the desk research as key for the introduction of the resilience concept into the design, building and maintenance processes of the transport infrastructures, the results of the consultation days of the SINTRAS project led to scale it up to a general issue and one of the main barriers for the innovation on different areas of the transport infrastructures.</p> <p>The underlying problem for an appropriate standardisation seems to be the fact that technologies are usually in a more advanced stage of development and deployment than the needed standardisation for the system to work properly. However, to some extent, rule should come once the good options are identified and chosen. Right timing of standardisation is an important issue; standards should not come too early, but neither too late.</p> <p>In this sense, forcing a standard too early stage can be a major mistake. Standardisation processes are lengthy, C-ITS is probably a good example in which the timing and efficiency of electro mobility charging standardisation was not that successful one. Early adopters may find themselves in a situation where the system has to be updated completely after the publication of the standards.</p> <p>Standards are typically applied on voluntary basis. Distinguishing between standards and political enforcing of standards is considered important.</p> <p>According to the experts interviewed, a standard system can be used for complete renewal of a major piece of infrastructure; but sometimes government funding rules forbid taking infrastructure that still has service lifetime left out of use. So much renewal involves overlaying some new infrastructure on top of legacy infrastructure. The new infrastructure has to be adapted to retrofit, due to which it may become non-standard.</p> <p>Regarding the specific resilience topic, standards have to be further developed by means of transport infrastructures and climate change, in spite of the facts that CEN has developed Guide 4 "Guide for the inclusion of environmental aspects in product standards" and the Commission is in dialogue with the three European standardisation organisations (CEN, CENELEC and ETSI) to prepare a programming and standardisation mandate.</p> <p>Some Member States have started to analyse how to adapt existing construction standards to the effects of climate change. An European-wide initiative would help to coordinate this type of action.</p>

Focus area(s) affected	FA2
Impact	Procurement processes mainly based on price hinder the incorporation of technology and innovation into transport infrastructure.
Root causes, including justification and trends	<p>General issue:</p> <p>(a) Technologies are usually in a more advanced stage of development and deployment than the needed standardisation for the system to work properly.</p> <p>(b) The time it takes to identify and to choose the best technological option.</p> <p>Resilient related issue:</p> <p>(a) Lack of information on the vulnerability level of infrastructures against climate change.</p> <p>(b) National regulations and standards are typically strongly embedded in the national system and context.</p>
Benefit of removal	The pace of innovation processes and the diffusion and implementation of technologies related to transport infrastructures would speed up. Member States would be more open to the construction and adoption of an integrated European regulatory framework and management system.
Actions	<p>(A5a) An improvement and continued adaptation of the regulation and standard frameworks to the new transport infrastructure demand to boost innovation and technology in the sector.</p> <p>(A5b) Implementation of European regulation/standards in national level, and enhancing the involvement of all relevant actors.</p> <p>(A5b) Implementation of European regulation/standards in national level, and enhancing the involvement of all relevant actors</p> <p>(A5c) Industry initiated and led standardisation process (ahead of regulation).</p> <p>(A5d) Access of users to large research infrastructures enhancing the standardisation process.</p> <p>(A7a) To develop large-scale pilot infrastructures to test new technologies to know their performance in real environments according security and reliability requirements.</p>
Cost-benefit of priority actions	Low-to-high-cost actions with medium-to-high benefits. Complementary, grouped actions are required

Barrier FA2-05	Large number of agents implied with different priorities and visions (Fragmentation)
Short description	<p>Although the Member States are still main entities in charge of the infrastructure design and deployment, other authorities connected to different links of the value chain and different modes of transport - such as private sector partners, regional and local authorities, infrastructure operators, research agents, designers and contractors - are also relevant actors when working towards an interoperable, multi-modal and accessible transport system.</p> <p>The large number of agents implied may act as a barrier when incorporating technology or innovation. The large number of agents involved is characterised by a general lack of collaboration across administrative levels (different roles) and transport modes, and incentives and lack of real coordination and joint decision-making. There are many actors and each have their own vision and incentives to act.</p> <p>Transport systems and related infrastructures have been built bottom-up, and</p>

	<p>new entrants are always accommodating themselves in the existing system and different solutions have been adopted in different countries, cities, etc. Seeking for a common European model is consequently a tough task - how to choose the solution to be spread to other regions? Picking out of existing solutions or something completely new? Major changes are expensive and often face resistance.</p> <p>Additionally, the value/supply chain related to transport infrastructure involves a great number of agents responsible for management or operation, project designing, construction, upgrading or maintenance, together with end users amongst others. Each of them have their own interests which in many cases are not duly integrated and working on a common approach. As a result, the actors along the value chain of the transport infrastructure do not give the same relevance to the adoption of innovation or new technologies into the process or even they do not have the same priorities.</p> <p>There is also room for improvement in terms collaboration of various actors along the value chain e.g. in the field of autonomous vehicles, the enhanced collaboration between OEMs and infrastructure developers would benefit both. Currently, the stakeholders see the deficit of collaboration as a barrier for the development. There are however some current initiatives to improve the situation. At the same time, the incentives and benefits for the infrastructure and vehicle sector are becoming more visible. In railway on the other hand the actors work more together e.g. under the Shift-to-Rail initiative. In maritime and aviation there are similar problems as in road transport.</p>
Focus area(s) affected	FA2; FA1
Impact	Low levels of cross-borders interoperability. Investment in adoption of innovation or new technologies is limited due to unclear benefits to different stakeholders.
Root causes, including justification and trends	<p>(a) Public policies set at national level do not have synchronised priorities in terms of general objectives, modes of transport, etc. between countries.</p> <p>(b) There is a lack of involvement of the different stakeholders in the decision-making process, starting by the definition of a common strategic vision.</p> <p>(c) Low levels of open innovation dynamics in the transport innovation system.</p>
Benefit of removal	Sharing a common strategy among all the stakeholders, so they work in the same direction, overcoming individual interests.
Action	<p>(A1a) To define a long-term vision and strategy at European Union level for the transport infrastructure and its transformation to address connectivity, resilience, new fuels and energy efficiency.</p> <p>(A1b) The adoption of open innovation dynamics by the transport sector including the final users.</p> <p>(A3a,b) To improve the alignment of RDI funding allocation and instruments with related framework public policy priorities, but also with the interests and needs of the sector's stakeholders.</p> <p>(A4a,c) To promote the research and development of innovative tools for infrastructure life cycle management to enhance the adoption of innovative products and solutions.</p> <p>(A4b) Adaptation and promotion of innovative tools for infrastructure life cycle management action</p> <p>(A8a) To develop broader diffusion initiatives targeted at Member States, the sector and final users.</p>
Cost-benefit of priority actions	Low-to-high-cost actions with medium-to-high benefits. Complementary, grouped actions are required

Barrier FA2-06	Policies at national level have insufficient transnational and network vision and specialisation of transport modes in terms of regulatory frameworks and management systems
Short description	<p>Public authorities have a strong position at national level when planning, executing, operating and financing transport infrastructure, and they focus on the enhancement of the local transport system tackling international connection in second place.</p> <p>Different regulatory frameworks, management systems and standards for each transport mode and each country, are normally strongly embedded in the national system and context, becoming a barrier for the integration of European transport system, in general, and for interoperability and multimodality, in particular. National regulations and standards can be mutually incompatible or too well established to be changed.</p> <p>There is no binding framework implemented by the European Commission regarding the trans-European transport network regulation, so it is considered a question of subsidiarity principle of each Member State when it comes to the deployment of transport infrastructure. In this sense, the European Commission can only give recommendations and ask Member States make their best efforts to achieve the goals set at European level.</p> <p>Cross-border projects are perceived as less profitable and the benefits are not always evident or equally shared. This is closely link with the funding gap. There is a need for increased financial incentives to make this kind of projects interesting for the MSs.</p> <p>A way to move forward is by means of European Union-level funding. There is a need for the European Union to fund those infrastructure projects for which Member States do not see the economic and social benefits.</p> <p>Moreover, major investors in transport infrastructure have been national public entities. Even if these infrastructures could be operated by independent governmental agencies or private organisations, states very often remain as operators of the infrastructure. This makes the transport infrastructure a rather closed market, with procurement processes mainly based on price (best economic offer) and closely linked to the national context. These kinds of contracts are an important barrier to the incorporation of technology and innovation into transport infrastructures. However, instruments such as Innovative Public Procurement processes or the adoption of new conditions in the concession contracts rewarding innovation could mitigate this barrier.</p> <p>Besides, infrastructure companies have been traditionally operating only in national markets, and there is unwillingness to cross-border collaboration, for example, between transport infra/ICT companies in the fear of losing business in own national clientele.</p>
Focus area(s) affected	FA2
Impact	<p>Low levels of cross-borders interoperability and strong resistance to change and to adopt standards that lead to the needed interoperability and multimodality levels, giving as a result that cross-border car usage is rapidly increasing, whereas the use of public transport stagnates.</p> <p>Procurement processes mainly based on price hinder the incorporation of technology and innovation into transport infrastructure.</p>
Root causes, including justification and trends	<p>(a) There is not enough awareness of the benefits of an integrated European transport system nor a common European identity with respect to the transport system across countries.</p> <p>(b) The lack of consideration of transport infrastructures as a facilitating asset to achieve broader goals in the domains of tourism, trade and</p>

	<p>industry that require of international connections for its enhanced performance.</p> <p>(c) It is difficult to define the right governance structure and sources of financing for complex cross-border projects.</p> <p>(d) The level of integration of the European Union transport market remains low in comparison to other parts of economy. Transport infrastructure has been historically designed to serve national rather than European goal.</p> <p>(e) The lack of incentives for the incorporation of innovation and technology into transport infrastructures.</p>
Benefit of removal	Considering the transnational connectivity of transport infrastructures a strategic asset for national competitiveness so there would be a stronger national commitment to improve the cross-border connectivity.
Actions	<p>(A1a) To define a long-term vision and strategy at European Union level for the transport infrastructure and its transformation to address connectivity, resilience, new fuels and energy efficiency.</p> <p>(A1b) The adoption of open innovation dynamics by the transport sector including the final users.</p> <p>(A1c) To increase the participation leading initiatives related to cross-border transport infrastructure projects.</p> <p>(A8a) To develop broader diffusion initiatives targeted at Member States, the sector and final users.</p> <p>(A8b) The exchange of good practices by Member States to learn best experiences to disseminate and adopt at national level.</p>
Cost-benefit of priority actions	Low-to-high-cost actions with medium benefits. Complementary, grouped actions are required

Barrier FA2-07	Unequal and limited ERTMS deployment across Europe
Short description	<p>ERTMS is a Unique European train control system designed to gradually replace the existing incompatible systems Europe wide, aiming at making rail transport interoperable cross-countries, safer and more competitive. Despite that ERTMS has been embraced by all the Member States and the Fourth Railway Package, the implementation has not progressed as planned in all countries. The reasons are various, for example:</p> <ul style="list-style-type: none"> • High costs of implementation and large investments made in existing system that has not necessarily reach end of its life-cycle. • Reluctance to change. There are long standing operating rules and signalling principles inside individual countries. • The costs of ERTMS are not always adequately related to their added value and benefits. • Challenges in making different parts of the supply chain working together towards production of compatible products. • Challenges in the backward compatibility with earlier versions.
Focus area(s) affected	FA2, FA1
Impact	Low levels of interoperability of the national train control systems across the European Union.
Root causes,	(a) High cost for implementation and unclear benefits.

including justification and trends	<p>(b) Minimal condition requirements of the existing infrastructure for optimal implementation and performance of ERTMS.</p> <p>(c) Complex integration process of different national regulations.</p> <p>(d) The lack of expertise in the application of the system.</p> <p>(e) The existence of other systems that are still in use and that have not reached the end of its life cycle.</p> <p>(f) Lack of clarity about related regulation and specifications.</p> <p>(g) Limited specifications on maintenance and repair of the system.</p>
Benefit of removal	Achievement of a single, fully interoperable railway system permitting seamless cross border connections between countries leading to significantly enhanced reliability, safety, capacity of the system, and cost savings.
Actions	<p>(A5a) An improvement and continued adaptation of the regulation and standard frameworks to the new transport infrastructure demand to boost innovation and technology in the sector.</p> <p>(A5b) Implementation of European regulation/standards in national level, and enhancing the involvement of all relevant actors.</p> <p>(A6a) The optimisation and the internal interoperability of the management systems initiatives being currently undertaken in the European dimension.</p> <p>(A6b) To guarantee compatibility among the versions of the existing systems related to digital infrastructure and intelligent transport services or implement change/transition management processes to improve efficiency and interoperability.</p>
Cost-benefit of priority actions	Medium-to-high-cost actions with high benefits. Complementary, grouped actions are required

Barrier FA2-08	Information gap and uncertainties on climate behaviour
Short description	<p>Climate resilience is a matter that is slightly arising in the case of transport infrastructure research and development. So far, climate change mitigation policies have prevailed over adaptation ones.</p> <p>Moreover, it remains a need for climate change information specifically tailored to transport infrastructure sector. The available information not always provide the level of detail needed by each stakeholder involved in infrastructure management, operation or construction to understand their own risks and to adopt appropriate responses.</p> <p>Additionally, the uncertainty about the way the climate system behaves makes increasingly difficult to model climate change at regional level, assess impact on infrastructure and make accountable cost-benefit analysis that demonstrate the advantages (at social and economic level) of acting ahead of time.</p> <p>Project promoters might have insufficient knowledge and life cycle perspective on climate issues and how to conduct resilience for projects, especially private sector-driven projects.</p> <p>This fact could stand as a barrier in the awareness-raising process of the resilience concept amongst transport infrastructure stakeholders.</p>
Focus area(s) affected	FA2
Impact	Lack of awareness on the vulnerability level of the transport infrastructure against climate change.
Root causes, including justification and trends	(a) Insufficient knowledge and life cycle perspective on climate issues and how to conduct resilience for projects, especially private sector-driven projects.
Benefit of removal	To foster the adoption of the resilience issue in the design, construction and maintenance of transport infrastructure.

Actions	<p>(A1c) To increase the participation leading initiatives related to cross-border transport infrastructure projects.</p> <p>(A5a) An improvement and continued adaptation of the regulation and standard frameworks to the new transport infrastructure demand to boost innovation and technology in the sector.</p> <p>(A5b) Implementation of European regulation/standards in national level, and enhancing the involvement of all relevant actors.</p> <p>(A5c) Industry initiated and led standardisation process (ahead of regulation).</p> <p>(A5d) Access of users to large research infrastructures enhancing the standardisation process.</p> <p>(A8a) To develop broader diffusion initiatives targeted at MSs, the sector and final users.</p>
Cost-benefit of priority actions	Low-to-high-cost actions with medium-to-high benefits. Complementary, grouped actions are required

Barrier FA2-09	Limited demand of new fuels and lack of innovative business models
Short description	<p>Attending to demand-supply criteria, the deployment of distribution infrastructure for new fuels could not be justified from the economic perspective due to the limited number of vehicles using them. On the other hand, the deployment of vehicles is also hampered by the lack of alternative fuels infrastructure. The development of innovative business models (private public partnerships, etc.) could support the development.</p> <p>Moreover, it is hard for petrol stations to adapt and expand their business to the needs of new fuels due to lack of incentives: there are large investments made on the existing infrastructure and a reluctance to change.</p> <p>There is a debate regarding which is the root of the problem: the lack of demand or the lack of supply. Some experts state that it is more relevant the fact of not having enough supply which is already tackled in EU level with the fueling infrastructure directive.</p> <p>Regarding the lack of demand, there is still some reluctance by consumers to buy alternative fuels based cars, because there is not enough trust in the technology and its future viability. Lack of supply is considered to be more important than lack of demand, however.</p>
Focus area(s) affected	FA2, FA5
Impact	Lower levels of development of infrastructures and technologies related to new fuels and energy efficiency in the transport sector.
Root causes, including justification and trends	<p>(a) The use of new fuels often increases vehicle price, which creates a barrier to consumer purchase.</p> <p>(b) There is a lack of European regulation and standards in the fields of refueling infrastructure, equipment and components.</p> <p>(c) Consumer unfamiliarity with the new technology or requirements for drivers to adjust their behavior, as well as the perceived differences in opinions or predispositions for or against advanced technology vehicles.</p>
Benefit of removal	To foster the deployment and implementation of infrastructures related to new fuels and energy efficiency.
Actions	<p>(A1a) To define a long-term vision and strategy at European Union level for the transport infrastructure and its transformation to address connectivity, resilience, new fuels and energy efficiency.</p> <p>(A5a) An improvement and continued adaptation of the regulation and standard frameworks to the new transport infrastructure demand to boost innovation and technology in the sector.</p>

	<p>(A5b) Implementation of European regulation/standards in national level, and enhancing the involvement of all relevant actors.</p> <p>(A5c) Industry initiated and led standardisation process (ahead of regulation).</p> <p>(A8a) To develop broader diffusion initiatives targeted at Member States, the sector and final users.</p> <p>(A8c) The diffusion of new mobility patterns amongst citizens at regional and local level to increase the demand of connected, efficient and intelligent transport infrastructures in the European Union.</p>
<p>Cost-benefit of priority actions</p>	<p>Low-to-high-cost actions with medium-to-high benefits. Complementary, grouped actions are required</p>

Focus Area 3

Smart mobility services (including provision and use of data, and urban mobility), freight and logistics

General barriers

Barrier FA3-A1	Stakeholders do not collaborate well with each other (example: still very few integrated payment possibilities in MMITS)
Short description	<p>Relevant stakeholders are not collaborating well with another on multiple levels. This includes, for instance, the collaboration of different public authorities that is hampered by inter-departmental conflicts and silo-thinking. Often public policy lacks a more holistic vision and clear incentives to work across various departments. This lack of collaboration and coordination holds also true for the various infrastructure owners, different public transport operators and industry actors.</p> <p>In the field of Smart Mobility Services this means that although new public transport information and booking services manage to cover information on several travel options, they do not yet cover the option of payment. Even if there are examples of information services integrating data from various public transport operators and new mobility services, they often still lack the possibility to actually make payments and buy tickets.</p> <p>The question is how can the lack of cooperation across different modes, departments and backgrounds be improved, such that better working MMITS can be developed? How can a “through-bookability” be ensured such that one ticket actually covers the whole mobility chain for one trip?</p>
Focus area(s) affected	FA3, FA4
Impact	Transport users face inconvenient mobility situation based on single-modality and non-integrated ticketing
Root causes, including justification and trends	<ul style="list-style-type: none"> (a) Lack of communication and trust among public transport (PT) operators and other mobility providers (b) PT operators fearing to lose customers (c) Traditionally, little overlaps and integration between different modes (d) Lack of political vision and intervention (e) Different tariff areas
Benefit of removal	<p>Better coordination among transport providers resulting in the integration of payment options and an improved service for mobility users</p> <p>Goal: one ticket for the whole mobility chain</p>
Actions	<p>(See also Barrier FA3-C1)</p> <ul style="list-style-type: none"> (A1) Foster the use of neutral trust parties/ neutral brokers (A5) Support cooperation and integration between established PT operators and new shared mobility services (A9) Develop ITS training/ support capacity building for public mobility stakeholders

	(A11) Push PT operators to develop integrated Smart Ticketing offers (A12) Test and demonstrate more cross-border integration of data in MMITS
Cost-benefit of priority actions	Barrier that requires complementary actions to be taken with differing degrees of costs and benefits associated.

Barrier FA3-A2	Insufficient availability of data (lack of open data)
Short description	<p>A big challenge is to make transport data publicly available including geographical coverage, real-time information, transport modes etc. as well as to ensure high quality and validity of data. Currently however, many travel and traffic data needed for comprehensive European Union-wide smart mobility services are not readily available.</p> <p>Many actors in the travel information value chain have made efforts to digitize their travel information (i.e. timetables, location of stations/stops etc.) but there are still many actors who have yet to do so. Often there are significant costs involved in gathering and/or converting travel and traffic information into a digital format for journey planning and information service purposes. Supposed obligations to open data sharing (in order to enable smart services) could interfere with requirements of data protection and control, considering the varying perspectives on the relative importance of an individual's privacy against other public interests. Furthermore, usually internal systems are not designed for publishing data and there is a need for support, implementation guidelines, frameworks and standards.</p> <p>Currently, the European Commission lays too little focus on the data evaluation. The European Commission should require all SMS-related projects to make their data open and publicly available. It was often criticised at the consultation days that the ITS Directive does not make open data mandatory.</p> <p>How can public authorities and mobility companies be encouraged to make their data publicly available in order to foster new and innovative mobility services?</p>
Focus area(s) affected	FA3, FA4
Impact	<p>Prevents fully-integrated MMITS that are part and parcel of the MaaS concept</p> <p>Data is not made available to other service providers and transport users</p> <p>Prevents inter- and synchromodality in freight</p>
Root causes, including justification and trends	<p>(a) Costs associated with polishing data, converting data into right format, making data publicly accessible</p> <p>(b) Little knowledge only about the benefits of making data publicly accessible</p> <p>(c) Lack of incentives to make data publicly accessible</p> <p>(d) Existing data protection laws</p>
Benefit of removal	More services, more transparency
Actions	<p>(See also Barrier FA3-A5, B2)</p> <p>(A3) Require all European Union-funded projects to make data publicly available</p> <p>(A4) Increase conditionality of funding</p>

	(A7) Set up of national transport data hubs and access points guaranteeing better maintenance and quality checks on data
Cost-benefit of priority actions	Actions have medium costs and medium benefits associated.

Barrier FA3-A3	Over-emphasis on hardware and infrastructure and undermining of the benefits brought by integration of (real-time) data in spatial/ urban planning
Short description	<p>Spatial/ urban planning in the European Union is often based on data that is already quite outdated. In order to move towards a more dynamic planning culture, more real-time data needs to be incorporated into our planning.</p> <p>To give an example, there are still many cities in EU Member States that rely on paper tickets in Public Transport (PT). Thus, there is little possibility to analyse the number of PT users, the hours when PT is mostly used, the stations with the highest number of users, etc. Also, the promises of Big Data and more flexible tariffs cannot be fully exploited.</p> <p>This also has to do with the prioritization of efforts and money. Data and data collection is seen as a ‘nice-to-have’ and not as essential for the daily operation. Also, the focus in transport is often on heavy infrastructure, not so much on soft measures. Thus, the question is how can the awareness on data-related questions be raised and data-based analyses more incorporated into planning?</p>
Focus area(s) affected	FA3, FA4
Impact	Little data availability and focus on data-related questions diminishes chances of developing on-demand solutions and increasing the efficiency of transport
Root causes, including justification and trends	<p>(a) Public authorities: focus often on infrastructure</p> <p>(b) Soft measures don’t spark interest (e.g. politicians, high-level ministers, the public)</p> <p>(c) Few training resources for public authorities in data collection</p>
Benefit of removal	Improve data collection and development of new services/ innovation resulting from these
Actions	<p>(A4) Increase conditionality of funding</p> <p>(A9) Develop ITS trainings/ support capacity building for public mobility stakeholders</p> <p>(A10) Better exploit the potentials of data and data mining</p>
Cost-benefit of priority actions	Low-cost actions with medium/high benefits

Barrier FA3-A4	Fragmented responsibility and/ or lack of coordination with respect to transport-related data management and digital services
Short description	<p>Even though each Member State has a national ITS office, there is little coordination with respect to smart mobility services and data-related aspects. Some Member States have established points of access in which the available and</p>

	<p>accessible travel data is stored. However, the existence of points of access across the European Union is fragmented. In many Member States there are several ministries in charge of different aspects of Smart Mobility Services. This is due to the fact that SMS cover a wide range of transport modes as well as both passenger and freight services. Often the ministries themselves do not even have a department that is mainly responsible for the application of SMS, data, digital services or similar objectives.</p> <p>In order to allow for European Union-wide multi-modal journeys (both passenger as well as freight-related), it is essential for service providers to know where the required available and accessible travel data are stored across Europe, and how they can be re-used.</p> <p>How can more coordination be achieved and data-related questions more effectively tasked? How can the public authorities be incentivised to assume responsibility to guarantee high-quality data provision? How can the ITS offices also assume a role as neutral broker of data sets from different data providers, e.g. in the world of logistics?</p>
Focus area(s) affected	FA3, FA4
Impact	<p>Little coordination</p> <p>No aggregation and easy provision of data</p>
Root causes, including justification and trends	<p>(a) Institutional set-up</p> <p>(b) Different modes of transport</p> <p>(c) SMS cover both passenger as well as freight transport</p>
Benefit of removal	Better access to transport-related data (irrespective of mode and purpose)
Actions	<p>(See also Barrier FA3-C2)</p> <p>(A1) Foster the use of neutral trust parties/ neutral brokers</p> <p>(A4) Increase conditionality of funding</p> <p>(A7) Set up of national transport data hubs and access points guaranteeing better maintenance and quality checks on data</p> <p>(A12) Test and demonstrate more cross-border integration of data in MMITS</p>
Cost-benefit of priority actions	Barrier that requires complementary actions to be taken with differing degrees of costs and benefits associated.

Barrier FA3-A5	Systems, services and data lack interoperability (lack of standards)
Short description	<p>The lack of interoperable data formats, protocols and interfaces requires the development or definition of data formats and standards that ensure flexibility and the promotion of interoperability. Coordinated European efforts, cross-border cooperation and agreements are needed to solve organisational and administrative challenges and make data sets compatible with each other and possible to merge. There are standards available but these are not coherently used across the European Union. Establishing better interfaces between transport modes would not only improve the organisation of transport and mobility solutions, but help to create robust business models for supplying information and</p>

	<p>services.</p> <p>As for the world of logistics, the Digital Transport and Logistics Forum (DTLF) has been initiated by the EC in 2015 which calls for more coordination of existing tools and standards in order to allow for the seamless flow of data across modes, sectors and countries. However, the DTLF does yet have to prove whether it can produce positive outcomes.</p> <p>How can more cooperation between different modes and operators be ensured so that intermodal transport is less complex and administrative burdens are diminished?</p>
Focus area(s) affected	FA3, FA4
Impact	Cross-border cooperation and integration of different data and data systems is difficult
Root causes, including justification and trends	(a) Traditionally, no incentives for open standards and formats
Benefit of removal	Better integration
Actions	<p>(See also Barrier FA3-A2, B2)</p> <p>(A1) Foster the use of neutral trust parties/ neutral brokers</p> <p>(A6) Establishment of national transport data hubs and access points</p> <p>(A7) Set up of national transport data hubs and access points guaranteeing better maintenance and quality checks on data</p> <p>(A9) Develop ITS trainings/ support capacity building for public mobility stakeholders</p>
Cost-benefit of priority actions	Actions are medium-cost with medium/high benefits

Mobility-as-a-Service barriers

Barrier FA3-B1	New mobility services, such as car-, ride or bike-sharing, are yet very little integrated in MMITS
Short description	<p>Car- and bike-sharing, ride-sharing, car-pooling, and parking lot-sharing are new services that become increasingly popular and successful in urban areas in the EU. MMITS need to include the information provided by these new sharing services in order to give users a complete set of mobility options. In order to allow for more integrated MMITS, urban data sets need to be standardised. To facilitate interoperability of software from one country to another, more effort should be dedicated towards the standardisation and architecture for multi-modal datasets. Also, MMITS will probably have a greater effect when additional data is made available. Information about the return journey, comfort, environmental aspects and cost comparisons of various options are able to contribute to the popularity of multi-modal travel information.</p> <p>How can new services, especially newer ones associated with the Sharing Economy, be better integrated into MMITS? How can municipalities and public</p>

	transport operators more strategically include sharing services into their PT offer?
Focus area(s) affected	FA3, FA4
Impact	Little integration of modes and services Registration for each platform always anew
Root causes, including justification and trends	(a) Often services have only very recently been launched and are not yet that well-established as big players with lobbying possibilities, e.g. Deliveroo, ampido, BlablaCar, etc. (b) Mistrust between different operators
Benefit of removal	Better integration of various modes and services
Actions	(A5) Support cooperation and integration between established PT operators and new shared mobility services (A9) Develop ITS trainings/ support capacity building for public mobility stakeholders (A10) Better exploit the potentials of data and data mining (A11) Push PT operators to develop integrated Smart Ticketing offers (A12) Test and demonstrate more cross-border integration of data in MMITS (A13) Promote the adoption of Smart Mobility Services through awareness raising campaigns
Cost-benefit of priority actions	Actions are low-cost with medium/ high benefits

Barrier FA3-B2	The quality of data is insufficient making Multi-modal Information Systems very inconvenient
Short description	The quality level of transport-related data in terms of how up-to-date, accurate, accessible, reliable and timely the information is given to the traveller is inconsistent across Europe. It is essential that basic levels of service quality are consistent across the European Union to ensure traveller satisfaction and their continued use of MaaS-related services. Although in some Member States there are certain regulations on how often data should be updated and how to ensure accuracy and reliability etc., this practice is not widespread across the European Union, resulting in fragmented service quality. How can a more coherent approach towards data quality be ensured across the European Union?
Focus area(s) affected	FA3
Impact	Inconsistency of service quality and data across the European Union
Root causes, including justification and trends	(a) Little training resources for public authorities in data collection and provision (b) No incentives to make data publicly available (c) Mistrust among different service providers
Benefit of removal	More and better data would result in better services and innovation in the mobility market Services would also be more reliable to users
Actions	(See also Barrier FA3-A2, A5) (A4) Increase conditionality of funding (A7) Set up of national transport data hubs and access points guaranteeing better maintenance and quality checks on data

Cost-benefit of priority actions	Barrier that requires complementary actions to be taken with differing degrees of costs and benefits associated.
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Barrier FA3-B3	Gaps in existing legislation and funding schemes for on-demand mobility services require new legislation and funding schemes
Short description	New mobility solutions that involve on-demand services differ very much from the traditional concept of public transport. Can public transport services without fixed routes, stops, etc. still be called public transport? Often liability systems, public transport laws and regulations prevent the funding of shared services. One example is the question whether it should be legal for a public transport provider to pay for two people using the taxi when this is cheaper than operating a whole bus? Another example is the introduction of car-sharing which in many countries was held back because of existing parking regulations. How can regulations and laws be adjusted such that on-demand and sharing services can more easily be introduced?
Focus area(s) affected	FA3
Impact	Difficulties for establishment of sharing and on-demand services due to outdated understanding of public transport
Root causes, including justification and trends	(a) Customer protection regulations (b) Liability issues
Benefit of removal	More efficient use of capacities such as vehicles or staff
Actions	(A6) Study and promote the use of sharing services (A9) Develop ITS training courses for public mobility stakeholders
Cost-benefit of priority actions	Actions are medium-cost and have medium benefits

Smart City Logistics, Synchromodality and e-Freight barriers

Barrier FA3-C1	Logistics sharing: the bundling of freight does not materialise due to a lack of cooperation and trust among the logistics stakeholders
Short description	Improving interaction between logistics stakeholders to enhance the potential for horizontal cooperation and fostering synergies is seen as crucial. This would result in an increase of load factors, a reduction of empty movements and a stimulation of co-modality which would ultimately make delivery more efficient. One solution to improve efficiency is, for instance, the establishment of regional logistics platforms that would be run cooperatively by industry actors. Another solution would be local consolidation centres from which a 3 rd party would deliver goods from all logistic companies to avoid all delivery vehicles coming into the city. Currently, however, it is difficult to develop new services and create synergies due to the reluctance of big logistics players to share their data. Also, the lack of knowledge about load factors and complementary incentives to increase these

	<p>prevents the combination of logistic flows. Companies, such as parcel deliveries, are reluctant to share vehicles due to branding problems.</p> <p>How can logistics companies be encouraged to better cooperate and bundle freight flows and also allow new logistics service providers to establish themselves on the market?</p>
Focus area(s) affected	FA3
Impact	Reduced efficiency of delivery, empty movements, single-modality
Root causes, including justification and trends	<p>(a) No incentive for big players to share their data: public authorities do not assume responsibility over this problem</p> <p>(b) Liability issues</p> <p>(c) Branding issues</p>
Benefit of removal	Innovative services and more efficiency in freight deliveries
Actions	<p>(See also Barrier FA3-A1)</p> <p>(A1) Foster the use of neutral trust parties/ neutral brokers</p> <p>(A2) Incentivise cooperation and integration along the freight chain</p> <p>(A6) Study and promote the use of sharing services</p> <p>(A8) Harmonise and apply environmental KPIs for logistics to monitor freight performance in cities</p>
Cost-benefit of priority actions	Actions are low-cost and have medium benefits

Barrier FA3-C2	Little work towards a freight system based on synchronomodality, including a lack of use of ICT and data governance
Short description	<p>Synchronomodality is the flexible and sustainable deployment of different modes of transport in a network under the direction of a logistics service provider, so that the customer is offered an integrated solution for the transport of goods. The decision on the mode(s) of transport to be used is left to the logistics service provider who has the flexibility to seamlessly switch between modalities. This applies to both the planning of transport and dealing with unexpected circumstances just before or during the transport. Synchronomodality would also allow for the consolidation of consignments of cargo, thus achieving additional efficiency benefits.</p> <p>A prerequisite for synchronomodality is, however, the integration of information technologies that can show capacities and free resources, predict waiting and handling times and manage slots and workflows. Many hubs are not yet well developed in terms of ICT and communication between logistics operators is limited, despite the fact that the amount of data that passes through hubs is large. How can a common platform be designed to coordinate synchronomodal transport chains? How can information be better synchronized and made available to other operators such that shipments can be bundled and switched more flexibly?</p>
Focus area(s) affected	FA3
Impact	The decision on the mode(s) of transport to be used is not left to a logistics service provider (expert with better overview) and freight is most often transported

	single-modally
Root causes, including justification and trends	(a) Bookings are usually not made a-modally (b) Bookings are usually not split up in different modes (c) Not always flexible switching between modalities possible
Benefit of removal	Making optimal use of all modes of transport and available capacity
Actions	(See also Barrier FA3-A4) (A2) Incentivise cooperation and integration along the freight chain (A7) Set up of national transport data hubs and access points guaranteeing better maintenance and quality checks on data
Cost-benefit of priority actions	Barrier that requires complementary actions to be taken with differing degrees of costs and benefits associated.

Barrier FA3-C3	Insufficient systematic urban freight data collection and management and lack of internalisation of environmental impacts of logistics operations (eco-performance)
Short description	<p>It is considered very important to improve the eco-performance of logistics operations in terms of energy use and emissions and incorporate these values into traditional KPIs, such as costs, service performance and effectiveness.</p> <p>In recent years a wide range of calculation methodologies, tools and emission factor databases have been developed without much coordination. This results in a situation in Europe in which it is difficult to compare the true environmental performance of different logistics operations with little compatibility between methodologies and databases (e.g. geography, sector, companies, etc.).</p> <p>Also, there are few adequate quantified statistics about transport flows in cities regarding light and heavy freight vehicles. Thus, little information is available about loading type, route, vehicles and fuels, or load factors, and, if so, only on a highly-aggregated level.</p> <p>A more focused data collection and management would contribute significantly to a sounder analysis of urban freight transport. This could prove helpful in calculating business-as-usual scenarios and measures to be taken to improve efficiencies of logistics transport.</p> <p>How can Environmental Performance Indicators (EPIs) in the logistics sector be agreed upon and how can Smart Mobility Services help achieving this such that environmental impacts can be taken into account into logistics operation planning and optimisation? How to achieve better data measurement?</p>
Focus area(s) affected	FA3, FA4
Impact	<p>Environmental impacts not taken into account in logistics operation, choice of mode or route planning</p> <p>Little awareness and knowledge in the measurement of eco-performance at city level</p>
Root causes, including justification and trends	(a) Lack of incentives for companies to measure eco-performance (b) Eco-performance not sufficiently covered in public procurement (c) Green logistics and freight only recently on the radar of the EU

Benefit of removal	More incentives for the logistics sector to operate more energy- efficiently, cooperate with each other and make intermodal shipments
Actions	(A8) Harmonise and apply environmental KPIs for logistics to monitor freight performance in cities (A9) Develop ITS trainings/ support capacity building for public mobility stakeholders
Cost-benefit of priority actions	Actions are low-cost and have medium benefits

Focus Area 4

Standardisation and interoperability

Barrier FA4-01	Poor collaboration between stakeholders
Short description	There is poor collaboration of the supply chain stakeholders on different fronts. Logistics service providers collaborating in supply chains afraid of losing competitive advantage due to possible leak of sensitive information to competitors. Infrastructure operators still did not created business and organisational models with their clients what results in weak competitiveness towards road freight transport. Public authorities do not have much impact on business sector as well as R&D sector does not have much success in implementing results on the market.
Focus area(s) affected	FA1, FA2, FA3
Impact	Poor collaboration among stakeholders result in non effective organisation of commodity and information flow along supply chains.
Root causes, including justification and trends	<p>a) Business partners cooperating in supply chains concern of loosing competitive advantage in case of leak of sensitive data due to the fact communication systems are not safe.</p> <p>b) Intermodal operators are still not competitive towards truck hauliers due to lack of critical mass of loads as well as lack of effective business models.</p> <p>c) Public sector does not have criterions to support logistics industry</p> <p>d) Logistics industry have limited interest in collaboration with R&D sector due to lack of success in effective implementation of its results on the market</p>
Benefit of removal	Improvement of collaboration of all direct and in indirect participants of supply chains may
Actions	<p>See also FA04-2,FA04-3,FA04-4,FA04-5</p> <p>(A1) Proposal of use of existing standards to operate supply chains in the EU</p> <p>(A2) Development of ICT solutions for converting different standards to basic ones</p> <p>(A3) Develop data models to be implemented along supply chains including SMEs</p> <p>(A4) Develop and test secure networks for data exchange</p> <p>(A5) Develop open service-oriented ICT for hubs as decision making place</p> <p>(A6) Test and implement Physical Internet concept of sharing and using data along SC</p>
Cost-benefit of priority actions	The transport industry struggling with the problem of serious mismanagement expects the ICT sector to provide it with support in achieving a much higher operating efficiency. ICT solutions, however, are very expensive and the achievement of positive effects depends on the participation of large number of users. The first stages of implementation usually do not show a rapid return on investment. After attaining critical mass, however, much faster rise in profitability of transport sector can be expected.

Barrier FA4-02	Trust on sharing information services and systems
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Short description	Efficient logistics is an increasingly important element of competitive advantage these days so competition between transport chains becomes more important than competition between single companies. In such environment, sharing information across supply chains is essential for their success in the market. On the other hand there is basic doubt among stakeholders that sensitive data placed in the supply chain communication system are not safe and maybe accessible for the others.
Focus area(s) affected	FA1, FA2, FA3
Impact	Disbelief in data security within supply chains significantly disturbs creating efficient flow of information and hinders development of trade. It also prevents transport companies from using pooling solutions to increase efficiency of their consolidated distribution activities.
Root causes, including justification and trends	(a) Collaboration of companies being competitors is never easy. Trust in other partners is the basic condition but also the most difficult to fill. (b) ICT systems are very complex and often failing being not fully reliable. (c) Successful activities of hackers publicised by the media contributes to the lack of confidence in ICT programs
Benefit of removal	The creation of secure ICT tools will result in rapid development of solutions for managing logistics processes that require the cooperation of many participants
Actions	See also FA04-01, FA04-03, FA04-04, FA04-05 (A1) Proposal of use of existing standards to operate supply chains in the EU (A2) Development of ICT solutions for converting different standards to basic ones (A3) Develop data models to be implemented along supply chains including SMEs (A4) Develop and test secure networks for data exchange (A5) Develop open service-oriented ICT for hubs as decision making place (A6) Test and implement Physical Internet concept of sharing and using data along SC
Cost-benefit of priority actions	The transport industry struggling with the problem of serious mismanagement expects the ICT sector to provide it with support in achieving a much higher operating efficiency. ICT solutions, however, are very expensive and the achievement of positive effects depends on the participation of large number of users. The first stages of implementation usually do not show a rapid return on investment. After attaining critical mass, however, much faster rise in profitability of transport sector can be expected.

Barrier FA4-03	Lack of industry well recognised business and operational models in horizontal collaboration
Short description	The supply chains are managed by the leading manufacturing and trading companies imposing business and operational models and communication standards on the collaborating logistics services providers. There are variety of different models tailored to the leading company needs. Companies participating in many supply chains are confronted with many operational and business models.
Focus area(s) affected	FA1, FA2, FA3

Impact	Logistics service providers participating in many supply chains have to build interfaces to different in-house ICT systems of companies managing these chains.
Root causes, including justification and trends	(a) Each mode is focused on solving own problems (b) Intermodal transport is dependent on railway punctuality (c) Intermodal transport needs heavy investments in terminals (d) Reaching critical mass of loads by intermodal operators is long term process. Risk of failure is very high.
Benefit of removal	Intermodal transport may be attractive alternative for clients and for the regions (environment)
Actions	See also FA04-01, FA04-02, FA04-04, FA04=05, FA04-09 (A1) Proposal of use of existing standards to operate supply chains in the EU (A2) Development of ICT solutions for converting different standards to basic ones (A3) Develop data models to be implemented along supply chains including SMEs (A4) Develop and test secure networks for data exchange (A5) Develop open service-oriented ICT for hubs as decision making place (A6) Develop new technologies and organisational solutions and implement them in the transport system (A14) Governance for network operations with shared assets and information (A15) Business models development with full transport assets utilisation (A16) Business models development with full transport assets utilisation
Cost-benefit of priority actions	The transport industry struggling with the problem of serious mismanagement expects the ICT sector to provide it with support in achieving a much higher operating efficiency. ICT solutions, however, are very expensive and the achievement of positive effects depends on the participation of large number of users. The first stages of implementation usually do not show a rapid return on investment. After attaining critical mass, however, much faster rise in profitability of transport sector can be expected.

Barrier FA4-04	Lack of flexible ICT
Short description	ICT solutions for logistics are complex , customised and expensive, this is why ICT support for transport operations when participation of a few collaborating participants is required is very poor. The attempts to implement cloud-based ICT platforms are not successful.
Focus area(s) affected	FA1, FA2, FA3
Impact	Management of transport networks is insufficiently supported by ICT technologies what means that logistics market is not efficient to high degree.

Root causes, including justification and trends	<p>(a) Fragmented market of ICT tools for logistics</p> <p>(b) High expense of implementing ICT solutions</p> <p>(c) In-house solutions used by big companies. No will to change them into universal ones due to high costs already spent and due to competition reasons</p> <p>(d) Diverse standards used by supply chain stakeholders disturbing to create clear communication systems</p> <p>(e) Failure of implementing electronic platform due to complexity, lack of standards and high investment expense.</p>
Benefit of removal	Implementing open electronic platforms will improve management of transport networks as well as ports (Port Community Systems)
Actions	<p>See also FA04-01,FA04-02, FA04-03, FA04-05, FA04-08</p> <p>(A1) Proposal of use of existing standards to operate supply chains in the EU</p> <p>(A2) Development of ICT solutions for converting different standards to basic ones</p> <p>(A3) Develop data models to be implemented along supply chains including SMEs</p> <p>(A4) Develop and test secure networks for data exchange</p> <p>(A5) Develop open service-oriented ICT for hubs as decision making place</p> <p>(A6) Test and implement Physical Internet concept of sharing and using data along the supply chain</p> <p>(A9) Enable solutions to be widely used</p> <p>(A10) Evaluation of potential integration of manufacturing and transport merge</p>
Cost-benefit of priority actions	The transport industry struggling with the problem of serious mismanagement expects the ICT sector to provide it with support in achieving a much higher operating efficiency. ICT solutions, however, are very expensive and the achievement of positive effects depends on the participation of large number of users. The first stages of implementation usually do not show a rapid return on investment. After attaining critical mass, however, much faster rise in profitability of transport sector can be expected.

Barrier FA4-05	Collaboration between modes
Short description	The share of intermodal sector in total freight transportation develops slowly due to severe competition from road transport. On the one hand intermodality needs huge investments in terminals and from the other hand it depends on railway which seems to be less adjusted to competition. There is also lack of interoperability and interconnectivity.
Focus area(s) affected	FA1, FA2, FA3
Impact	Lack of interoperability between different modes and will to closely collaborate brings domination of road transport sector which offers quick and flexible transport services at moderate cost.

Root causes, including justification and trends	<p>a)The carriers do not tend to cooperate with other modes due to hard competition on the freight market.</p> <p>b) Intermodality needs huge investments in hubs where transshipment from one mode into another is effected. Coverage of these expenses needs significant loads to be carried. This in turn require ability to compete</p> <p>c) Intermodal operators still did not created effective business and operational with railway. Delays caused by railways badly affects reputation and reliability of intermodal operators.</p> <p>d) Intermodality suffers also from lack of interoperability of national railway systems what badly affects international traffic.</p>
Benefit of removal	A balance in the use of various modes of transport leads to environmental protection and transport infrastructure utilisation
Actions	<p>See also FA04-01,FA04-02,FA04-03,FA04-04</p> <p>(A1) Proposal of use of existing standards to operate supply chains in the EU</p> <p>(A2) Development of ICT solutions for converting different standards to basic ones</p> <p>(A3) Develop data models to be implemented along supply chains including SMEs</p> <p>(A4) Develop and test secure networks for data exchange</p> <p>(A5) Develop open service-oriented ICT for hubs as decision making place</p> <p>(A6) Test and implement Physical Internet concept of sharing and using data along SC</p>
Cost-benefit of priority actions	The transport industry struggling with the problem of serious mismanagement expects the ICT sector to provide it with support in achieving a much higher operating efficiency. ICT solutions, however, are very expensive and the achievement of positive effects depends on the participation of large number of users. The first stages of implementation usually do not show a rapid return on investment. After attaining critical mass, however, much faster rise in profitability of transport sector can be expected.

Barrier FA4-06	Modular units facilitating inland and air transport
Short description	Containerisation of goods has been a game changer in commercial trade facilitating bundling cargo in maritime routes and allowing outstanding performance and efficiency. However, this is still not transferred into the inland transport, making use of smaller sub-containers and boxes more adequate to some flows and combination of flows. This is preventing both easy bundling of cargo and reduction of trans-shipment costs hence preventing the reaching of appropriate conditions to fully deploy synchromodal transport. Such modular units have to be compatible with already existing assets used in maritime transport.
Focus area(s) affected	FA1
Impact	<p>Lack of compatibility of loading units (incomplete utilisation of the loading space)</p> <p>Increased costs in intermodal supply chains (e.g. trans-shipment costs)</p>

Root causes, including justification and trends	(a) small share of inland waterway and air transport on the overall transport market (b) the dominant role of sea containers on the overall long distance transport market
Benefit of removal	Reduction of trans-shipment costs and transport transit time
Actions	See also FA04-07 (A11) Deploy available technologies (drones, augmented reality) (A12) Continue developing supporting technologies (modular units) (A13) Continue work on IoT and PI models
Cost-benefit of priority actions	Low- to high-cost actions with medium to high benefits. Modern technologies and close collaboration between stakeholders are required (research and operational level)

Barrier FA4-07	Interoperable solutions for transshipment
Short description	The transport world is developing towards open logistics service systems which are physical, digitalised and operationally interconnected. Interoperable transshipment techniques in transport operations are crucial to make intermodal transport (combination of all transport modes) more effective, more competitive to single road transport providing added benefits of economic growth and environmental protection. Interoperable transshipment have to enable fast and low cost handling of freight in loading and unloading operations: vehicle to vehicle, vehicle to warehouse, warehouse to vehicle for long distance and urban transport and respecting the need of efficient operation in networks.
Focus area(s) affected	FA1
Impact	Low share of inter-modal transport Low utilisation of handling resources in transshipment point (sea ports, container terminals, logistics centres)
Root causes, including justification and trends	Variation in loading units standards
Benefit of removal	Flexible transport network service on low-cost and efficient basis with a wider choice of technologies available Transshipment technologies that are able to cope with various standards of freight containers and swap bodies and other transport units Coherence and interoperability
Actions	See also FA04-06 (A11) Deploy available technologies (drones, augmented reality) (A12) Continue developing supporting technologies (modular units) (A13) Continue work on IoT and PI models

Cost-benefit of priority actions	Low- to high-cost actions with medium to high benefits. Modern technologies and close collaboration between stakeholders are required (research and operational level)
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Barrier FA4-08	Standards that hinder optimisation in transport
Short description	Different standards, regulation and procedures in Member States prevent the seamless cross border transport operations as well as the synchromodal transport when the transport chains involve several countries.
Focus area(s) affected	FA1
Impact	Lack of full transport infrastructure utilisation Lack of full transport assets utilisation
Root causes, including justification and trends	In rail transport, at least, SMEs have a hard time introducing innovation due to dominance of big players Variation in legislative regulations and procedures based on the local level interest - national interests prevail (e.g. working time of locomotives drivers, truck drivers pay rates, length of cargo trains)
Benefit of removal	Infrastructural legislation, organisational synchronisation leading to full interoperability and transport optimisation
Actions	See also FA04-03 , FA04-04 (A7) Set KPIs for assessing transport impact on energy, environment and economy (A8) Develop simulation tools that will assess impact of trends, policies, technologies (A9) Enable solutions to be widely used (A10) Evaluation of potential integration of manufacturing and transport merge. (A14) Develop new technologies and organisational solutions and implement them in the transport system (A15) Governance for network operations with shared assets and information. (A16) Business models development with full transport assets utilisation
Cost-benefit of priority actions	The cost of implementing standards are very high but so are the benefits. This is necessary to achieve an effective solution affecting transport interoperability.

Barrier FA4-09	Market dynamics
Short description	Logistics has traditionally been a sector with low innovation investments, due to smaller margins and high fragmentation that make it difficult to implement new technologies and processes, discourage collaboration because collaborations are currently negotiated at huge cost, prevents data sharing because stakeholders are concerned about competition/ disintermediation/commodification of services and discourage investments. Investors cannot be sure they will capture the benefit of investment (i.e. no one is prepared to invest in common infrastructure) and because some investments only improve one link in a chain which does nothing if the next link is still a bottleneck. Investments should be a national or even supranational business.

Focus area(s) affected	FA1
Impact	Lack of full transport infrastructure utilisation (rising costs) Lack of full transport assets utilisation (congestion) CO ₂ emission
Root causes, including justification and trends	(a) Rapid progress in the field of ICT solutions (b) Constantly increasing customers requirements (e.g. transit time and cost reduction) (c) Market competition
Benefit of removal	
Actions	See also FA04-03 (A14) Develop new technologies and organisational solutions and implement them in the transport system (A15) Governance for network operations with shared assets and information. (A16) Business models development with full transport assets utilisation
Cost-benefit of priority actions	Mostly medium cost actions with high benefits. The process of implementation of the resources sharing concept will be moderately costly. Cooperation models are required.

Focus Area 5

Alternative fuels other than electrification

Barrier FA5-01 (incl. FA5-03)	Supply weaknesses and innovation chain discontinuities
Short description	Lacking supply of infrastructure (for refuelling and recharging) and alternative fuels (production and market availability) means that many alternative fuels are not available on the market and the end-user in practice has no alternatives to choose from. Supply of vehicles and other means of transport capable of using alternative fuels is also lacking, i.e. market for these technologies is immature. There are gaps along the innovation chain, e.g. between demonstrations and real market. Investments in R&D or implementation are not adequate and do not stretch all the way to market introduction and uptake.
Focus area(s) affected	FA5, FA2
Impact	Alternative fuels and vehicles are not available on the market for end-users Slow progress towards commercialisation
Root causes, including justification and trends	(a) Production of alternative fuels is a risky business case (immature technologies, costly processes, unsure profit) (b) Chicken and egg problem of supply and demand for alternative fuels and related vehicles and infrastructure - neither is strongly incentivising the other (c) Competition between various alternative fuels and technologies hampers progress (d) Current limitation in production volumes of alternative fuels because of limited feedstock access or lacking production facilities or capable personnel. (e) Incentives for RDI and opening production of sustainable second generation alternative fuels are missing. (f) Lacking support framework for financing, funding and investments and lack of predictability in the markets discourages investments. (Uncertainty in oil price development also affects investments.)
Benefit of removal	Opening up of the market on supply side (availability of alternative fuels for end-users) Progress from R&D towards market ready products intensified and accelerated
Actions	(A1) Long-term, aligned policies (A2) Incentive and disincentive schemes (A3) Regulation and standards (A4) Research, development and innovation (incl. funding and piloting) (A6) Infrastructure (A7) Public-private collaboration
Cost-benefit of priority actions	Low-to-high-cost actions with low-to-high benefits. Complementary, grouped actions are required.

Barrier FA5-02

Low demand and user acceptance

(incl. FA5-06)	
Short description	Demand for alternative fuels and vehicles capable of using alternative fuels is weak among end-users. Concerns over purchasing price, technological aspects and refuelling infrastructure of the new fuels compared to conventional powertrains, safety, sustainability, long-term availability etc. of alternative fuels hinder uptake of alternative fuels as well as vehicles and other means of transport capable of using them.
Focus area(s) affected	FA5
Impact	End-users do not adopt alternative fuels because of various concerns and hence market demand is not articulated to industry. This creates uncertainty on future market opportunities and discourages business and technology development and investments.
Root causes, including justification and trends	(a) Alternative fuels are typically costlier than conventional fuels (b) Chicken and egg problem of supply and demand for alternative fuels and related vehicles and infrastructure - neither is strongly incentivising the other (c) Lack of information (consumers, end-users) on technical performance, suitability and safety of alternative fuels. (d) Uncertainty about the real impacts, e.g. environmental.
Benefit of removal	Better knowledge-base to enable informed decisions on alternative fuels and consequent preparedness on demand side to adopt alternative fuels (resulting potentially on increased demand)
Actions	[See also barrier FA5-05] (A2) Incentive and disincentive schemes (A3) Regulation and standards (A5) Public procurement (A9) Active cities and municipalities (A10) Information and awareness raising
Cost-benefit of priority actions	Low-to-medium-cost actions with low-to-high benefits. Complementary, grouped actions are required.

Barrier FA5-04 (incl. FA5-09)	
Weak, short-term policy support	
Short description	Stated policy goals (on European level) are not implemented as real long-term policy measures and actions, especially on national and local levels. Policies often fail to cover all modes and use cases, and political prioritisation of one alternative fuel is often done at expense of the other alternative fuels (e.g. promoting electromobility, while paying lesser attention to modes not capable of electrification). Short-term commitment and uncertainty hamper progress; this applies to investments in R&D, commercialisation and commercial production, user acceptance, etc.
Focus area(s) affected	FA5
Impact	Policy support is not translated into real actions or focusses on one solution only.

	Lack of long-term policies means that risks and uncertainty are heightened and support measures may prove inefficient.
Root causes, including justification and trends	<p>(a) Other transport issues than climate and air quality are prioritised and alternative fuels policies get less attention and fail to be implemented in practice</p> <p>(b) Other policies affect and hamper alternative fuels policies, e.g. conflict with industrial policies</p> <p>(c) Challenge of balancing different objectives in order to be technology-neutral, e.g. conflicts between alternative fuels and domestic industry objectives.</p> <p>(d) Policies and actions are too short sighted to serve long-term industrial R&D&I, commercialisation and market uptake. Support schemes and policies are typically linked to short political cycles and</p> <p>(e) Short-sighted decision-making and policy planning focuses on the present or near future, and there's a lack of long-term policies and policy-packages that would provide predictability and also include exit strategies</p>
Benefit of removal	<p>Policies as support framework to facilitate market entry and uptake of alternative fuels.</p> <p>More predictable playing field with short-, medium- and long-term agendas incorporated would encourage industries and investors towards alternative fuels.</p>
Actions	<p>(A1) Long-term, aligned policies</p> <p>(A6) Infrastructure</p>
Cost-benefit of priority actions	<p>High-cost actions with high benefits.</p> <p>Important to ambitiously commit to long-term consistency.</p>

Barrier FA5-05	High cost of alternative fuels
Short description	High costs of alternative fuels or vehicles capable of using them, especially because of high production costs. Alternative fuels are therefore more costly than conventional fuels on the market.
Focus area(s) affected	FA5
Impact	Price of alternative fuels is typically not competitive against conventional fuels
Root causes, including justification and trends	<p>(a) High production costs of alternative fuels because of complex or immature technologies, etc.</p> <p>(b) Low price of conventional fuels</p> <p>(c) Small production volumes distribution connect to limited availability</p>
Benefit of removal	Price-competitiveness of alternative fuels
Actions	<p>(A2) Incentive and disincentive schemes</p> <p>(A4) Research, development and innovation (incl. funding and piloting)</p>
Cost-benefit of priority actions	<p>Medium-cost actions with medium-to-high benefits.</p> <p>Actions need to address appropriate stages of innovation.</p>

Barrier FA5-07	Dominance of the existing system
Short description	Lock-in situation in supply and demand practices with conventional fuels. Business-as-usual comfort and change resistance hinder progress with alternatives.
Focus area(s) affected	FA5

Impact	Conventional fuels remain dominant ('above competition')
Root causes, including justification and trends	(a) Sufficient performance and availability of the conventional fuels on acceptable price (no acute change needs perceived) (b) Existing support systems for conventional fuels (e.g. support for production) (c) Established processes, actors, use cases, infrastructure, etc.
Benefit of removal	Fair playing field for alternative and conventional fuels, allowing entrants to the existing markets
Actions	(A2) Incentive and disincentive schemes (A5) Public procurement (A10) Information and awareness raising
Cost-benefit of priority actions	Low-to-medium-cost actions with low-to-high benefits. Complementary, grouped actions are required.

Barrier FA5-08	Fragmented market across Europe
Short description	The fuel markets portray an un-level playing field, and there is e.g. variability in availability of different alternative fuels as well as in support measures and strategies.
Focus area(s) affected	FA5
Impact	Fragmentation hampers progress in both in supply and demand side
Root causes, including justification and trends	(a) Variation of strategies and policies (and support measures) in Member States (b) Variation in market conditions (affecting industries / supply) (c) Variation in availability, standards, etc. (affecting end-users / demand)
Benefit of removal	Coherence and interoperability
Actions	(A1) Long-term, aligned policies (A3) Regulation and standards (A8) Transnational market creation (A9) Active cities and municipalities
Cost-benefit of priority actions	Medium-to-high-cost actions with medium-to-high benefits. Complementary, grouped actions are required.