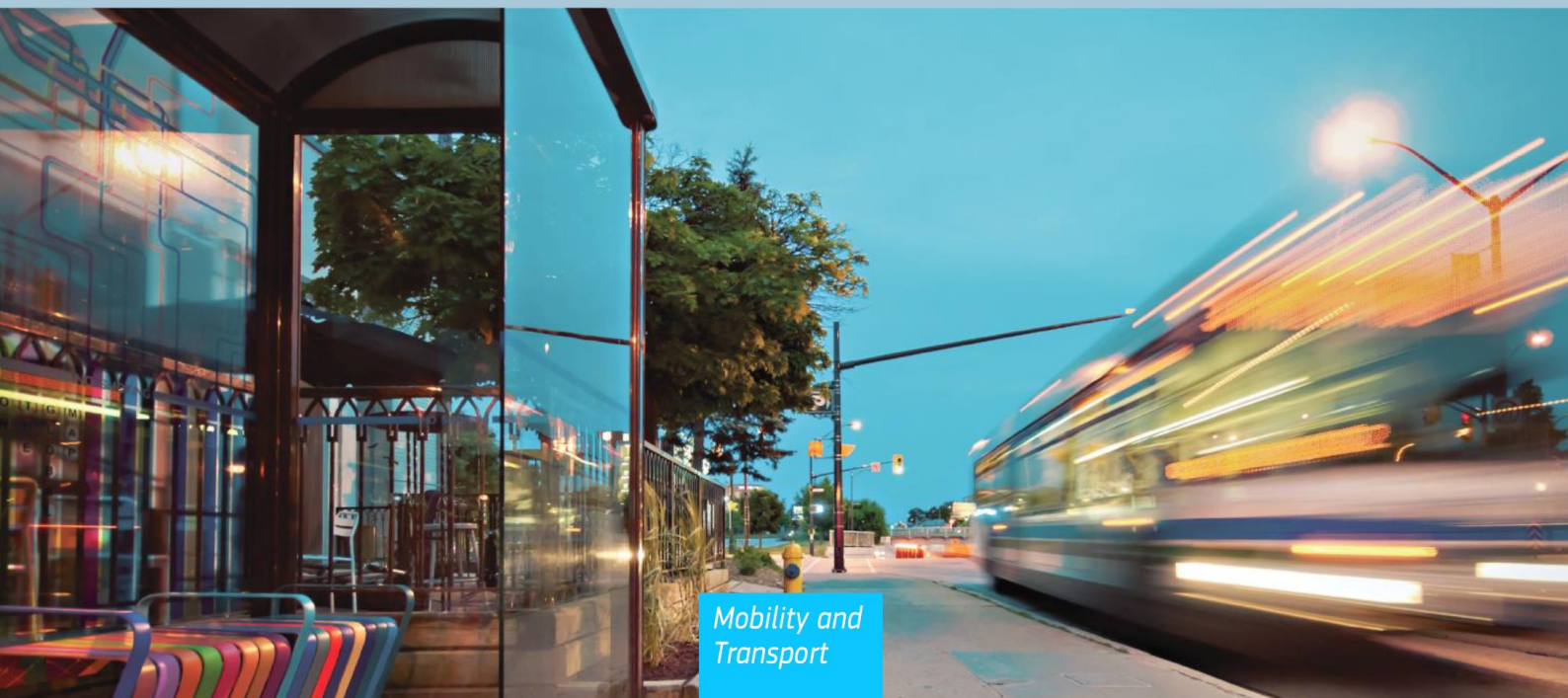
European Commission

Smart Mobility and Services

Roadmaps 2019



Mobility and Transport

STRATEGIC TRANSPORT AND INNOVATION AGENDA

Smart Mobility Systems and Services

Roadmap 2019

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Final Version: 06.09.2019

EXECUTIVE SUMMARY

Smart Mobility Sytems and Services

New mobility systems and services need to be evaluated in terms of their contribution to overall energy and transport system sustainability, rather than solely on their sectoral and often incremental impact along existing modes. Similarily, efforts at deploying electric, shared and automated vehicle systems should be reviewed in terms of their strategic contribution to overall transport systems redesign rather than be predominately focused on electrifying, automating and expanding existing and unsustainable road-based individual motorisation modes.

Challenges of Integration

The central challenges of integrating smart mobility systems and services are to:

1. Prioritise smart, sustainable and integrated mobility systems that provide public transport connectivity and individual public mobility in both urban and rural settings.
2. Identify and implement governance and regulatory frameworks that support active mobility and light travel modes, improving road safety for pedestrians, cyclists and micro-mobility users.
3. Facilitate smart urban, land-use and infrastructure design to allow for behavioural change and to prioritise active mobility, micromobility, ridepooling, public transport and sustainable freight services.
4. Ensure smart and distributed zero-carbon primary transport energy supply, taking into account also energy demand from digital services and virtual mobility.
5. Provide for integrated energy and transport transformation and long-term sector-coupling, as well for as sufficiency in travel demand.
6. Establish ubiquitous and fair-access digital public infrastructure to ensure socially inclusive digital services, to enable equitable data-sharing and evidence-based public policy and to facilitate collaborative service innovation in private and public transport offerings.
7. Provide robust governance, regulatory and standardisation frameworks to enable scaling and effective integration of smart mobility services as a public good.
8. Identify and implement functional frameworks for both technical interoperability and shared operating models across current modes and purposes.

9. Support solutions for flexible physical infrastructure that can be functionally shared across type, time, mode and vector of transport for both passenger and freight services.
10. Validate and integrate sustainable automated, air and virtual mobility.

Opportunities for Innovation Action

Moving forward, innovation actions should facilitate the pro-active integration of smart mobility services with existing public transport and utility systems to unlock their potential to significantly leverage low-carbon and efficient mobility in European cities and rural settings. This will require a renewed focus on their potential contribution to modal shift, behaviour change, energy transition and intelligent demand and land use management.

To this end, the implementation roadmap recommends designing and prioritising innovation actions targeting:

1. Development of sustainable and integrated smart mobility systems connecting urban and rural mobility services and promoting modal shift, sustainable land use, sufficiency in travel demand and active and light travel modes.
2. Design of effective operating models for integrating smart mobility with public transport services and zero-carbon energy systems.
3. Fair-access public digital infrastructure and mobility data management solutions.
4. Implementation of intermodality, interoperability and sector coupling.
5. Validation and integration of automated, air and virtual mobility.

Priorities for implementing innovation actions should focus on:

1. Increasing scale, scope and leverage of innovation action.
2. Managing and governing urban, rural and regional mobility systems and services.
3. Advancing sustainable system design, interoperability and sector coupling.

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1 INTRODUCTION

This implementation roadmap complements the Strategic Transport Research and Innovation Agenda (STRIA) Smart Mobility Systems and Services Roadmap 2017 - one of seven STRIA roadmaps included in the European Commission Staff Working Document ‚Transport Research and Innovation Contribution to the Mobility Package' from May 2017[1], which identifies and reviews options of smart mobility innovation for low-carbon transport and mobility in Europe.

1.1 Policy Objectives and Targets

The 2011 Transport White Paper of the European Commission formulates ambitious urban mobility policy objectives, following on the established need to cut transport GHG emissions by 60 % compared to 1990. These include the full phasing out of conventionally fuelled vehicles in city centres by 2050 and close to zero-emission logistics in cities by 2030. In more detail, the goals are:

- 20 % reduction in GHG emissions from 2008 levels by 2030, and a 60 % reduction from 1990 levels by 2050,
- 40 % decrease in GHG emissions from new cars in 2021 compared to 2005 and a 19 % decrease for new vans in 2020 compared to 2012, and
- 10 % renewable share in road and rail transport energy by 2020 and 14 % by 2030.

These goals were reiterated in ‚A European Strategy for Low-Emission Mobility'[2], as well as the communication ‚A Clean Planet for all'[3].

Finally the Graz Declaration[4] on clean, safe and affordable mobility develops additional priorities for implementation. In a joint statement on 30 October 2018, the EU transport and environment ministers recognised clean, safe and affordable mobility as a key priority for EU transport policy. The Graz Declaration stated the following core objectives:

[1] Towards clean, competitive and connected mobility: the contribution of Transport Research and Innovation to the Mobility package, SWD(2017) 223 final, accessed on 04 September 2019; https://ec.europa.eu/transport/sites/transport/files/swd20170223-transportresearchandinnovationtomobilitypackage.pdf

[2] A European Strategy for Low-Emission Mobility, COM(2016) 501 final, accessed on 07 May 2019; https://ec.europa.eu/transport/sites/transport/files/themes/strategies/news/doc/2016-07-20-decarbonisation/swd%282016%29244.pdf

[3] A Clean Planet for all – A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM(2018) 773 final, accessed on 07 May 2019; https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_en.pdf

[4] Graz Declaration ‚Starting a new era: clean, safe and affordable mobility for Europe', published on 30 October 2018, accessed on 07 May 2019; https://www.eu2018.at/latest-news/news/10-30-Graz-Declaration.html

- Clean vehicles: rapid introduction of zero-emission vehicles and decarbonised fuel options,
- Strategy for sustainable mobility management and planning,
- Active mobility to promote health and sustainability,
- Safe and inclusive mobility, and
- Multimodality and infrastructure.

On the basis of these European goals for the transport sector, this implementation roadmap for Smart Mobility Systems and Services seeks to propose an action plan of priority European innovation actions to facilitate European innovation in sustainable, clean, safe and affordable mobility to ensure more rapid attainment of long-term European transport goals to 2025 and 2030.

The implementation roadmap is based on consultation with a wide range of European stakeholders and experts, including at the ‚Future Mobility for European Cities: Graz Forum for the EU's Strategic Transport Research and Innovation Agenda' which took place from 26-27 November 2018 in Graz, Austria, as well as at a STRIA validation workshop on 15 May 2019 at the European Commission in Brussels.

The aim is to identify transport research and innovation actions that can advance sustainable and smart mobility systems and services in Europe and contribute to successful and timely implementation of EU transport decarbonisation goals.

2 SCOPE AND VISION

Decarbonising transport and the sustainable transformation of mobility systems is a pressing challenge for global and European climate change mitigation. Understanding and differentiating the performance and potential of emerging new and potentially ‚smart' transport and mobility systems will be fundamental in implementing successful and sustainable transformation paths.

Digitalisation is currently reshaping the sector. ICT-enabled web, mobile and big data applications are spawning new mobility and transport services and systems. Traditional automotive, public and private transport models are being challenged as new players are emerging with disruptive service offerings; many of the new models are blurring traditional demarcations between public transport and private mobility, including in the area of urban logistics. New mobility services increasingly catalyse public-private co-development and co-delivery of integrated mobility and transport systems and services, as well as shared and open use of public space, data and infrastructure.

Significant changes can be observed in user behaviour and lifestyle in relation to transport that will affect the decarbonisation impacts of new service models in the

transport sector. Younger generational cohorts and other user groups are currently opting for reduced motorisation rates and modal shift away from daily use of the automobile and towards multi-modal, shared, public and active travel modes. Overall, transport users have embraced digitalisation and the use of smartphones, mobile web applications and social media. These behavioural shifts are supporting new shared mobility and transport business models, services and markets, which collectively open new pathways to sustainable mobility. If such behavioural trends persist, they can offer a principal support factor for decarbonisation, provided that innovations are building on decarbonised mobility systems and promote genuine intermodality. Forward innovation actions and policies present an opportunity to reinforce these promising behavioural trends.

In that context, cities and regions are confronted with the challenge of transforming their transport modal splits and flows by integrating these emerging changes into evidence-based policy making and to provide effective tools for decision making processes (SUMPs, SULPs, UVARs)

The principal prospects for decarbonisation are strong: A better utilisation of underused assets in transport fleets and infrastructures can accommodate increasing demand and reduce the share of unsustainable travel modes. Smart mobility systems and services have the promise to contribute to the needed decarbonisation of the transport sector and might also help to address persistent problems of congestion and accessibility in urban and rural areas. However, new innovations in technologies and use need to optimise the whole transport system, and not road-based car travel only to make a long-term contribution to decarbonisation.

2.1 STRIA Smart Mobility Systems and Services Roadmap

The STRIA Roadmap Smart Mobility Systems and Services reviewed smart mobility technologies and services and their potential and dynamic contribution to overall transport transformation as well as related environmental, public health, urban development and energy policy goals. It recommends innovation actions that are focused on facilitating smart mobility systems and services which avoid further lock-in of unsustainable modes of transport and which deliver equal progress across the core levers of transport transformation available, which are:

- Fuel, vehicle and circulatory efficiency,
- Fuel substitution,
- Modal shift, and
- Land use and demand management.

A key challenge will be to deploy these levers while also ensuring sufficient travel behaviour and demand. While efficient and sustainable technologies and services can make a significant contribution to overall transport sustainability, these will

need to be complemented by levers such as sustainable land use, intelligent design of public space as well as other levers that can lead to a reduction in overall travel demand such as virtual mobility.

Activating these levers will require deploying multi-sectoral actions that in equal measure activate:

- Technology innovation,
- Social and use innovation,
- Regulatory innovation, and
- Organisational and institutional innovation.

The roadmap recommends innovation actions that facilitate balanced and equitable integration of these levers and domains into future public and private mobility systems and services in the context of European smart city and smart energy goals. The objective is to initiate transformative innovation actions that comprehensively address technological, social and institutional transformation of energy, land use and transport systems. This will also require innovations in governance, procurement and regulation at all levels of European public administration and government. Technology innovation should complement and enable behavioural change, social innovation, sustainable land use and the intelligent design of urban space.

2.2 State of European Transport Transformation

While interest in smart mobility technologies and services has been very strong, and significant progress has been made in their initial implementation and deployment in European cities, it is important to note that to date smart mobility services remain an insignificant element of overall European transport and mobility supply. Despite their high and disruptive profile neither on-demand, shared, autonomous nor electric mobility systems have yet had any notable impact on overall transport demand, modal split and related emissions in Europe to date, nor has their potential contribution to decarbonisation been sufficiently validated, in particular in the case of smart and automated mobility.

New service models and innovation can strongly support a shift to transport decarbonisation, or further lock in unsustainable travel behaviour. A key task will be to establish empirical validation of the sectoral and systemic decarbonisation impacts of such technology, systems and services innovation, and ensure that technologies and service innovations are not taken forward for their own sake, but in view of achieving a transition to a low-carbon, efficient and accessible transport system.

So far, policy and innovation efforts remain overwhelmingly focused on incrementally optimising existing individual motorisation modes (‚default car') and

automobile technologies rather than on leveraging integrated transport and mobility strategies. Breaking this path-dependency is a key innovation challenge.

In its latest briefing on transport transformation in Europe[5], the European Environment Agency summarises the progress of transport decarbonisation efforts and highlights related transport performance and demand figures to 2017:

- GHG emissions from transport have been increasing since 2014. By 2016, transport emissions were 26.1 % higher relative to 1990. Preliminary estimates from EU Member States show that GHG emissions from transport were 28 % above 1990 levels in 2017.
- The average CO_2 emissions of new passenger cars slightly increased for the first time since data monitoring started. Meanwhile average CO_2 emissions of new vans continue to fall, with the largest annual reduction occurring in 2017. However, considerable reductions still need to take place in the coming years to meet the EU's 2020/2021 targets.
- The use of diesel remains dominant in Europe, representing 67 % of total fuel sold for road transport use in 2016. However, more petrol passenger cars than diesel cars were sold in 2017 (for the first time since CO_2 monitoring for passenger cars started).
- The EU's share of renewable energy in transport rose slightly from 7.1 % in 2016 to 7.2 % in 2017. It remains well below the 10 % target set for 2020 under the EU's Renewable Energy Directive. Just two Member States (Austria and Sweden) have already reached the 10 % goal.
- Electric cars are slowly penetrating the EU market. Despite significant increases in sales in 2017, battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) represent only 0.6 % and 0.8 %, respectively of new passenger car registrations in the EU.
- Transport continues to be a significant source of air pollution, especially of PM and NO_2, although these emissions have been reduced in the last decade due to the introduction of fuel quality standards, the Euro vehicle emission standards and the use of cleaner technologies.
- Road traffic is the most widespread source of environmental noise in Europe.
- Passenger transport demand in the EU-28 increased by 2.5 % between 2015 and 2016, the second largest annual growth rate since 1999.
- Car passenger travel remains the dominant transport mode accounting for well over 70 % of total passenger transport. Rail passenger travel is stable, accounting for 6.8 % of transport demand in 2016.

[5] Progress of EU transport sector towards its environment and climate objectives, published on 22 November 2018 and last modified on 17 January 2019, accessed on 07 May 2019; https://www.eea.europa.eu/themes/transport/term/term-briefing-2018

- Air transport demand continues to grow and now boasts a modal share of passenger transport of over 10 % — the largest share since 1995. Compared with 2015, air transport grew by 6 % in 2016.
- The modal share of freight transported over land remained largely constant and is still dominated by road transport (76 %), followed by rail (17 %) and inland waterways (6 %).
- In 2016, the main contributors to the increase in total freight transport were road and maritime freight (plus 5.2 % and 6.4 %, respectively). Total freight transport increased by 4.6 % compared with 2015, the largest annual increase since 2010.

This recent review by the European Environment Agency makes it clear that business as usual is not an option if significant and meaningful progress is to be made towards low-carbon, sustainable European mobility systems and services and the attainment of critical sustainability and decarbonisation goals.

3 CONTRIBUTION TO POLICY OBJECTIVES

3.1 Challenges of Integration

It is apparent that given the continued rise in transport demand and related transport emissions, incremental efforts at fuel efficiency and fuel substitution along existing mode shares will not be sufficient to deliver medium- or longterm transport and energy policy goals. Given continuous growth in demand for individual car-based motorisation and mobility services, these incremental measures are not delivering against European transport sustainability, decarbonisation, emissions and fleet replacement targets.

Urgent action is required to meet the EU's transport decarbonisation goals and to provide for effective mobility transition paths. These goals are unlikely to be reached, unless a more fundamental transformation is achieved away from road-based freight and individual motorised transport. A key challenge will be to reduce overall primary fuel demand of European mobility systems beyond current ambitions of gradual fuel substitution. This will require fundamental modal shift, transformative urban and regional land use, behavourial change and consequential energy efficiency improvements, as well as more rapid decarbonisation of primary energy supply in transport.

In passenger transport, innovation actions to date have predominantly focused on incremental fuel efficiency and fuel subsitution and electrification, automation in individual motorisation and freight, as well as on enabling individual motorised mobility-on-demand (i.e. ‚shared' mobility), rather than on activating significant

modal shift, sustainable land use, vehicle right-sizing, and active mobility strategies. Deployment of individual mobility-on-demand services has often been concentrated in core urban agglomerations with existing high public transport connectivity and on providing additional access to car and road-based mobility without concurrently expanding public transport capacity and demand across urban and rural areas or ensuring that mobility-on-demand is fully integrated with public services. Although progress has been made expanding active mobility mode shares in European cities, motorised individual road transport remains dominant and current strategies of electric, shared and automated individual car-based mobility are likely to exacerbate this trend.

While offering high potential for transport decarbonisation, less focus has been placed on the expansion and innovation of smart public transport services (both rail and road-based) in combination with micro-emobility, micro-transit and active mobility. These present opportunities for significant modal shift away from car-based individual motorisation (combustion, automated or electric). Recently new ridepooling services and micro-transit offerings, such as shared and autonomous shuttles or shared micro-mobility services, have been piloted in a number of European cities and, if operated in coordination with public transport, offer promising potential for integrating personal micro-emobility and public mobility-on-demand in ridepooling and micro-transit modes. These would complement current trends towards active and personal electric mobility (micro-emobility) and also provide flexible solutions for non-urban and rural mobility. Overall these services should strategically contribute to modal shift (i.e. significantly decrease overall vehicle kilometres and individual car-based mobility) and to vehicle right-sizing (i.e. signifcantly reducing weight, size and speed of vehicles) to effect improved economic, social, spatial and energetic efficiency of European mobility systems. It is important to note that this will also very much require the substantial expansion of backbone, high-throughput, high-speed public transport systems (i.e. rail, light rail and bus rapid transport) while ensuring that public transport services evolve towards new forms of publicly accessible and usable mobility.

Urban and regional freight services have also seen significant innovation through the deployment of real-time smart logistics information and tracking networks, warehouse automation, a growing fleet of electric delivery vehicles and the emergence of sustainable micro-distribution by cargo bikes or other micro-vehicles, including, potentially, drones. However, urban freight transport demand continues to experience high growth rates driven by online retailing and delivery as well as general economic growth. It remains heavily road-based and dependent on oil-derived fuels. Efforts at modal shift in freight transport have had no significant impact to date. Growth in urban freight traffic adds to addional pressure on urban space and creates conflicts with other transport modes. Advancing smart, zero-carbon urban logistics, freight and delivery transport systems that promote meaningful modal shift (to rail and micro-mobility) and efficiently and sustainably

integrate with existing public transport systems and utility infrastructures should be an urgent priority.

Water-borne urban transport, as well as air and virtual mobility have been of a lesser or negligble focus, and future innovation actions should be directed at exploring and validating the potential contribution of air mobility (i.e. low altitude aerial and electric VTOL) and virtual mobility systems and services in particular. Urban and rural air mobility could provide for disruptive impact and could offer an alternative mode for electric urban freight and passenger transport, but a range of environmental, safety, technical and governance challenges will need to be validated and met to ensure it can be sustainably integrated with surface mobility modes and urban infrastructure.

Hence, smart mobility systems and services need to be evaluated in terms of their contribution to overall energy and transport system sustainability, rather than solely on their sectoral and often incremental impact along existing modes. Similarily, efforts at deploying automated and autonomous vehicle systems should be reviewed in terms of their strategic contribution to overall transport systems redesign rather than be focused on sharing, automating and expanding existing and unsustainable road-based individual mobility modes. Electrification should also proceed on the basis of right-sized vehicles and efficient modes rather than along established vehicle configuration and modal shares. The equitable, shared, safe and efficient use of urban space will be a further determinant of sustainable and smart mobility systems and services.

Therefore, the central challenges are to:

- Prioritise smart, sustainable and integrated mobility systems that provide public transport connectivity and individual public mobility in both urban and rural settings.
- Identify and implement governance and regulatory frameworks that support active mobility and light travel modes, improving road safety for pedestrians, cyclists and micro-mobility users.
- Facilitate smart urban, land-use and infrastructure design to allow for behavioural change and to prioritise active mobility, micromobility, ridepooling, public transport and sustainable freight services.
- Ensure smart and distributed zero-carbon primary transport energy supply, taking into account also energy demand from digital services and virtual mobility.
- Provide for integrated energy and transport transformation and long-term sector-coupling, as well for as sufficiency in travel demand.
- Establish ubiquitous and fair-access digital public infrastructure to ensure socially inclusive digital services, to enable equitable data-sharing and evidence-based public policy and to facilitate collaborative service innovation in private and public transport offerings.

- Provide robust governance, regulatory and standardisation frameworks to enable scaling and effective integration of smart mobility services as a public good.
- Identify and implement functional frameworks for both technical interoperability and shared operating models across current modes and purposes.
- Support solutions for flexible physical infrastructure that can be functionally shared across type, time, mode and vector of transport for both passenger and freight services.
- Validate and integrate sustainable automated, air and virtual mobility.

A vital aspect of transport and mobility transformation will be to progress behavioural innovation and the acceptance and adoption of sustainable technology and services by transport and mobility users. This will require integrating innovation action across technological, behavioural, regulatory and economic domains. This roadmap is focused on identifying necessary and sufficient innovation levers of European transport and mobility transformation and potential pathways to sustainability and decarbonisation. While of great importance, defining specific political pathways and policy instruments towards the implementation of these levers is outside the scope of this roadmap and should be developed in democratic decision-making by the responsible institutions of governance at local, national and supra-national level as a matter of urgency.

3.2 Opportunities for Innovation Action

Moving forward, innovation actions should facilitate the pro-active integration of smart mobility services with existing public transport and utility systems to unlock their potential to significantly leverage low-carbon and efficient mobility in European cities and regions. This will require a renewed focus on their potential contribution to modal shift, behavioural change, energy transition and intelligent demand and land use management

To this end, the roadmap recommends designing and prioritising innovation actions targeting:

1. Development of sustainable and integrated smart mobility systems connecting urban and rural mobility services and promoting modal shift, sustainable land use, sufficiency in travel demand and active and light travel modes.
2. Design of effective operating models for integrating smart mobility with public transport services and zero-carbon energy systems.
3. Fair-access public digital infrastructure and mobility data management solutions.
4. Implementation of intermodality, interoperability and sector coupling.
5. Validation and integration of automated, air and virtual mobility.

Priorities for implementing innovation actions should focus on:

1. Increasing scale, scope and leverage of innovation action.
2. Managing and governing urban, rural and regional mobility systems and services.
3. Advancing sustainable system design, interoperability and sector coupling.

4 PORTFOLIO OF PROPOSED ACTIONS

The objective of the consultation process initiated at the Graz Forum is to define a set of transport research and innovation actions that can progress the implementation of the STRIA Smart Mobility Systems and Services Roadmap, target key integration challenges and contribute to systemic EU transport transformation, decarbonisation and energy policy goals. A set of innovation actions is introduced and proposed in this Chapter.

4.1 Development of sustainable and integrated smart mobility systems connecting urban and rural mobility services and promoting modal shift, sustainable land use, sufficiency in travel demand and active and light travel modes

Scope

Next generation smart mobility systems and services will require sustainable interlinkage of urban agglomerations and more densely populated areas with peri-urban areas, shrinking regions or rural mobility services. Integrated sustainable mobility systems should be developed in large-scale implementation that can validate overall systems design, urban design and land use impacts, user accessibility, social acceptability and the effective interoperability and smart coordination of diverse mobility services and energy systems across both urban and non-urban areas. Integrated, sustainable and smart mobility systems should promote significant modal shift, sustainanable land use, suffiency in travel demand and active and light travel modes.

Challenges

- Prioritise smart, sustainable and integrated mobility systems that provide public transport connectivity and individual public mobility in both urban and rural settings.
- Identify and implement governance and regulatory frameworks that support active mobility and light travel modes, improving road safety for pedestrians, cyclists and micro-mobility users.
- Facilitate smart urban, land-use and infrastructure design to allow for behavioural change and to prioritise active mobility, micromobility, ridepooling, public transport and sustainable freight services.

- Provide for integrated energy and transport transformation and long-term sector-coupling, as well for as sufficiency in travel demand.
- Provide robust governance, regulatory and standardisation frameworks to enable scaling and effective integration of smart mobility services as a public good.

Proposed Actions

1. **Smart mobility solutions sustainably interlinking urban and rural mobility systems**

   There is a need to test and develop at scale the integration of new mobility solutions connecting urban and rural services and providing for socially equitable service levels and access. Actions should develop tools that extend the concepts of new mobility services from urban centers and more densely populated areas to peri-urban areas, shrinking regions or rural systems. Actions should focus on enabling significant modal shift and prioritising overall public transport and collective mobility services connecting urban, peri-urban and rural areas.

2. **Develop urban design and land use strategies that promote active, micro and public mobility and that facilitate the integration of passenger and freight services**

   Smart urban design and land use strategies can facilitate the management of mobility demand and contribute to the attractivness of active mobility, micromoblity, ridepooling and public mobility services. Effective and sustainable land use management can also contribute to more efficient freight and logistics systems and services. Actions should focus on integrating urban, land use and infrastructure design solutions with smart mobility services to promote sustainable and sufficient mobility demand and supply.

3. **Defining new governance concepts, tools and technologies through large-scale systems implementation**

   It is vital that transformative concepts, tools and technologies for smart, integrated passengers and goods mobility are developed in large-scale implementation encompassing overall urban and regional mobility systems that allow for cross-sectoral integration, systemic validation, effective scaling and rapid transfer. Actions should integrate mobility systems at the regional level and across all modes and all user, operator and governance levels having all stakeholders involved in the process.

4. **Frame transport policy to foster inclusion, public acceptance and respect for diversity through research on behavioural change and user needs**

   There is a need to foster a broad involvement of all stakeholders and to establish collaborative initiatives in order to incorporate user needs with policy and technology innovation. Actions should define operating models with a

special focus on the needs of social groups at risk, but also in relation to public participation and co-creation. Furthermore, responsible research and innovation actions should investigate which type of mobility services optimally serve or respond to ‚users' mobility needs and their demand for the delivery of goods.

4.2 Design of effective operating models for integrating smart mobility with public transport services and zero-carbon energy systems

Scope

Effective collaboration of cities, users, public and private transport providers and industry should be a central theme in the development of smart mobility technologies, solutions and systems. To meet the challenge of decarbonisation publicly owned and operated systems (such as backbone public rail and bus networks, municipal energy production and distribution) must work in tandem with and integrate private services (such as shared electric and autonomous vehicles or vehicle charging facilities), all of which will utilize new technologies that will need to be developed with both public and private investment. New operating models are required to allow public transport, mobility, data and energy services to collaborate effectively with private individual mobility providers in co-delivering sustainable mobility and transport systems. From a municipal and regional institutions' perspective, this will require innovative approaches to cross-sectoral planning, public participation and procurement and the shared use of embedded physical and technical infrastructure.

Challenges

- Ensure smart and distributed zero-carbon primary transport energy supply, taking into account also energy demand from digital services and virtual mobility.
- Identify and implement governance and regulatory frameworks that support active mobility and light travel modes, improving road safety for pedestrians, cyclists and micro-mobility users.
- Provide for integrated energy and transport transformation and long-term sector-coupling, as well for as sufficiency in travel demand.
- Provide robust governance, regulatory and standardisation frameworks to enable scaling and effective integration of smart mobility services as a public good.
- Identify and implement functional frameworks for both technical interoperability and shared operating models across current modes and purposes.

Proposed Actions

1. **Design and development of effective operating models that sustainably integrate public and individual mobility service provision**

   On-demand, automated and shared individual mobility services have some potential to make a sustainable contribution to overall urban and rural mobility systems, provided they are effectively integrated with public transport systems, facilitate significant modal shift and promote sustainable land use and fuel substitution. Actions should focus on designing and implementing governance and operating models, that allow for effective public regulation, enable efficient collaboration and technical interoperability between public and private mobility operators and promote socially equitable, integrated and sustainable mobility systems. This will require novel solutions for the public governance, management and administration of private-public co-production of urban and rural mobility systems as well as for the management and operation of public space and digital infrastructure. Actions should also focus on developing appropriate business models, public finance and procurement solutions to support overall transport transformation and integration.

2. **Development of integrated multimodal solutions providing a sustainable energy-transport nexus**

   The development of effective solutions for interfacing smart mobility services, renewable energy systems and sustainable vehicle design is a key prioritiy for transport decarbonisation and energy transformation. A vital objective is to significantly increase energy efficiency of mobility systems and to significantly decrease primary energy demand in transport. Actions should facilitate integrated solutions that provide for a significant increase in the share of renewables, systemically integrate local energy resources and contribute to effective and dynamic grid integration of zero-emissions mobility, including active and light mobility modes. Actions should further account and provide for sustainable energy demand and supply of and for digital and virtual mobility solutions.

4.3 Fair-access public digital infrastructure and mobility data management solutions

Scope

Private companies, governments and public entities should be equally encouraged to provide and share user and urban data collected on the use of public space and infrastructures wherever it is available (in such a way that protects the privacy of its citizens) so that users, governments, cities, third party apps, operators, developers and innovators can access it to inform their decisions and innovate their applications. Smart mobility and cities will combine publically and privately developed infrastructures. Moving forward, fair-access to public digital infrastructure, public connectivity and public digital space will be vital to ensuring equitable and inclusive access to overall mobility services to all users.

Equally, making aggregate traffic data (from all sources private and public) accessible in a fair and equitable manner, will help users, municipalities and service providers to integrate them into their systems and establish truly ‚cross-infrastructure' integrated mobility systems. The collection and collation of real-time comprehensive mobility data will be vital to inform effective and evidence-based public policy and the sustainable management of European mobility and transport systems.

There is a need to develop a large-scale public data pool that can provide independent, rigorous, empirical and real-time data on the environmental, social, economic and spatial performance of European mobility and transport systems to researchers and policy makers. Developing a sound database on the real world performance of different mobility systems and services will be vital for advancing effective public policy on mobility, urban development, technology adoption, health and social equity in transport and for designing and interrogating relevant indicators. While a wealth of data is collected, collated and made available at the local and regional level, this is often insufficiently rigorous or not of adequately comparative format to allow for aggregation of transport behaviour, health, environmental, emissions or spatial effects across Europe. Creating such robust and comparative pan-European data sets will be vital in providing evidence-based information and decision support for policy and political decison-making processes and the general public. Providing such evidence will be of central importance to effecting behaviour change, policy innovation and public acceptance.

Challenge

- Establish ubiquitous and fair-access digital public infrastructure to ensure socially inclusive digital services, to enable equitable data-sharing and

evidence-based public policy and to facilitate collaborative service innovation in private and public transport offerings.

Proposed Actions

1. **Collecting and collating systemic and dynamic mobility data to contribute to effective policy-making and implementation**
   Actions should seek to contribute to a shared pool of empirical data that integrates cross-sectoral evidence related to transport and mobility in order to provide robust and comparable information to the general public, researchers, policy makers, governments and industry. Actions should advance capacity building and cooperation actions between different governance levels and economic and social actors to improve overall availability and public access to comparative data on the performance of European mobility and transport systems.
2. **Fair-access digital infrastructure and mobility data management**

   Harnessing the potential of smart mobility services for sustainable and integrated mobility system will require providing fair access to connectivity, data and services to all users. Actions should focus on establishing digital public infrastructure and digital public space providing for ubiquitious fair access connectivity (i.e. public wifi or other publicly accessible network solutions) and preventing digital divide and social exclusion from digital infrastructure and services. Actions should further focus on effective data management strategies that provide public agencies, citizens and all other stakeholders with fair access to mobility data collected by operators and service providers to inform their decisions and plan their mobility. Actions should provide for effective and innovative solutions for Business-to-Business, Business-to-Consumer and Business-to-Government transport data sharing and service collaboration. Actions should explore and test distributed ledger, fog computing, and peer-to-peer applications that can support decentralised, secure data management and transaction for relevant users and service providers.

4.4 Implementation of intermodality, interoperability and sector-coupling

Scope

Support in the development of technical standards for communication and interoperability of user devices, vehicles, critical infrastructures, energy systems and mobility data will be vital. It is important that such standards can evolve and adapt with technologies to prevent innovation stagnation. This should encompass dialogue and close cooperation (including joint goal setting and the application of joint governance models such as quadruple helix innovation) between users, governments, science and industry (including both incumbents/long-term players in the mobility sector and start-ups). Multi-stakeholder standard setting will allow for the most intelligent standards to be adopted. Such standards should not be too prescriptive (thus hindering innovation and technological developments), but should also facilitate robust privacy frameworks, decarbonisation and cross-sectoral interoperability to as great an extent as possible.

Challenges

- Identify and implement governance and regulatory frameworks that support active mobility and light travel modes, improving road safety for pedestrians, cyclists and micro-mobility users.
- Facilitate smart urban, land-use and infrastructure design to allow for behavioural change and to prioritise active mobility, micromobility, ridepooling, public transport and sustainable freight services.
- Provide for integrated energy and transport transformation and long-term sector-coupling, as well for as sufficiency in travel demand.
- Provide robust governance, regulatory and standardisation frameworks to enable scaling and effective integration of smart mobility services as a public good.
- Identify and implement functional frameworks for both technical interoperability and shared operating models across current modes and purposes.
- Support solutions for flexible physical infrastructure that can be functionally shared across type, time, mode and vector of transport for both passenger and freight services.

Proposed Actions

1. **Design and development of efficient solutions for integrated infrastructure and mobility systems shared by passenger and freight services**

   A key challenge of sustainable transport transformation is to overcome the separation of physical infrastructures and services for public, individual and freight mobility. Developing shared use of physical assets and integrated service models will be a vital factor in increasing the overall efficiency of infrastructure use and promoting decarbonisation. Actions should focus on developing solutions for the flexible, concurrent and multimodal shared use of existing infrastructures for both passenger and freight transport allowing for more efficient utilization of vehicles and fixed assets and contributing to more efficient, sufficient and safe use of public space.

2. **Expand and extend the role of active and light travel modes and use of micro-mobility solutions as part of integrated intermodal mobility systems**

   Modal shift to active and light travel modes mitigates negative environmental impacts on air quality, noise, water and soil emissions and contributes to safer public and road spaces, improved health, well-being and quality of life. Actions should integrate smart services, novel micro-vehicles, and appropriate infrastructure for active and light mobility for passengers and freight, in particular for first and last mile services. Crucial priorities are fostering bicycle-friendly infrastructure, improvement of road safety for users of active modes as well as optimisation of public space for pedestrians, cyclists and micromobility for passengers and freight. Actions should further focus on developing effective and equitable management and regulation of the use of public space prioritizing and integrating active and light mobility.

4.5 Validation and integration of automated, air and virtual mobility

Scope

Automated mobility: The arrival, legalisation and rollout of Level 4 autonomous vehicles could pave the way for driverless mobility services. While innovating vehicle technology, automation does not a priori contribute to either decarbonisation or systemically more efficient transport and mobility systems. A key challenge will be to sustainably evolve shared automated mobility in integrated urban and rural mobility systems, and to avoid further lock-in of unsustainable individual car- and road-based modes of transport. A central issue to be resolved will be the cost and energy efficiency of such solutions which currently feature both high costs for vehicles and infrastructure and high energy consumption which needs to be accounted for systemically with regard to energy demand of digital and big data backend systems.

Air mobility: A rapid proliferation of drone and low-altitude aerial mobility technology is also taking place due to a combination of forces, including automation. The potential integration of urban and rural air mobility into existing horizontal transport systems will add further complexity to the organisation of the transport and mobility services. Early evidence indicates that light-weight drone platforms can deliver both economic and energetic efficiencies in the shortrange distribution of small goods and can support a number of valid use cases in critical and emergency services. Drone and low-altitude aerial mobility is now technically possible for passenger transport also, and the combined demand for such on-demand air mobility solutions will require significant governance, regulation and infrastructure innovation. As with automated ground vehicles, these services should not replicate unsustainable individual mobility and logistics services but complement integrated mobility systems for both passengers and goods.

Virtual mobility: Virtual mobility solutions and services (i.e. teleworking, teleconferencing and other forms of virtual service provision collaboration and communication) may provide a valuable contribution to mobility and transport sufficiency by enabling the avoidance of unnecessary transport of both people and goods. While empirical evidence of the positive contribution of virtual mobility has been mixed and recognizing that personal travel time budgets appear to remain constant as users often substitute avoided travel with other travel purposes, innovation actions should focus on validating and expanding virtual mobility and other services for example in teleworking, distance-learning, health and social care, distributed and additive manufacturing and other collaborative forms of work that can contribute to reducing overall travel demand for people and goods. It will be vital, however, to also account for the energy intensity of such virtual mobility services to ensure that they contribute to an overall reduction in primary energy demand from transport and related services.

Challenges

- Provide for integrated energy and transport transformation and long-term sector-coupling, as well for as sufficiency in travel demand.
- Validate and integrate sustainable automated, air and virtual mobility.

Proposed Actions

1. **Test and validate the potential contribution of automated mobility services to sustainable, zero-carbon and integrated public transport systems**

   The positive contribution of automation, in particular of individual car-based mobility services, to overall sustainable mobility systems has yet to be validated and should be assessed in terms of its impact on modal split, sustainable land use, and spatial efficiency and equity. Actions on automation should aim to provide for solutions that promote significant modal shift, sustainable land use and efficient primary energy demand. Actions should test and validate which automation use cases and technology solutions contribute to integrated energy and transport transformation and the overall sustainability of European transport systems. Actions should focus on validating automation as an enabler of fuel substitution, modal shift and ridepooling, intermodality, sustainable land use and overall system efficiency rather than being focused on automating individual car-based motorisation. Actions should further focus on effective regulatory strategies and systemic cost-benefit analysis regarding automated mobility and define and implement valid and sustainable use cases for automation.

2. **Test and validate real-world integration and governance of air mobility with urban and rural transport systems**

   Drones and electric low-altitude air mobility will require customised governance across all levels and addressing both transport of people and goods. Actions should define effective regulations regarding airspace, energy supply, security, safety, noise, visual pollution, technology, certification and standards that are required to enable sustainable integration and implementation of air mobility services. Actions should focus on defining governance and operational frameworks for integrating air mobility with existing air traffic, land use, environmental and security management systems and regulations. Whether and how low-altitude electric air mobility systems for freight and/or passenger services will provide for disruptive innovation and can make a positive contribution to sustainable transport transformation will need to be explored in dedicated realworld test beds and living labs that provide for sufficient scale and diversity of use cases. Actions should explore, test and demonstrate how air mobility can be sustainably integrated with urban and rural surface transport systems and what interfaces and dedicated infrastructure are required. Actions should focus on enabling the testing of a wide range of solutions and technologies to allow for rapid innovation and policy learning while ensuring public safety and acceptance. Initial actions should focus on valid use cases in emergency and critical services and sustainable logistics. Actions should focus on validating use cases in particular for emergency and critical services as well as for intermodal small goods logistics chains. Actions in passenger transport

should focus on validating and prioritising the potential of drone-based ridepooling and public transport services.

3. Validate and integrate virtual mobility

Replacing physical mobility and transport demand with virtual services has the potential to reduce overall transport demand and to open up new pathways for the organisation of work and social collaboration. Shifting mobility flows to virtual platforms that allow for social interaction, communication and value creation (e.g. teleworking and distance-learning) can release physical public space for more productive uses and provide for more liveable cities and regions. Actions should focus on exploring and validating the potential contribution and real-word performance of virtual mobility services and provide evidence that they can contribute to travel avoidance and more sufficient travel behavior. Actions should validate that the use of virtual mobility services provides for genuine reduction in overall travel demand and that travel purposes are not substituted as users adapt personal travel time budgets without an overall decrease in travel demand. Actions should further empirically investigate and validate the energetic performance of virtural mobility services, the proportion of reneweable energy in their overall enery supply as well as the overall primary energy demand of virtual mobility services and their backend infrastructures to ensure meaningful impact on decarbonisation and sustainability.