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Strategic Transport Research Innovation Agenda (STRIA)
SMART MOBILITY AND SERVICES ROADMAP

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1 Policy Framework, Baseline and State of the Art

Introduction/Context

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

Digitisation 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. Mobility-as-a-Service (MaaS) will increasingly catalyse the public-private co-development and co-delivery of mobility and transport systems and services, as well as shared and open use of public space, data and infrastructure.

The principal prospects for decarbonisation are strong 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 address persistent problems of congestion and accessibility. However, new innovations in technologies and use need to optimise the whole transport system not road-based car travel only to make a long-term contribution to decarbonisation.

In spite of modest, evolutionary innovations, transport continues to represent over 20% of CO_2 emissions and is projected to continue to rise significantly to 2050 even in benign scenarios. Most significantly, transport's share of overall CO_2 emissions continues to increase in current linear projections. Recent scenarios offer little confidence that the policy mix currently deployed towards mitigation will have sufficient decarbonisation impact. Projections toward 2050 appear to offer a stabilisation of current absolute CO_2 emissions from global transport at best and a rather more probable increase of CO_2 emissions, albeit with a reduced rate of increase.

Notably, these scenarios do not yet fully incorporate the innovation dynamics of recent years. A key requirement is for new mobility services to build on zero- and low-carbon technologies, and to contribute to modal shift, efficient demand management and sustainable land use.

The critical link between new technologies and services and transport decarbonisation

Based on current scenario projections, a radical transformation of transport systems is required and will become a key policy challenge. Transport transformation and innovation scenarios currently focus mainly on fuel efficiency, fuel substitution, and end-of-pipe carbon capture as levers for decarbonisation. Future efforts need to focus on the combined and synergetic effects of integrating urban energy, infrastructure and mobility systems including via modal-shift measures, expansion of public transport options, and sustainable land use governance.

So far, policy and innovation efforts remain overwhelmingly focused on incrementally optimising existing private 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.

The potential carbon mitigation performance of emerging new technologies and services such as multi-modal, electric, autonomous, low-altitude aerial, vertical and on-demand mobility has not yet been extensively evaluated, in particular in their integrated application. They 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.

Aim of this roadmap

The aim of this roadmap is to assess evolving technology and use innovations in the field of smart mobility services in view of their systemic decarbonisation potential and with a particular focus on their urban application; to identify needs and priorities for further R&I actions at European level; and to establish a set of guiding recommendations.

Given long investment cycles for transport capital investment, European cities will be increasingly faced with competing claims on future urban transport infrastructure and long-range investment pathways. Identifying and evaluating cost-effective, equitable and successful innovation regimes in cities and beyond is a central European climate and transport policy challenge.

Shaping this new public space will be a strategic opportunity and challenge for European cities, regions and governments. In this context, aspects of both user behaviour and the urban implementation context need to be considered:

User behaviour and lifestyle

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 (i.e. Generations Y, Z and Alpha) 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 are embracing digitalisation and the use of smart phones, 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 provide a principal support factor for decarbonisation, provided that use innovations are building on decarbonised mobility systems.

Smart and sustainable cities

Future transport and mobility services cannot be envisaged as stand-alone sectoral solutions. Given significant urbanisation in Europe, these will need to be embedded in wider smart and sustainable city strategies aimed at increasing urban resource efficiency and decarbonisation. Hence smart mobility services and systems will need to interface with multi-sectoral and city-wide strategies for optimising the use of energy, spatial, economic and material resources. The smart and sustainable city paradigm offers a very useful framework for future integrated mobility and transport services and systems; but path-dependencies need to be considered as well. Cities should also not been seen as stand-alone systems but as embedded in larger regional and European and global mobility systems. Sustainable and efficient linkages between future urban and extra-urban transport networks, including rail and air travel systems, will need to be developed.

2 STRIA Policy Framework and Priorities

The specific aims for this review of STRIA policy and actions on smart mobility and transport systems are to:

- Identify areas of smart services and use innovation that can enable integrated decarbonisation pathways and where further R&I action is needed
- Establish research and innovation priorities and related configuration of funding streams and tools.

The criteria for the STRIA policy and implementation framework on smart mobility and transport systems and services are to identify innovation tools that:

- Stimulate innovation that achieves integrated and balanced performance across key mitigation levers
- Link coordinated and integrated STRIA actions on smart mobility systems to systemic achievement of EU transport decarbonisation targets to 2030 and 2050
- Design for rapid systems invention and diffusion
- Enable leverage of private, institutional and crowd capital to sustain STRIA innovation streams

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 per cent 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.

Moving forward new mobility systems and services have to be examined with regard to their contribution across the core transport decarbonisation levers available:

- Demand and land use management
- Modal shift
- Fuel substitution
- Fuel/energy efficiency

The remainder of the section discusses briefly the role and relevance of new mobility service innovations to contribute to these levers and to meeting overall decarbonisation targets.

Demand and land use management

With the proliferation of digital technologies and the emergence of the connected traveller it will be easier to influence demand real-time by shifting demand in time (out of peak hours) and space (to alternative locations or routes through intelligent applications and user information services. Integrated urban traffic management and mobility information systems can contribute significantly to optimising transport flows through cities and in rural regions.

Cities can enable greater public transport capacity and efficiency by providing door-to-door mobility information and guidance systems and by facilitating intermodal travel chains. In conjunction with active traffic management strategies for prioritising sustainable modes of transport, digital mobility innovation offers a significant opportunity for cities to optimise, transform and sustain integrated public transport systems. If individual mobility services can be integrated (in first/last mile and supplementary function) with public transport systems, the overall efficiency of urban mobility systems can be greatly enhanced and thus contribute to avoidance of unsustainable modes and efficient demand management

With regard to urban logistics and delivery services, smart mobility services enable avoidance of unnecessary vehicle movements in urban areas by making last mile deliveries more efficient by consolidating goods flows. A key challenge will be to develop shared data, infrastructure and logistics business model~~s~~ for urban goods distribution that deliver a more efficient utilisation of public transport infrastructure across both passenger and goods transport modes.

There is, however, a risk that disruptive technologies such as on-demand intelligent mobility vehicle automation and electrification of road transport could generate more demand for mobility by providing easier access to these services and vehicles and improving the 'image' of individual travel. The possibility to spend travel time efficiently, in an automated vehicle, for example, may increase trip lengths and therefore result in urban sprawl and further traffic growth. Equally, individual mobility services could counteract current positive trends toward public transport and active travel modes.

The contribution of mobility service innovations to sustainable demand and land use management is thus dependent on their embedding in an overall mobility and transport strategy for the whole city. New economic and technological trends influence land use patterns and people's lifestyles. Digitalisation, on-demand mobility, flexible and cleaner production can increase the chances of higher density development and a more balanced mix of land uses (residential, commercial, production, schools, parks), potentially reducing demand for unsustainable travel modes. Identifying and validating the positive contribution that new mobility services and systems can make to sustainable, transit-oriented urban development should be of central concern to European innovation efforts.

Modal shift

Reducing the share of travel by combustion engine vehicles can lead to significant reductions in CO_2 emissions. This involves a reduction of use of personal-use and single-occupancy vehicles by promoting the use of more energy-efficient modes such as conventional public transport, other shared transport, as well as cycling and walking. Across a number of Europe cities daily travel modes have shifted away from the automobile and towards public transport or active travel (London, -12%, Berlin -8% from 1998-2013, Brussels -18% from 1999-2010).

New technologies, big data and real-time information on demand and supply will make these tools more efficient in promoting modal shift. The measures include financial measures (dynamic pricing of road-use and parking), mobility budgets, business models for mobility-as-a-service, incentivizing sustainable modes over individual car use, regulatory interventions to restrict access to sensitive areas and parking, integrated intermodal terminals and park and ride services, integrated ticketing and real-time information covering all modes.

While it is currently not realistic to expect that all car travel can be shifted to other modes, it is desirable that car travel shifts to more sustainable practices by promoting carpooling and ridesharing services together with the transition towards electric mobility. Car sharing and short term rental in principle do not reduce passenger/vehicle kilometre ratios and as such do not constitute modal shift, but they have the potential to decrease the overall amount of vehicles required.

Automated shared services could further reduce car ownership. Yet, with a stable or increasing requirement for mobility, automated vehicles will only reduce emissions and energy consumption if they are zero-emission and sustainable from a full system perspective.

The shared use of physical infrastructure (e.g. off-peak use of underground or light-rail passenger networks for goods distribution) could provide for significant modal shift potential by moving goods delivery from road to (electric) rail systems. Where available, better integration of water-borne urban passenger and goods mobility could also provide for more efficient and sustainable use of existing urban transport infrastructure.

Fuel substitution

Fuel substitution is a central lever to be deployed in decarbonizing transport by seeking to reduce the CO_2 intensity of energy use in transport and to decarbonize propulsion systems (TTW Emissions) The current aim is to shift as much fleet share as possible from gasoline and diesel cars towards electric vehicles. Further market pull and pricing measures that foster the purchase of alternative fuelled cars are required to make such shifts happen and to reach emissions targets in the upcoming decades.

Smart mobility innovations contribute to decarbonisation where they are integrated into the fabric of an urban area. Shared electric vehicles within and across corporate and public fleets increase availability and attractiveness through common use solutions. To attain maximum decarbonisation impact, however, smart mobility innovations will need to be integrated with renewable energy, smart grid and energy storage systems (i.e. not be solely focused on the electrification of existing fleets and modes).

Fuel and vehicle efficiency

The reduction of the existing conventional car fleet's fuel consumption by increasing the vehicle fleet's fuel efficiency has been the main lever of CO_2 emission mitigation to date. Stricter emission standards have increased the energy efficiency of cars during the last decades. Emission thresholds for new cars sold in Europe is currently 130g CO_2 per km and 95 g CO_2 per km from 2022 onwards. Between 2000 and 2010 average European car emissions decreased by 18%. Two major reasons for this are reduced fuel consumption of conventional automobiles and an incremental uptake of alternative-propulsion vehicles.

Mobility services innovations are not directly linked to fuel or vehicle efficiency as such, but rather support indirectly through optimising use conditions and contributing to fleet modernisation.

3 Trends, Technologies, Services and Innovation

This section discusses further key innovation trends in technology and use innovations for both public and private passenger and freight transport and mobility services, as well as underlying trends in data analytics and broader governance issues.

Smart mobility services in public and private passenger transport

Public transport services
European public transport systems are actively adopting new, ICT-enabled user navigation, routing, booking and ticketing applications. These provide users with real-time timetabling and route optimisation, seamless travel and digital ticketing. Smart public transport services and systems can provide the backbone for future integrated smart mobility. Allowing multiple infrastructures to integrate and communicate with one-another, can pave the way for 'one stop shop' platforms that consolidate multiple forms of transport and provide 'mobility as a service'.

Sharing and short-term rental
Car-sharing schemes (both point-to-point and station-based networks) continue to grow in number throughout Europe, with automotive manufacturers and traditional rental-car companies currently dominating the market. A convergence of sharing providers and mobility services models is to be expected.

Mobility as a service (MaaS)
Technological, socio-demographic and behavioural change are facilitating a move towards multimodal transport – combining walking, cars, buses, bikes, trains and other forms of shared transportation. Driven by the transition from "owning" to "using", Mobility as a service (MaaS) enables multimodal mobility by providing user-centric information and travel services such as navigation, location, booking, payment and access that allow the use to consume mobility as a seamless service across all existing modes of transport.

Public and private business models, payment methods, technologies, and user choices will continue to coevolve alongside data sharing by users and public infrastructures, and increasing cooperation between the public and private sectors. Mobility as a service should also provide more cost-efficient mobility options to consumers and households by reducing vehicle acquisition and maintenance expenditures.

Mobility-on-Demand

Primarily software-driven, MaaS is the precursor of specifically-designed 'Mobility on-demand' transportation hardware and services. The transformation and convergence of transport and mobility systems and services presents a unique opportunity to develop post-fossil, user-centric, smart mobility systems based on access to individual, public, shared and active mobility, rather than ownership of private automobiles. This in turn requires the integration of personal electric vehicles (PEV) into multi-modal public transport and mobility-on-demand systems to allow users flexible and convenient access to a range of travel modes while socialising the high initial costs of switching to electric vehicle-based mobility.

Integrated Mobility-on-Demand services can contribute to modal shift to public transport and also address the spatial inefficiencies of private individual motorised transport. User-centric urban mobility systems will provide ubiquitous check-in/check-out user access to enable both inter- and multimodal mobility on demand and enhance overall transport efficiency. In future integrated and sustainable mobility-on-demand systems, electric mobility will become a component of both power and public transport infrastructure and systems. The smart integration of tariff structures, data and user interfaces as well as the disposition of rolling stock across these sectors is a central challenge, which requires new business models and scheduling, booking, navigating, ticketing and charging solutions.

Autonomous Transport Systems

Big Data and advances in artificial intelligence – in particular by providers from outside of the transport and automobile sectors – are driving development of autonomous systems. In the transport and mobility sector, a renewed focus has emerged on automating passenger vehicles and moving towards fully autonomous individual mobility. Autonomous systems are equally being deployed in public transport, including busses and rail systems.

Autonomous electric vehicles are expected to form a significant component of 'mobility as a service' for urban transport. As with sharing models, autonomous vehicle (in public or private service) technology will blend with MaaS models and can potentially also enable ubiquitous smart traffic management. In deploying electric and shared autonomous vehicles (SAEVs) the benefits of these mobility strategies can be combined to greater effect.

The arrival, legalisation and rollout of Level 4 autonomous vehicles could pave the way for driverless mobility services, undertaken by SAEVs that will offer door-to-door, on-demand mobility services across modes integrated with backbone high-throughput public transport networks. Various business models and providers will define these mobility services: individual users, public transport providers, automotive, EV and micro-vehicle manufacturers, third-party logistics platforms; the high-technology and services sector (more-so than the traditional automotive) appears to be leading innovation in this area.

Fleets of autonomous vehicles in densely populated areas may result in a significantly reduced requirement for privately owned vehicles (according to one study, with current battery technology and a sufficient charging infrastructure, a substitution rate of 5.5 privately owned vehicles for each SAEV can be predicted). Deploying fleets of SAEVs should provide for more efficient charging and power management solutions as vehicles can autonomously monitor battery levels and access charging points independently. The increased ease-of-use of these vehicles further reduces barriers to user acceptance of electric vehicles with regard to cost and range anxieties. SAEVs can also contribute to future business models for shared individual mobility as the utilisation of vehicles is optimised and can be activated on demand and without human labour.

Such services can supplement or substitute current rigid-line public-transport systems in particular in first and last mile journeys (and will consequently be significantly cheaper than on-demand driver-operated transportation services).

Smart mobility services in freight and logistics

Significant growth in small-goods and large-goods logistics activity is to be expected; by 2050, freight activity is expected to increase by as much as 250%. Strong growth in online retailing and attendant increases in freight volumes and last mile goods delivery are leading to rising carbon emissions from road-based freight distribution. Future mobility and transport services cannot be viewed in isolation from future urban logistics. Changing retailing behaviour also affects personal travel behaviour. Counterintuitively, this may also lead to additional passenger transport demand, as users are freed up to pursue alternative trip purposes. Clearly the rise in urban goods traffic will lead to further conflicts and capacity constraints on the use of urban space and thus is inextricably linked with overall transport transformation.

Systems, freight and logistics

The evolution of 'smart' systems that allow for cooperation between infrastructures (road, rail, air, shipping) to allow for seamless freight transport will be crucial in facilitating increased capacity – from the port to the last-mile. Loading and unloading cargo that is electronically tagged (thereby carrying all required information to allow for reliable international tracking and reduced border delays) onto autonomous convoys of self-driving trucks will be aided by automated robotics systems. Wide-scale deployment of autonomous freight shipping is imminent; increased mobile internet availability, adoption of (and developments in) Differential GPS and Automatic Identification Systems and advancements in computer vision will accelerate a transition towards crewless cargo ships and fully autonomous docks. Logistics will also become increasingly smart, as artificial intelligence advancements (such as machine learning) allow for the leveraging of data collected throughout the transport chain, rapidly identifying bottlenecks, solving path optimisation problems, and coordinating efficient flows through and across infrastructures.

It is becoming increasingly likely that many of the future smart mobility services envisaged for personal transportation - electric, autonomous, shared, and connected - will initially be developed and implemented in the goods delivery sector (i.e. logistics) which is already leading innovation in many of these areas. Given health and safety, regulatory and political concerns regarding autonomous vehicles and the application of total data and user transparency, steady-state integrated and electrified mobility-on-demand systems are likely to be deployed in freight distribution first. In the context of this report, new freight and logistics services and systems will be reviewed against the same evaluative framework as personal transport systems in terms of delivering against integrated decarbonisation levers.

Drones and low-altitude aerial mobility

A rapid proliferation of drone technology is taking place due a combination of forces, such as technological transfer from other industries, 'bottom-up' open innovation practices such as accessible platforms and collaborative research and significant R&D drives from large companies looking to operate commercial drones in the retail sector.

The integration of vertical urban mobility into existing horizontal transport systems will add further complexity to the organisation of the urban transport and mobility services. Early evidence indicates that light-weight drone platforms can deliver both economic and energetic efficiencies in the short-range distribution of small good. Effective integration of drone-based delivery systems with other urban logistics, public transport and building services infrastructure is a promising innovation vector. Drone and low-altitude aerial mobility is now technically possible for passenger transport also and the combined demand for such on-demand vertical urban mobility solutions will require significant governance, regulation and infrastructure innovation.

Underlying trends in data analytics and governance

Big and Open Data

Faster and cheaper processing (as per Moore's Law) has led to the rising significance of data and in particular Big and Open Data. Freely available data capacity and computing power now enable significant optimisation of energy efficiency, spatial distribution and utilisation of transport, mobility and smart city assets and systems.

Big and Open Data and ICT can provide the tools to connect users, moving stock and infrastructure and to integrate optimisation of transport systems across these domains. It is important to note that data collation and ICT in itself is not smart and cannot provide for smart services and systems. The potential lies in deploying data availability and smart data analysis to develop smart strategies for optimisation in the physical realm rather than simply collecting data in the virtual.

Data Governance

The flow of big and open data, while of central importance for smart mobility services and systems, will, however, require significant governance and regulatory design to ensure the interests of all stakeholders and their access to available data are equally protected. Individual data privacy rights and the ownership of mobility and city data will need to be addressed and regulated to ensure both competition and freedom from illegal governmental or commercial surveillance.

The line between public and private data resources is blurring – potentially to the benefit of all transport users (e.g. Transport for London makes public large amounts of its operations data; this allows third party providers to provide user-centric offers around it). Public and private transport providers should be encouraged make public – and share – as much of their data as possible to provide seamless user interfaces across modes. Ensuring the privacy and anonymity of their users should be visibly paramount to ensure user acceptance.

Data availability and processing

Transport systems need – and are increasingly able – to aggregate and analyse data from multiple sources and networks to dynamically respond to demands and operate more efficiently.
There are a number of important enabling trends:

- Data provision from sensors that are smaller, less expensive and more reliable.
- Artificial intelligence systems, machine learning and data processing capabilities that are improving, and transport networks that are becoming increasingly 'connected' (via more reliable wireless internet connectivity, increasingly accurate GPS, etc.).
- Sensors and data processing capabilities that are increasingly interconnected via the 'Internet of Everything' (IoT); traffic networks and infrastructure are "learning" from the data collected and adapting toward greater efficiency.
- Growing data storage capacity that allows for larger amounts of data to be stored relatively easily and for little cost.

These enablers are driving innovation and development towards connected mobility and integrated transport information management systems, however existing governance and management systems are often constrained by sectoral regulation and management focus. Current infrastructure governance often does not yet allow for seamless data connectivity across separate infrastructure systems such as mobility, energy, and built environment and across both private and public service users and providers.

Mobility optimisation

'Big Data' collection and analysis (from multiple transport networks, public and private) and path optimisation algorithms can intelligently schedule and reschedule journeys to avoid bottlenecks, sensibly distributing commuters during busy periods (such as rush-hours) to smooth traffic flow and increase the efficiency of the entire transport network. Vehicle-to-vehicle (v2v) and vehicle-to-infrastructure (v2i) communications will allow for increased safety and greater (energy) efficiency on the roads. However, smart traffic management systems must ensure international interoperability to allow for an environment of competitive solutions to evolve across the EU. Traffic optimisation strategies will need to be a component of overall transport and mobility system governance and management, rather than focus on optimising conventional vehicle flows which can create further unsustainable demand.

Mobility and transport services and systems at city level

Digitalisation of public infrastructure

Digitalisation and service innovation are generating transformation across all transport domains. Within the overall Smart City paradigm, smart mobility and transport systems are embedded into wider urban systems integration relating to smart energy, utilities and infrastructure. Assessment of smart mobility services needs to account for the contribution to wider smart city performance, in particular with regard to renewable energy and electrification strategies, as well infrastructure management and urban design.

Smart mobility service and technology innovations are often user-based and vehicle or infrastructure-centric. Vertical solutions need to be intelligently linked across different transport sectors to optimise infrastructure use. Sustainable integration of users, vehicles and infrastructure is a core transformation lever that has great potential for cross-sectoral optimisation and deep decarbonisation impact. Supporting innovation at the systemic – not the elemental – level can accelerate the transition to low-carbon, user-centric, smart mobility systems based on access to individual, public, shared and active mobility.

Open flow of data across infrastructure and user domains is an important enabler for smart mobility services and systems innovation; however the design, governance and maintenance of public digital infrastructure will require dedicated public resources and regulatory frameworks.

Smart city design, sustainable land use and spatial governance

European cities are pursuing a range of smart city design, targeted local emissions regulations (including CO_2, NOX and noise) and spatial governance strategies aimed at increasing the overall resource and spatial efficiency of urban systems and at improving overall quality of life for citizens.

These include low-emission or congestion charging zones, transit-oriented development and public space reconfigurations that reclaim road surfaces for other urban and environmental functions. These are generally receiving broad public support and will increasingly reshape urban centers away from car-based design. This also includes a marked refocusing of surface infrastructure towards non-motorised and active travel modes such as walking and cycling. Cities are also striving to repurpose inner city space dedicated to individual motorised transport to different economic uses.

Urban design and spatial planning will continue to transform as smart city and mobility systems evolve. By reducing congestion, pollution, and energy use, smart mobility solutions may lead to a 'revival of inner cities' (by simultaneously reducing the cost of travel over all distances there is a risk, however, they may also lead to more rapid exurbanization).

Smart urban design and spatial governance is increasingly also enabling alternative vehicle design and a move towards non-car based individual micro-motorisation with lightweight and small size (one, two or three wheeled) personal electric vehicles. With limited speed and spatial footprint such micro-vehicles are expected to further accelerate urban land use reconfiguration and the shared use of urban road surfaces with non-motorised mobility modes.

4 EU Transport and Mobility Systems and Services Innovation: Key Recommendations

Aims and Priorities

Moving forward EU STRIA action will need to develop scalable innovations that combine smart and sustainable solutions to allow for long range deep decarbonisation of transport systems and the ecological modernisation of urban infrastructures.

There also exists a unique opportunity to develop and take European sustainable innovation to the global market and sustain long-term economic success, energy security and infrastructure resilience. A key challenge will be the intelligent integration of business and governance models for new mobility technologies, services and systems **to stimulate innovation and to assure both efficient and equitable access to sustainable mobility.**

Innovative operating models

Effective collaboration of cities, users, science 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) must work in tandem with privately owned and run services (such as shared electric and autonomous vehicles), all of which will utilize new technologies that will need to be developed on the basis of both public and private investment. New operating models are required that allow for backbone public transport and mobility services to collaborate effectively with private individual mobility providers to co-deliver sustainable mobility and transport systems. Municipal and regional institutions will need to be equipped with strategic capacity to transform and develop stable operational frameworks for new urban mobility. This will require innovative approaches to cross-sectoral planning, public participation and procurement and the shared use of embedded physical and technical infrastructure.

Development of integrated mobility systems

A core focus should be to enable cities, users, science and industry to collaboratively devise multi-stakeholder solutions to the complex problem of mobility and to test and develop them at sufficient scale. It is in the interest of all stakeholders that the private and public sector collaborate not just on research, but on on-the-ground operations such as data sharing, network and infrastructure access, and the development of inclusive user interfaces. The burden of research and analysis should be shared by the private and public sectors, as each will rely on the other for effective technological advancement and sustainable use innovation.

Sharing Data and Infrastructure

Companies, governments and public entities should be equally encouraged to provide 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, 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; only by making data such as aggregate dynamic mobile phone and traffic data, the real-time location of buses or the accurate arrival time of trains ‘open’ will third parties be able to integrate it into their systems and establish truly ‘cross-infrastructure’ integrated mobility systems.

Future interoperability

Support in the development of EU Technical Standards for communication and interoperability of user devices, critical infrastructures, v2v and v2i will be vital. It is important that such standards can evolve and adapt with technologies to prevent innovation stagnation. This should encompass a dialogue between users, governments, science and industry (including both incumbents/long-term players in the mobility sector and startups). 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 international interoperability to as great an extent as possible.

Key Recommendations:

- *STRIA innovation funds should be awarded in openly structured calls rather than by prescribing specific solutions and targets. Innovation projects should be selected based on evaluation of systemic decarbonisation ambitions and intended impacts.*

- *Innovation actions should focus on single city, large-scale and city-led lighthouses which*
    - lead to sustained integration of solutions into city operations at real scale (beyond small scale pilots) and at the spatial level of the daily urban system (DUS) and pursue long-term decarbonisation impacts
    - develop the strategic capacity of municipalities and regions to manage integrated transport systems and infrastructure
    - effectively integrate partners from the quadruple helix of government, science, industry and user in the shared development of future mobility and transport services and systems in real-world settings
    - contribute to the *integration* of new mobility service innovations with existing (public) transport infrastructure into an overall urban mobility system allowing for optimal (co)use of infrastructure for passenger and freight transport
    - beyond facilitating new mobility services focus on a more efficient use of existing (public) transport infrastructure within wider sustainable land use and urban development strategies

- *Innovation strategies and programmes should design and deploy innovative but robust arrangements for public-private co-production of transport and mobility services, addressing in particular:*
    - the shared and efficient use of existing physical transport infrastructures, (in particular backbone urban transport infrastructures, parking structures, delivery nodes and intermodal hubs), across public, private, passenger and freight sectors and modes
    - the secure collation, management and protection of user and city data in public and commercial open data platforms and public digital infrastructures

- the enablement of real-time, informational, transactional and operational interoperability across public and private service providers, municipal operators and individual users
- the innovative integration of access, tariff and user interface systems for public and private transport and mobility services

- *Innovation actions should design and implement governance, regulatory, and public procurement strategies that:*
  - deploy integrated indicators and urban plans and focus on validating balanced impact across integrated indicators of transport decarbonisation and sustainable land use.
  - catalyse and strengthen the development of integrated planning tools and open, real-time data systems to allow for the validation and optimisation of integrated mobility eco-systems against overall sustainability targets (e.g. SUMPS)
  - Enable integrated and strategic public procurement of open, interoperable and cross-sectoral solutions