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New Mobility Services Roadmap

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Table of contents

1. Glossary

Acronym	Definition
NMS	New Mobility Services
KPI	Key Performance Indicator
MoU	Memorandum of Understanding
GDPR	General Data Protection Regulation
IP	Intellectual Property
SMA	Sustainable Mobility Authority
PTA	Public Transport Authority
MaaS	Mobility as a Service
PRM	Persons with Reduced Mobility

2. Introduction

Following the 2017 ERTRAC urban mobility roadmap, which identified the research and innovation needs to meet societal challenges and economic patterns emerging in cities and impacting urban transport, this focused roadmap specifically addresses **shared and new mobility services** and their role in a sustainable urban mobility ecosystem. It aims at defining the research required to reap all potential benefits these new services can bring to urban mobility, while avoiding the drawbacks and negative externalities resulting from an inefficient and unregulated development of mobility innovations.

With growing digitalisation and the generalised adoption of mobile devices by citizens, the number and variety of new and shared mobility services, which are inherently digital in nature, has recently exploded in cities. This requires reshaping the role of public authorities as orchestrators of an urban mobility ecosystem, which combines both public and private sector-driven mobility services. With a multitude of commercial mobility service operators, the landscape of urban mobility has suddenly been transformed, if not overpopulated. There is clearly a need to frame this new panel of urban mobility players, to ensure their commercial services support public policy objectives, an alignment which is not a given. Innovative services have shown great potential to improve the accessibility, inclusivity, liveability, and sustainability of people and goods transport in cities. At the same time however, they represent certain risks, which must be anticipated through well-thought-out urban mobility policies. This cleavage between risks and opportunities appears in previous research focusing on various types of new mobility services:

- While **micromobility** vehicles such as shared e-scooters could replace polluting vehicles for certain trips, they contribute to higher waste and pedestrian disturbance, are not optimal from a road safety point of view, and can induce an unwanted modal shift away from active travel or public transport, when misused and unregulated1
- **Mobility as a Service** (MaaS) improves access to the full range of available transport services, potentially reducing car use/ownership, but a purely commercial approach, without public sector oversight, may nudge users towards the most commercially interesting rather than the most sustainable modes. This could prove detrimental to public transport and active travel, which are the essential backbone of urban mobility2
- The benefits of **autonomous vehicles** (AVs) in terms of road safety, vehicle use optimisation, accessibility, economy3, etc., are to be weighed against the need for required infrastructure investments, and the risk of potential rebound effects, such as an increase in car-travelled distance, with a resulting congestion rise and environmental consequences4.

This roadmap addresses diverse innovations with different potential impacts on urban mobility: services providing physical vehicles like shared micromobility or car-sharing schemes, but also fully digital services such as MaaS applications or ride-hailing platforms, as well as technological innovations like automated vehicles, and drones. What is considered as a “new mobility service” (NMS) has not yet been regulated and upsets the traditional transport system in the city. It relates to new actors, new types of ownership and business models, new types of vehicles, and new uses of public space, therefore resulting in new monitoring and enforcement needs, impact assessments, demand management approaches, permit schemes and regulatory frameworks.

[1] POLIS paper on Micromobility, 2019.
[2] POLIS paper on MaaS, 2017.
[3] Kris Redant and Hinko Van Geelen, “Connected & Autonomous Vehicles and road infrastructure. State of play and outlook”, Belgian Road Research Center, Brussels, 2020.
[4] POLIS paper on road vehicle automation, 2018.

This roadmap highlights the research needed in four main areas:

- Studies to be conducted on **fair and efficient policies and regulatory frameworks**, to ensure NMS are best used, i.e. their potential is maximised and their possible disbenefits and negative externalities are mitigated. These include improved impact assessment, governance models, policy incentives and disincentives, public-private partnerships, and new business models.

- Investigations to be run on **user needs and user behaviours**, and how to align them with both the additional resources to travel made available through NMS and the common objectives of sustainability, accessibility, health, and inclusion.

- Actions to be taken for a more adapted **digital infrastructure and data management**, including the development of new tools for traffic management based on data sourcing, the establishment of algorithmic governance, progress on data sharing approaches, and MaaS infrastructure and processes.

- Research required for an optimisation of **urban space and physical infrastructure** management across different modes, both old and new. This includes research and trials on the impact of the reallocation of road space and dynamic curb side management, enablers for intermodality and multimodality, and studies on how to deploy new mobility services and reduce car dependence in suburban areas and how to better connect them with urban cores.

These recommendations on research priorities are not exhaustive. They provide guidance on a path to follow to frame the evolution of NMS. They have been drafted based on interviews with 15 urban mobility experts from various domains and sectors: research institutes, NMS providers of different kinds, industry, cities, related associations, and other key transport stakeholders. They also build upon the work of European projects addressing related issues, and publicly available reports from recently conducted research. This ERTRAC roadmap has been developed in close consultation with the joint ERTRAC-ERRAC-ALICE Urban Mobility Working Group.

3. Policy goals & regulatory frameworks

To ensure that NMS support urban mobility policy goals in the best possible way, the latter must be clear and efficient. The diversity of policy and regulatory frameworks with which NMS are confronted illustrates the challenge of defining optimal rules, processes, and guidance, and at the same time reveals the wide range of different local contexts and ecosystems across cities.

Clear and efficient policies and regulations should enable the development of sustainable and fairly distributed NMS, which complement public and traditional transport means. On the other hand, they should limit the expansion of services with a heavy environmental footprint, detrimental to citizens' health and safety, source of congestion and enhancing access inequity. To ensure policy makers can set up such optimal frameworks, more research is needed on what works and does not work, and tools should be developed to support them in creating such an optimal regulatory environment. This part elaborates recommendations on the assessments required to define the most suited frameworks, then on the adoption of the right tools to incentivize the right services, and finally on the governance model and key characteristics to prioritise in order to achieve an efficient and sustainable urban mobility ecosystem.

3.1. Impact assessment

New mobility services change the face of cities and the habits of citizens. Assessing these changes would help to understand what benefits the services can bring, and what negative impacts they may have. Such information can provide evidence of the concrete impacts of NMS deployment, and support decision-making for a better evolution. For example, what is the modal shift caused by the availability of new types of vehicles such as e-scooters: do e-scooter rides replace car trips or rather active travel and public transport?

Some providers have started gathering such data, but research at city level would be necessary to validate the results. Therefore, **exchange and cooperation with the stakeholders able to collect such data is required, as well as capacity-building in the public administrations, for them to manage this cooperation and exploit the data available.**

3.1.1. Aspects to assess

The modal shift generated by NMS is an important part of the assessment of their impact on the urban mobility ecosystem, but it is surely not the only one. Different aspects of NMS must be considered and observed to identify their **influence on travel behaviour, citizens' health and safety, the city's economy, the use of urban space, and the impact on the urban fabric as a whole**. They are non-exhaustively listed in table 1 below. Some of these aspects have already been the subject of international research[5], but the impact assessment should be done at local level, involving cities and other local authorities, who need fact-based guidance to make choices for local transport policies.

[5] ITF Report, "Good to Go? Assessing the Environmental Performance of New Mobility", 2020.

Public impact assessed	NMS aspect	Elements for assessment
Availability of transport services for citizens	Availability	Localisation of stations and vehicles, number of vehicles available, charging infrastructure set-up, public space used for parking
Accessibility of transport services for citizens	Accessibility	Transport capacity of the vehicles, access for PRM, conditions for access (e.g., smartphone)
Affordability / Equity of access of transport services for citizens	Cost of using NMS	Subscription price, charging price, maintenance costs, etc.
Suitability of services to citizens' needs	Use by citizens	Origin/destinations, day periods of trips, profiles of users
Energy consequence on the grid of the use of transport services	Energy consumption	Charging times and intensity, time of charging, place of charging
Environmental consequence of the availability of NMS	Environmental footprint	Life cycle of vehicles and batteries, emissions, energy consumption in the manufacturing process
Efficiency of freight services	Use of public space	Parking places of vehicles, times, and periods of occupancy in relation with freight activities
Diminution of individual car trips	Mode choice	Survey users to get data on a potential modal shift
Citizens' safety and security	Safety of vehicles and infrastructure	Number and conditions of crashes
Compliance with rules	Monitoring of fleet size and distribution, parking	Geofencing limits

Table 1 - Impact assessments to conduct at local level

Impacts of policies, regulations and mobility solutions (including their design and deployment) are multi-dimensional and should be assessed in different ways, according to the (possibly conflicting) perspectives of the various stakeholders. They should, therefore, be addressed by **multi-criteria approaches**, thus emphasizing the "trade-offs" those solutions reflect and the "values" conveyed by policies and regulatory frameworks. For example, the life cycle assessment of vehicles should be conducted under different MaaS configurations, rather than specifically for each service. This would give different evaluations of MaaS options for one travel from A to B.

3.1.2. Tools to develop for assessment

The impacts assessed should be structured in a hierarchical way, allowing an assessment at different decision-making levels. They should depend on the context and on the specific urban characteristics, and on the maturity level of technology adoption.
Conducting impact assessments at a given point in time, and in defined places, will bring evidence on the potential socioeconomic benefits of transport options, supporting policy making. But how to make sure policies remain up to date and relevant with regards to the evolution of local contexts? **A continuous real-time assessment is necessary to monitor and support the development of NMS which contribute to policy goals**.

Data and digitalisation are key assets to build on for real-time monitoring of NMS. This is acknowledged by all mobility stakeholders. **What is needed, is a definition and classification of the data required, identifying which aspect of NMS impacts it enables to assess and how**, i.e. use cases defining what data is needed for what purpose.

- Currently, NMS data shared with public authorities is used to monitor the compliance of NMS operators with operating rules such as fleet distribution, fleet size and service area limits[6]. However, despite the potential value, it is currently not so much used to inform the design and management of infrastructure such as lanes and parking places, to monitor road safety and implement traffic calming measures, or to support the enforcement of operating rules. It is also not much used to incentivise or discourage the deployment of new services.

- There are expectations that data-sharing from NMS would contribute to increase road safety and improve infrastructure, facilitate access to micro mobility vehicles and services, improve social mobility, and quality of life. To achieve these expectations, resources and capacity-building are required for the public sector, to bridge the gap with private sector data skills, or at least the perceptions thereof. Use cases showing how data can contribute to the above-mentioned goals are indexed on the New Urban Mobility platform[7]. **This indexation is however still in progress and must be maintained and constantly kept up to date.**

Beyond the data definition, **research on the most efficient legal conditions and viable business models allowing the collection of this data is also needed**.

- Indeed, both public authorities and private actors identify privacy concerns and the compliance with GDPR as a challenge in the process of data sharing and exploitation for impact assessment and policy information[8]. The **commercially sensitive** nature of the data represents an issue as well on the public side for exploitation and could be eased with defined legal frameworks, and with the corresponding data agglomeration mechanisms, which enable information exchange while protecting private and public privacy (e.g., business models).

- Besides, the **cost o**f data collection and storage is an important challenge for the private side, while the analysis of shared data requires an expertise considered as an obstacle by public authorities. To solve these issues, viable business models must be defined and tested.

NMS operators on their side are asking as well for smart indicators to analyse their role within the urban mobility ecosystem. They would appreciate the definition of smart **Key Performance Indicators** (KPIs) at city level, for their services to be most relevant in local contexts. Traditional indicators currently used to monitor the performance of urban mobility systems do not cover recently developed services.

[6] HOMEM DE GOUVEIA, Pedro, BABIO, Laura, "Sharing data for shared micromobility", POLIS Survey Report, January 2021, available online, last consulted on April 9, 2021.
[7] NUMO, "Micromobility & Your City, A Mobility Data Tool for Cities", available online, last consulted on April 9, 2021.
[8] HOMEM DE GOUVEIA, Pedro, BABIO, Laura, "Sharing data for shared micromobility", POLIS Survey Report, January 2021, available online, last consulted on April 9, 2021.

These indicators are difficult to translate into data and are not reflecting the situation on the ground, as shown by the works conducted within the SUMI project funded by the EU[9]. **Further research is necessary to develop the right indicators, providing key evidence for the adoption of adequate policies**.

3.2. Governance models

Beyond the analysis of impacts and consequences of NMS on the urban mobility ecosystem, research must be conducted on the most appropriate governance models for the integration of the respective NMS, as well as their complementarity with public transport and active travel, into a comprehensive urban mobility ecosystem. To avoid a harmful competitive consideration of services, leading to the success of most commercially oriented ones, solid and comprehensive frameworks must be established. Besides, governance must be able to both adapt to suddenly emerging NMS and anticipate potential innovations to best frame them.

3.2.1. Governance of individual mobility services operating in a city

Shared commercial mobility services operating in cities should be governed and regulated to make sure they align with public mobility policy goals, complement public transport and active travel instead of "cannibalising" it, and contribute to a better, more sustainable and more inclusive urban mobility ecosystem.

Risks of negative externalities for each service should be derived from assessment enabled through the aforementioned approaches. Based on these analyses, more or less stringent regulatory or legal procedures (MoUs, permits, licences, tenders, ...) can be introduced at city level to ensure NMS offer opportunities which are beneficial to citizens, without crowding public space, worsening access inequities or air quality. **Research on the impact of different governance models and the different features included is needed.** This should also consider the mutual effects of different decisions and various implemented NMS in the city.

EU-funded research is elaborating a state of play of NMS' impacts on regulatory and governance frameworks[10]. Given the currently very dynamic landscape, this undertaking must however be constantly updated with contributions from various cities in various contexts and progressive insights in terms of what works best in which context. Moreover, the potential and impacts of the "sharing economy", which go far beyond the currently deployed NMS, with fuzzier forms of collaborative networks and services (e.g., with "informal logistics" in last mile delivery systems) should be integrated. The proposed dashboard[11] must be used by cities including NMS in their governance and regulatory frameworks, as a precondition for quality, to have the impact intended. **To encourage exploitation, communication efforts are needed, and resources and capacities are required at city level to be invested in this framework's elaboration and updates.**

For an optimal governance of NMS, a model based on a Sustainable Mobility Authority (SMA) rather than a Public Transport Authority (PTA) would enable the integration of all areas influencing urban mobility into transport governance. This SMA would not only cover public transport but also parking, land-use, public space (as Transport for London does, and many cities do). It would have the control on the current situation and be able to manage future mobility.

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[9] The SUMI Project has provided support to urban areas to apply the WBCSD mobility indicators, has created a bench-marking add-on to the WBCSD calculator tool, and has built experience for the improvement of the WBCSD mobility indicators.

[10] The EU-funded GECKO project supports authorities in developing the most appropriate regulatory framework and governance model, through guidance, recommendations and case studies, for the transition to a new mobility era of cooperative, inclusive, competitive, sustainable and interconnected mobility across all modes, through evidence-based research.

[11] Regulatory Frameworks Dashboard developed in the framework of the GECKO project, more detail at http://h2020-gecko.eu/tools/dashboard.

3.2.2. Governance for MaaS

MaaS integrates different transport services into a mobility offer. It personalises the mobility offer with the delivery of services belonging to the public sector (e.g., selling public transport tickets) as well as private sector (e.g., shared mobility). It can induce inclusivity of the transport system through this personalisation of offers, and sustainability with the promotion of alternatives to private car use, as well as improve multimodality and intermodality. However, it can also lead to higher costs, discourage sustainable modes' use, underservice unattractive areas and user groups and therefore reduce accessibility, and disconnect users from providers and authorities[12].

Considering this duality, **a need for definition and study appears on the best role for public authorities (enabler, leader, ...) and on the right balance between public and private stakeholders in the roll-out of MaaS.** Principles and characteristics for public sector oversight must be provided, as the diversity of Europe's cities and regions make it unlikely that a single MaaS model would be universally applicable. Such principles need to be translated into concrete operational MaaS models with clearly defined roles and responsibilities for the different actors involved and concerned. At local level, further pilots should be conducted to identify and replicate well-functioning governance models. Besides, different business models must be tested for data reciprocity.

At European level, more research is needed into the barriers hindering the large-scale deployment of MaaS and how they can be overcome. These include public-private sector cooperation, the lack of trust, the lack of a viable business case for MaaS, walled gardens between different operators, commercial sensitivity and privacy issues, etc. Much more sophisticated regulatory instruments and management tools are required to view MaaS not as a set of combined mobility services, but as a really integrated "service ecosystem" with diverse components, also including payment and reservation or dynamic information on occupation/location for example (this represents a challenging change of paradigm).

Digital integration represents an important precondition to inter- and multimodality. In this regard, **a European legal framework on data-sharing and business agreements would support a well-functioning and publicly overseen MaaS. It should cover data ownership and transfer rights, as well as responsibilities of data providers. The research needed includes legal analysis and definitions, as well as best practices sharing.**

The inclusion of the **transport of goods** into MaaS and the overall urban mobility system which must be overseen by public authorities also represents a field to be investigated. Beyond optimisation of the existing system, as the innovative services proposed by ride-hailing companies show, this integration also enables disruption readiness by ensuring alternative options for essential goods' delivery[13]. Legal implications and operational issues must be analysed, and pilot tests should be conducted to provide feedback on most efficient and sustainable governance models for these services.

3.3. Incentives, public-private partnerships, new business models

Besides the assessment of NMS' impacts on mobility, tools are needed for authorities to enable the integration of the right NMS into the urban mobility ecosystem. Under "right", a contribution to the achievement of public policy goals is understood, such as long-term sustainability targets as envisaged in the European Green Deal, accessibility, safety, equity, or resilience. Various tools can be put in place, for which research under different forms is needed to obtain optimal results.

[12] Transforming Transportation with MaaS?, Karen Vancluysen, Electronomous workshop, November 13th 2020.
[13] Lisbon case, POLIS webinar, May 2020.

Several stimulation tools exist, which can be deployed in European cities and optimised through further research, tests or pilot projects, and exchange of best practices:

- **Public-private partnerships** (PPPs) with demand-responsive services, to meet accessibility, equity and social inclusion goals, and fill service gaps that can never be met by mass transit, e.g., efficient mobility services in remote, suburban, and rural areas, at off-peak hours and at night, and for target groups with specific needs. An example of a successful PPP is the collaboration between a local transport authority and a ride-hailing company, where the company offers rides between tram and bus stops for a flat fare in the evening, when buses stop while trams still ensure services, to provide a connection between the 2 stops. This innovative partnership supports the service gap compensation at night. Different advanced public-private cooperation models are required to foster collaboration and service integration between entities such as local and regional authorities, transport operators, NMS providers, local businesses, ...).

- **Incentive schemes**, to stimulate the filling of service gaps by private transport services' providers, and the complementarity with existing public transport supply. These include financial support to private providers or for certain trips, whereas partnerships are agreements between private stakeholders and authorities. MaaS can be used as a tool for incentive schemes implementation: it can enable automatic subsidies for targeted trips that meet specific public policy requirements[14]. Innovative "cost-benefit sharing" schemes between public and private actors need to be developed. They need to be assessed regarding the impact of services. The partnership contracts including these schemes define the impact of the actual service level, but a regular check and potential adaptations of the services are needed to ensure the expected impacts on society are achieved. Besides the stimulation to complement public transport, incentives affect the demand in energy related to the use of NMS. Indeed, regulating the price demanded for vehicle charging according to the grid peaks and off-peaks, thanks to taxes or subsidies for example, encourages NMS providers to ensure they do not over-solicit the grid for the charging of their vehicles, from e-scooters to e-cars.

- **Multimodal mobility hubs** can enhance intermodality and facilitate the combination of different shared sustainable mobility services. They can support the development of viable business cases by creating the necessary critical mass, involving citizens who are users, but also employers who generate mobility demand, real-estate and housing stakeholders who can induce car-dependency, etc. The hubs limit the marginal cost of new services or additional vehicles, while leveraging the digital benefit and the number of customers using and demanding services. Previous pilot projects[15] show the necessity of conducting sociological studies on user and travel behaviour for this set up, as well as branding the hubs for public trust, integrating them into a broader mobility strategy, and implementing infrastructure developments related to the use of hubs, such as cycle paths, cycle parking, etc. It is also important to consider the impact of these hubs on the use of urban land and the organisation of urban spaces, particularly in central parts of cities.

- **Dynamic ride sourcing** can minimise the social cost of transport, by matching any driver willing to share their ride with a passenger through a platform. Research should help understand why such models are permitted in some countries or areas and not in others, and also define how viable these services are with not-for-profit aims, i.e., aims for social and environmental benefits. The mechanism design should be investigated: incentives for drivers and passengers to participate, legal framework and insurance for taxi and ridesharing in cities, etc.

- Creating **innovation accelerators at local level**, overseen by local authorities, allows the establishment of a common framework for all local innovations, including principles to be integrated in the development of new services, support and orientation, and monitoring of

[14] The MoDI project funded through the 2020 Smart Economy call and coordinated by the city of Leuven provides insight into the extent to which control of the mobility behaviour of residents and visitors is possible through the use of MaaS in combination with the use of a third-party payment system based on tests with end users.
[15] The EU-funded eHubs project investigates the set-up of hubs for electric micro-mobility and logistics vehicles, from e-scooters to e-cargo bikes and e-cars.

evolutions. These accelerators can include tools and resources to exploit available data for the right development of new services and its inclusion in decision support systems. Capacity-building and training are needed to make this a reality on the local level. Though such city-led innovation communities are developed with European support[16], more must be set up to have a wider results exploitation.

EU Research & Innovations needs with regards to policy goals and regulatory frameworks		
Impact assessment	1.	Encourage a continuous real-time impact assessment at local level, through exchange and cooperation with the stakeholders able to collect the required data, and capacity-building for public administrations to manage the cooperation and exploit the data available
	2.	Define and classify the data required for impact assessment, identifying which aspect of NMS impacts it enables to assess and how, enriching the first model developed by the New Urban Mobility platform (use cases)
	3.	Support the definition of the most efficient legal conditions and viable business models allowing the collection of the necessary data
	4.	Deepen research on the right indicators to monitor the performance of urban mobility systems and NMS
Governance models	5.	Investigate the impact of the different governance models and the different features included, and communicate on research about NMS' impacts on regulatory and governance frameworks
	6.	Test governance models integrating all areas influencing urban mobility into transport governance
	7.	Conduct studies on the best role for public authorities (enabler, leader,...) and on the right balance between public and private stakeholders in the roll-out of MaaS
	8.	Deepen the research on the barriers hindering the large-scale deployment of MaaS and how they can be overcome
	9.	Define a European legal framework on data-sharing and business agreements to support a well-functioning and publicly overseen MaaS
Incentives, public-private partnerships, new business models	10.	Conduct further research, tests, pilot projects, and exchange of best practices on optimal stimulation tools for NMS development

Table 2 - Research recommendations on Policy goals & regulatory frameworks

[16] The European project SPROUT focuses on city-led innovation responses, managing an open innovation community to stimulate the discussion on the future of urban mobility, and to validate pilot cities' experience. It provides training to generalize pilot solutions, and support to adapt innovations to regional ecosystems.

4. User needs and user behaviour

The development of NMS is often consumer-driven: NMS expand when they meet a demand from citizens. Hence, aligning user needs and behaviours with public objectives will both support the expansion of these services and their contribution to sustainable mobility policy goals. To ensure this alignment, the habits and demands of citizens and freight consumers must be observed and listened to, as well as their evolution with the availability of new services, the implementation of targeted policies, and the occurrence of disruptions, like the pandemic crisis. Besides, to fully adopt rules, citizens must have the opportunity to shape them, so they must be involved in their design and implementation. Finally, education and training, adapted to specific profiles, must be conducted to influence citizens' behaviour, and encourage its alignment with public objectives.

4.1. Studies on user habits, behaviour and reaction to policies

Different aspects of the travel habits and demands of citizens must be studied to allow their alignment with public interest, thus securing the development and deployment of appropriate services. Most generally, the reasons and mechanisms leading to the decision to move and the selection of a specific mode to go or transport goods from one place to another are the key parameters affecting user behaviours. They should be observed, theorised, and tested, in changing contexts and with different variables, such as the introduction of policy measures, the provision of trainings, the evolving sanitary context, working or education patterns, etc. Variables to study and potential methods and approaches for each of them are proposed in table 2 below.

Variable affecting user behaviour	Relevant approaches
Personal characteristics and complexity of mobility-reality (location, family situation, age, gender, self-confidence, luggage, health, etc.)	Qualitative psychological study, behavioural & sociological studies
Social expectations, reputation, image, behaviour of others (first mover dilemma)	
Inertia and social habits[17]	Motivational models, social and economic behavioural studies
Policy measures[18]	Test & pilot projects, economic research, political and sociological studies
Economic measures (affordability, price, rebates, payment options, perceived fairness of price)	
Advertising and media promotion	

[17] Anne Durand, Lucas Harms, Sascha Hoogendoorn-Lanser, Toon Zijlstra, "Mobility-as-a-Service and changes in travel preferences and travel behaviour: a literature review", The KiM Netherlands Institute for Transport Policy Analysis, Ministry of Infrastructure and Water Management, September 2018, consulted in March 2021.
[18] Tabith S. Combs, Carlos F. Pardo, "Shifting streets COVID-19 mobility data: Findings from a global dataset and a research agenda for transport planning and policy", Transportation Research Interdisciplinary Perspectives 9, 2021, available online.

Training and education	Test & pilot projects
Availability of new services[19], and of safe and convenient infrastructure (incl. showers, storage, etc.)	Test & pilot projects, sociological studies
(Perceived) safety and security, stress-level, aesthetics and comfort, fun	

Table 3 - User behaviour aspects to study for better alignment with public objectives

Behavioural studies have already produced some results on elements triggering people's choice of a specific means for travel. However, they shed light on further **needs for analysis of users' adoption of new services and decisions when using these services**[20]. Besides, they are conducted in view of specific modes in particular, and other modes remain uncovered: MaaS and automated driving have recently fed research on user acceptance and adoption for example, while the same aspects for on-demand, free-floating, micro-mobility services and new freight services seem more difficult to observe.

Indicators defined for cities to monitor the efficiency of their transport policies and their impact on citizens' quality of life must include the observation of user behaviour in a context of multimodality and multiplication of available services. Recommendations coming from EU-funded research[21] notably mention the need to integrate in existing indicators the following emerging practices and uses of mobility services by urban travellers:

- vehicle renting vs owning
- e-commerce increase
- free-floating services expansion
- micro-mobility vehicle and infrastructure safety
- ...

The pandemic crisis has given rise to a profusion of behavioural analyses, revealing among others the **distinction between travel needs and logistics needs** (both relating to the fundamental need of accessibility). Indeed, while demand for transport plummeted, a boom of e-commerce has been observed[22] during the crisis period. Solutions must be found to leave space for sustainable people mobility and leisure activities, while answering citizens' expectations for on-demand logistics. Investigations have started on crowd shipping, as the EU-funded LEAD project currently assesses, to harmonise mobility demand and e-commerce consumers' needs[23]. **Further research and capacity building would enable the expansion of innovative services bringing several solutions and meeting different needs in a fair way at the same time.**

[19] Anne Durand, Lucas Harms, Sascha Hoogendoorn-Lanser, Toon Zijlstra, "Mobility-as-a-Service and changes in travel preferences and travel behaviour: a literature review", The KiM Netherlands Institute for Transport Policy Analysis, Ministry of Infrastructure and Water Management, September 2018, consulted in March 2021.
[20] Anne Durand, Lucas Harms, Sascha Hoogendoorn-Lanser, Toon Zijlstra, "Mobility-as-a-Service and changes in travel preferences and travel behaviour: a literature review", The KiM Netherlands Institute for Transport Policy Analysis, Ministry of Infrastructure and Water Management, September 2018, consulted in March 2021.
[21] Ralf Brand, Marcel Braun, Susanne Böhler, Stephanie Kessler, Siegfried Rupprecht, SUMI Final Recommendations, August 2020.
[22] Arthur D. Little and UITP, "The Future of Mobility post-COVID", July 2020.
[23] Edoardo Marcucci (MOLDE), Valerio Gatta (MOLDE), Giacomo Lozzi (POLIS), "City Logistics landscape in the era of on-demand economy", LEAD project (Grant agreement No 861598), pending EC approval.

4.2. User acceptance and adoption of public policy objectives

To ensure adopted policies have the expected impact on urban mobility services, behaviour, and the entire system, they must be communicated about to, understood, and accepted by citizens.

Some NMS with a potential positive impact, have strong social implications, like sharing and pooling resources (vehicles, spaces, ...). They require the set-up and deployment of new forms of collaboration, and new, carefully designed business models.

Acceptance can be achieved by designing solutions with a full understanding of users' needs, based on in-depth analyses going beyond the need to go from a to b. State-of-the-art techniques in traditional mobility surveys lack the dilemma between stated vs. revealed preferences. New tools and methodologies need to be developed to really identify the accessibility needs in personal contexts.

Involving citizens in the process of designing public goals and policies, and implementing them, also supports the acceptance of measures and reinforces their efficiency[24]. This requires know-how, competences, and tools, as shown in recent European research[25]. Beyond current studies and works, **capacity-building at local level is necessary to conduct participation activities, as well as the set-up and experimentation of tools facilitating these activities. Pilot projects on citizen co-creation processes would improve the acceptance of public interventions.**

In addition to designing public goals and policies, **citizens can also be involved in the implementation of measures**. They can contribute to studies, observation, and analysis, as has already been the case in several EU-funded citizen-science projects:

- Involvement in traffic or air pollution technical assessment empowers citizens to take a leading role in the production of data, evidence, and knowledge around mobility at local level. It enables to co-design informed solutions to tackle a variety of transport challenges and opens up new opportunities for transportation policy making and research[26].

- New citizen-centred approaches to mobility and air quality, using insights from social psychology, enable both understanding of the human dimension of vehicle use to improve policymaking, and awareness raising among people for self-efficacy and a more sustainable behaviour[27].

In addition to the dissemination and expansion of these techniques and resources, **a better definition of the right communication channels to be trusted by the target audiences is needed**. For instance, to encourage fewer men to drive cars, you would need to communicate via a male-oriented TV/radio show, showcase stereotypical heterosexual men undertaking the desired behaviour (e.g. cycling to work or walking to sport trainings) for vicarious experience, and show other men approving this behaviour for verbal persuasion[28].

[24] European Platform on Sustainable Urban Mobility Plans, Manual on Participation, 2016.
[25] The DecidiUM project funded by EIT Urban Mobility has conducted an analysis of best practices in citizen engagement for urban mobility, drafted a citizen engagement strategy and elaborated an online tool to facilitate citizen participation in urban mobility decision-making.
[26] The WECOUNT project funded by the EU under the H2020 programme enables citizens to initiate a policy-making process in the fields of mobility and air quality, with fully automated measurement data collected through a sensor in combination with a low-cost computer and software, counting traffic at street level.
[27] The CLAIRCITY project, also funded by the EU under the H2020 programme, engages citizens across Europe to better understand their environmental behaviours in their local contexts. It encourages them to provide policy suggestions and feeds back this knowledge to policy makers, citizens, and influential organisations at local level.
[28] Fogg-Rogers, L.; Hayes, E.; Vanherle, K.; Papics, P.; Chatterton, T.; Barnes, J.; Slingerland, S.; Boushel, C.; Laggan, S.; Longhurst, J. Applying Social Learning to Climate Communications - Visualising 'People Like Me' in Air Pollution and Climate Change Data. Sustainability 2021, 13.

Different measures can influence the travel behaviour of citizens, from soft measures such as information, communication, and promotion[29], to positive incentives through digital technologies[30]. Though research and capacity-building has been conducted on various types of policy measures, **more work is needed to define the right combination to influence travel behaviour according to public objectives**, in terms of economic and legal research, best practice exchange and pilot projects.

4.3. User typology and training

In urban environments that are increasingly complex and heterogeneous, there is an urgent need for tailored NMS that specifically address some "naturally" excluded segments of the population, such as elderly, migrants, etc. To be socially inclusive, mobility services may have to be designed adopting a radically different mind-set. **Defining a typology of users supports the social inclusiveness of NMS.**

Moreover, a typology of users enables targeted education and training, which is another method to align user behaviour and demands with public objectives, in addition to engagement and participation.

To improve the safety of urban mobility, in the context of NMS integration in the system, **trainings must be delivered to users, and especially the most endangered ones – children**. These trainings can be integrated into school programmes, or just provided through material distributed to parents and citizens. Safety equipment can also be provided to children. Trainings can also be delivered to other target groups but must be planned strategically according to city objectives and evidence-based analysis of the safety situation (see assessment part of this roadmap).

Communication about public policy objectives is also essential, for these to be understood and followed by mobility users. As mentioned in the citizens' engagement part, **defining the target audience, the right channels to reach out to them and the right messages to transmit are keys to policy success.** Following the example of actions for education of travellers on their behaviour's impact on the climate[31], future communication efforts need to be segmented[32]. Organising information sessions relying on data collected on-the-ground, with relevance for users, can support their adhesion and engagement for certain policy objectives. Pilot projects can also be used for this purpose. There is a need to **define relevant and shareable data** on energy-consumption of specific transport modes for example. **Methods must be tested to bring this data to users' knowledge** as well.

Another aspect of user typology is the distinction between the travel dimension considered when elaborating transport policies, and mobility services integration. Trips with both ends in the same local territory (centre parts and suburbs for example) lead to different needs in terms of new mobility services than trips with an origin in a given local territory and a destination in another place (origin and destination in different countries for example). **A classification of journeys based on geographical criteria is needed to improve NMS integration in transport policies.**

Finally, a **gender perspective should be included in the analysis of impacts of NMS, in the integration of multiple services and modes, and also in urban space management and planning.**

To conclude, aligning citizens' use and demands for services with public policy objectives is key to ensure NMS development aligns with public interest. To this end, observation and communication are essential, and political and sociological research is needed on measures' impacts on travel and e-consumers' behaviour.

[29] The EU-funded project PASTA (Physical Activity Through Sustainable Transport Approaches), ended in 2017, has promoted active mobility in cities (i.e., walking and cycling), including in combination with public transport use, as an innovative way of integrating physical activity into our everyday lives.
[30] The EMPOWER project, funded by the EU under the H2020 R&I programme from 2015 to 2018, has targeted drivers of conventionally fuelled vehicles, aiming to change their travel choices by rewarding change with a range of positive incentives including points, discounts, rewards, community support, prizes, cashback, and games on smart devices.
[31] Climate Outreach, "Britain Talks Climate - A toolkit for engaging the British public on climate change," 2020.
[32] Fogg-Rogers, L.; Hayes, E.; Vanherle, K.; Papics, P.; Chatterton, T.; Barnes, J.; Slingerland, S.; Boushel, C.; Laggan, S.; Longhurst, J. Applying Social Learning to Climate Communications - Visualising 'People Like Me' in Air Pollution and Climate Change Data. Sustainability 2021, 13.

EU Research & Innovations needs with regards to user needs and user behaviour		
Studies on user habits, behaviour, and reaction to policies	1.	Support the observation and analysis of variables affecting user behaviour, based on suggested relevant approaches in Table 2, with a focus on users' adoption of new services and decisions when using these services
	2.	Include the context of multimodality and multiplication of available services in indicators defined for cities to monitor the efficiency of their transport policies and their impact on citizens' quality of life
	3.	Distinguish travel needs from logistics needs, and build capacity for the expansion of innovative services bringing several solutions and meeting different needs in a fair way at the same time
User acceptance and adoption of public policy objectives	4.	Build capacity at local level to conduct participation activities, and set up and test tools facilitating these activities. Conduct pilot projects on citizen co-creation processes to improve the acceptance of public interventions
	5.	Provide recommendations for a better definition of the right communication channels to be trusted by the target audiences
	6.	Investigate the right combination of measures to influence travel behaviour according to public objectives
User typology and training	7.	Encourage the definition of a typology of users to support the social inclusiveness of NMS
	9.	Support the delivery of trainings to users, especially the most endangered ones, to improve the safety of urban mobility
	10.	Provide recommendations to define target audiences, accurate communication channels, and key messages with relevant and shareable data to raise users' awareness of the necessary topics
	11.	Classify journeys based on geographical criteria to improve NMS integration in transport policies
	12.	Ensure the inclusion of a gender perspective in the analysis of impacts of NMS, in the integration of multiples services and modes, and also in urban space management and planning

Table 4 - Research recommendations on User needs and user behaviour

5. Digital infrastructure and data management

"Data is the new gold", the European Commission recognised back in 2011 already. As the research recommendations on policy goals and regulatory frameworks and on user needs and behaviour in this roadmap show, data is needed for many purposes to align the development of NMS with public interest: real-time impact assessment, integration of services, monitoring and enforcement, communication with operators and citizens, incentivisation, personalisation of the mobility offer, and even citizens' participation in urban mobility policy design. Therefore, research priorities on data sourcing, collection, storage, sharing, governance, and technical enablers as well as supporting digital infrastructure are addressed in this chapter. First, recommendations are made for innovative data management tools and their application for traffic management. Second, priorities for research to improve the governance of digital infrastructure, allowing efficient use of the data, are detailed. Then, data sharing needs, approaches, and technical innovations are analysed. Finally, aspects of MaaS digital infrastructure that need to be improved for MaaS to become operational and support policy goals are identified.

5.1. Innovative tools for data management and application for traffic management

Data on mobility and traffic is key to inform citizens and policy makers, improve both travel behaviour and transport policies, and monitor the success of the latter. With the increase of multimodality, this data becomes even more important, and at the same time more difficult to collect. This data collection is an issue at local level because it requires investment in costly and cumbersome equipment. EU-funded research, led by city authorities, proposes pilot projects to implement a solution for Traffic Management as a Service (TMaaS) in small and medium sized cities[33]. To improve the solution developed, **further pilots and capacity building actions should be conducted for the integration of NMS into traffic management, and prioritisation of the most sustainable and accessible modes.**

Beyond these proposed next steps on TMaaS, challenges which should be further investigated include:

- The **demonstration of the value added** without establishing a framework capable to assess changes – which would represent a dissuasive cost for small and medium-sized cities,
- The **guarantee of financial sustainability**, which requires the definition of the business potential of this innovation, and the design of a working business model,
- The **upscaling and transferability of the platform**, which demands interoperability of the solution developed, openness to other actors than the companies who developed it, and communication and exchange to enable other cities to use the tool.

Apart from the application for traffic management, the collection, digestion, and good use of complex mobility data is necessary to support the integration of new and fast-developing modes of transportation, enhance collaboration between operators, and facilitate modal shift towards more sustainable and accessible transport modes. But as identified in the case of TMaaS, defining an attractive business model also represents a challenge for the emerging market of data aggregators, who are needed to support cities with raw data treatment, GDPR compliance, and other data management

[33] The TMaaS project conducted by the city of Ghent proposes a platform tailored to the city it is deployed in, providing an overall picture of mobility in the city, including real-time traffic events thanks to third parties' data, position of public transport vehicles based on In-vehicle GPS trackers, etc.

issues. Indeed, as defined in the POLIS survey report on sharing data for micro mobility[34], cities themselves do not feel they currently have the capacity to manage and analyse the data generated by NMS. To solve this issue, some initiatives propose the provision of a digital layer between cities and operators, offered by third-party aggregators who collect and analyse that data for the cities, while others stress it is important for local authorities to also develop such data collection and analysis skills in-house. **It is clear that more research, convergence, and trials are needed to make the digital collaboration between cities and operators sustainable and use the potential offered by data to the fullest.**

In addition to improving interoperability and encouraging convergence towards a common set of data formats and specifications, identifying the use cases where data collection and analysis adds value, and defining a functioning model for the aggregation and management of data from all NMS, experience must be shared on tools and platforms enabling decision-making based on this data. The development of Decision Support systems for public transportation planning is a solution proposed and developed by recent EU-funded research[35], which **needs to be enriched with new algorithms to use it in a wider domain than public transportation[36], namely the management of urban mobility including NMS, also taking recently emerged challenges into account, such as sanitary conditions, increased demand for active travel and new user behaviours.**

5.2. Digital infrastructure governance

Digital infrastructure and data management are meant to enable better governance of the urban mobility ecosystem. This leads to questioning the governance models of the tools themselves: owning and controlling the data, structuring processes of data collection, transfer, and integration into decision support systems, are key to influence the mobility system governance and NMS integration. **The models and principles of data control, data treatment through algorithms, and the structure of governing bodies must be subject to research, tests, and validation processes.**

Results of works conducted by the Sustainable Mobility for All initiative, supported by the World Bank Group and the United Nations, provide extensive recommendations on governance and accountability of control of data and structure of the governing body[37]. Among relevant research and innovation actions to conduct, the following priorities can be quoted:

- **Experimentation of new control models**
  - Explore new control models through methods such as developing and funding pilot projects for innovative control models (e.g., data trusts and data collectives) or establishing or identifying preferred institutions to govern new data control structures.

- **Research, multistakeholder discussion and guidance on legal frameworks for data management algorithms and data sharing infrastructure**
  - Examine IP laws to avoid unreasonable barriers to data sharing, initiate discussion on ownership rights, conditions for transfer of ownership, liabilities for misconduct, and limits of liabilities, in particular for co-created data, provide guidance on the responsibilities of data providers and data controllers toward the quality and traceability of their data.

- **Frameworks for public private partnerships**
  - Create frameworks for public–private partnerships that allow mobility organisations and stakeholders to collaborate in governing local data sharing initiatives.

[34] HOMEM DE GOUVEIA, Pedro, BABIO, Laura, "Sharing data for shared micromobility", POLIS Survey Report, January 2021, available online, last consulted on April 9, 2021.
[35] The SIADE SaaS project, running from 2017 to 2020, has provided an intelligent, intuitive, and visual system designed for optimal management of transport networks through mass data analysis.
[36] SIADE SaaS Newsletter, Issue 3, February 2020, available online, last consulted on April 15, 2021.
[37] Sustainable Mobility for All. 2021. Sustainable Mobility: Policy Making for Data Sharing. Washington DC, License: Creative Commons Attribution CC BY 3.0, available online, last consulted on April 15, 2021.

- **Harmonisation of data sharing**
  - Define optimal organisation of governing bodies to enable data sharing best practices convergence, build greater consistency and efforts harmonisation, and ensure data interoperability across geographies.

A report from the International Transport Forum on transport governance with algorithms[38] also proposes some guidance on how to ensure algorithms are well used. According to the report, public authorities have three different perspectives on the algorithmic governance framework:

Aiming to regulate algorithmic systems to bring them in line with the public policy outcomes they are mandated to deliver	**Trying to use algorithmic systems to carry out their regulatory tasks**	**Find that algorithmic systems may supplant certain traditional regulatory mechanisms they have historically deployed**

These perspectives shed light on the potential of bidirectional data sharing processes: digital infrastructure can support both the information of decision makers and the transmission of their decisions. The report proposes recommendations to exploit this potential while mitigating the risks represented by algorithms in terms of safety and security, data protection and privacy, responsibility and liability, transparency and explainability, fairness and bias, and welfare and wellbeing. Building on these recommendations, some aspects requiring research at European level can be identified:

- Evaluate the level of **impact of algorithms** on the urban mobility system, to enable the identification of algorithms requiring an increased assessment and oversight;
- Establish **coding protocols** for potentially impactful algorithms;
- Define a framework and standards for authorities to **make regulations machine and human readable by default** – as already started in some EU-funded projects targeting specific regulations[39];
- Conduct **analyses and comparisons of human and algorithmic decision-making** performances, to push the best options;
- Establish **robust regulatory frameworks** that ensure accountability for decisions taken by algorithms;
- Provide clear **guidelines on impact assessments** regarding algorithmic systems that could have a consequential effect on regulated outcomes or within the public domain;
- Define **recommendations on new regulatory approaches** to maximise regulatory learning, early deployment benefits and a de-risked experimentation.

5.3. Data sharing approaches and technical innovations

Data sharing has already been defined as an enabler to integrate NMS in the urban mobility ecosystem and make sure they contribute to public policy goals. For this enabler to be operational and effective, specific approaches to data-sharing are required, and some technical innovations are needed. In addition, timing should be considered: data produced and shared with a delay might become useless, depending on the use cases of this data.

[38] Philippe Crist, International Transport Forum's Corporate Partnership Board, "Governing Transport in the Algorithmic Age", OECD/ITF Report, 2019, available online, last consulted on April 15, 2021.
[39] The UVAR Box project, a preparatory action funded by DG MOVE, develops machine-readable standards for the digitisation of urban vehicle access regulations.

The right timing for sharing must be defined according to the data identification. At EU level, the following steps could help to enable the right approaches and develop the required technical innovations:

- Set-up of a **data-sharing culture** to overcome potential barriers related to habits, mistrust and reluctance, through demonstrations, pilots and community-building, beyond currently running projects[40].

- Define the **types of data and data use cases** needed to evaluate the impact of NMS on the mobility ecosystem, and how they serve public policy design. A living and constantly adapting mobility data mapping is necessary, keeping outcomes of recent initiatives up to date and most adapted to local contexts through pilot projects and best practices exchanges.

- There is a need for the definition of **European data specifications and standards**, identifying among all existing specifications and formats, the most suitable ones to become the standard(s) for the purpose of regulation and data exchange, and further developing them for that purpose, including addressing aspects of GDPR compliance, commercial sensitivity, proportionality, and reciprocity.

- Examples of existing specifications are, among others, the Mobility Data Specification Standard (MDS) developed in the US, the City Data Standard for Mobility developed by 5 Dutch cities, TOMP-API for MaaS, etc.

- Finally, spreading awareness of existing **technologies enabling data sharing** and related regulatory opportunities supports the uptake of these technologies and their adaptation and upgrade for each use case. Further pilot projects and communications on them are needed at EU-level. An example of such a technology is a tool to identify the right data agglomeration/ anonymisation level enabling the expected service assessment while preserving privacy or business case concerns (for private and commercial or business data).

5.4. Enabling MaaS

Data sharing is also a building block of MaaS. Defining data sharing protocols to overcome technical, cultural, and legal barriers to service integration in a common system is required at EU level.

To develop a MaaS model overseen by the public sector, an open data ecosystem that is governed by a set of rules meeting the needs of commercial (data) integrators, public authorities and users alike is needed. Such an open data ecosystem would enable transport authorities and local government organisations to deliver an integrated offer themselves, or monitor MaaS systems of third parties with some degree of strategic control, ensuring these are accessible, sustainable and meet wider city and regional goals[41]. **European support is required for capacity-building and empowerment of local and regional authorities to define a clear vision and strategy, leveraging transport operators and defining the parameters and objectives of a MaaS system. There is a need for communication on the features required for the MaaS System, and pilots to test different models, as there will not be a single model for all European cities and regions, considering their diverse contexts, available services, topography, demographics, skills, etc.**

Considering the different MaaS models that are emerging, with different perspectives on the roles played by each stakeholder, **more research is needed to analyse models, their pros and cons, and the respective roles of the public and private sector.**

For a most efficient MaaS, adapted to user needs and attractive to travellers, which would rely on a

[40] The MobiDataLab project, started in February 2021, will contribute to foster the data sharing culture in the EU.
[41] Polis Traffic Efficiency & Mobility Working Group, "MOBILITY AS A SERVICE: IMPLICATIONS FOR URBAN AND REGIONAL TRANSPORT", Discussion paper offering the perspective of Polis member cities and regions on Mobility as a Service (MaaS), September 2017.

viable business model, payment of services must be included in the platform, in addition to parking services, tolling information, and all relevant data to re-balance the polluter pays principle.

Even if MaaS is quite dependent on (massive) data and on "open data ecosystems", its successful design and deployment will strongly depend on the participation of the different stakeholders and on co-creation processes that are complex and interdisciplinary, thus requiring new approaches and nudging initiatives. The data required and the purpose for which it will be used (commercial or policy goals) should be identified and agreed on. **Business and cooperation models as well as transparent data sharing agreements between operators and public authorities must be defined on this basis.**

5.5. Conclusion

To conclude on research and innovation required at EU level to set up digital infrastructures and support data management, which contributes to aligning NMS with public policy goals, more use cases must be trialled, viable business models identified, and capacity-building among local authorities supported. Algorithmic governance must be investigated more in depth, and innovation must support technical enablers for data sharing and integration into a comprehensive MaaS ecosystem.

EU Research & Innovations needs with regards to digital infrastructure and data management		
Innovative tools for data management and application for traffic management	1.	Conduct further pilots and capacity building actions for the integration of NMS into traffic management, prioritisation of the most sustainable and accessible modes, and to address identified challenges
	2.	Include the context of multimodality and multiplication of available services in indicators defined for cities to monitor the efficiency of their transport policies and their impact on citizens' quality of life
	3.	Conduct more research and trials to make the digital collaboration between cities and operators sustainable and use the potential offered by data to the fullest
	4.	Enrich current research on decision support systems with new algorithms, to use it in a wider domain than public transportation, namely the management of urban mobility including NMS, also taking recently emerged challenges into account, such as sanitary conditions, increased demand for active travel and new user behaviours

Digital infrastructure governance	5.	Research, test, and conduct validation processes for models and principles of data control, data treatment through algorithms, and the structure of governing bodies
	6.	Conduct research and innovation actions on governance and accountability of control of data and structure of the governing body based on recommendations from previous research in the framework of the Sustainable Mobility for All initiative
	7.	Conduct targeted research on algorithms, based on recommendations from previous studies (e.g., ITF 2019 report on algorithms)
Data sharing approaches and technical innovations	9.	Support the definition of the right timing for sharing data according to the data identification
	10.	Encourage the set-up of a data-sharing culture
	11.	Keep outcomes of recent initiatives on data and use cases typologies up to date and most adapted to local contexts through pilot projects and best practices exchanges
	12.	Identify the most suitable European data specifications and standards for the purpose of regulation and data exchange, and further develop them
	13.	Conduct further pilot projects and communication to spread awareness of existing technologies enabling data sharing and related regulatory opportunities
Enabling MaaS	14.	Build capacity and empower local and regional authorities to define a clear vision and strategy for MaaS, leveraging transport operators and defining the parameters and objectives of a MaaS system
	15.	Communicate on the features required for the MaaS System, and conduct pilot tests of different models, as there will not be a single model for all European cities and regions
	16.	Analyse the different proposals of MaaS models emerging, their pros and cons, and the respective roles of the public and private sector
	17.	Encourage local level definition of business models and cooperation models between operators and public authorities, also for the inclusion of additional services in MaaS

Table 5 - Research recommendations on Digital infrastructure and data management

6. Urban space and physical infrastructure

The breakthrough of NMS in cities has resulted in the occupation of urban space and the use of infrastructure by new types of vehicles. Micro-mobility vehicles compete with traditional bikes, mopeds, and sometimes with pedestrians for public space, while cars from all types of services – rented, shared, taxi – generate congestion on lanes sometimes also taken by public transport and freight vehicles[42]. The scarcity of urban public space requires smart space management and prioritisation. From reallocation of available space to more sustainable forms of transport, intermodal hubs and interchanges enabling more seamless combinations of sustainable modes, to dynamic management of curbside and infrastructure, and the integration of suburban areas in strategic planning, future research must set up the needed enablers for the development and expansion of sustainable, accessible, fair, and efficient services through urban space interventions. The "15-minute city" concept also is gaining ground and has an enormous potential in shaping urban planning and mobility services, with extremely positive impacts on urban quality of life.

6.1. Reallocation of space and infrastructure

The disproportionate allocation of public space in favour of motorised traffic[43], a legacy of decades of car-centred urban planning, poses a challenge to achieving sustainable mobility policy objectives. At the same time, public space is a very powerful tool at the disposal of public authorities to bring about change, and over the past years, a trend towards 'giving the streets back to the people' has been observed in many cities. By taking away space from certain modes and giving more to others, the use of unsustainable transport means can be discouraged and that of sustainable ones incentivised. Smart public space management is also a key enabler for the scaling up of NMS. First, it can help to increase the acceptance of new mobility services, by mitigating negative externalities caused by the inadequate use of urban space, such as wrongful parking, and cluttering or the illegal use of sidewalks by e-scooters. Second and more importantly, it can help to develop more sustainable and accessible NMS, with stations and hubs for shared devices and charging infrastructures, dedicated lanes for light and active modes, pick-up and drop-off zones, etc. The reallocation of space is also important to transform roads from mere transit spaces into public spaces with a higher socioeconomic value to people – a feature which has become extremely important for local recreation during the COVID-19 pandemic. Two main types of obstacles to reallocation of space away from motorised-focused use are identified by recently conducted pilots and research:

- Challenges to the durable implementation of temporary space reallocation interventions introduced during the COVID-19 crisis, such as pop-up bike lanes, pedestrian zones, and "stay function"[44] places, parking spaces reconverted into parklets or outdoor terraces, residential low-speed zones, etc. With the reduction of mobility demand, cities have become "sandboxes" where new measures can be tried out, and some of the quickly implemented temporary measures are now incorporated in cities' post-lockdown mobility plans[45]. However, such permanent medium- to long-term implementation remains a challenge due to the fragmentation of responsible institutions, public acceptance of a shifting of the status quo, and a lack of standards for data collection supporting the purpose and enforcement of these measures[46]. EU research can help overcome these challenges with following actions:

[42] Barriers to implementing Dynamic Kerbside Management, Per Solér, WSP Sweden, ReVeAL international workshop, October 2020.
[43] COVID-19 SUMP Practitioner Briefing, CIVITAS SATELLITE CSA, July 2020.
[44] Arthur D. Little and UITP, "The Future of Mobility post-COVID", July 2020.
[45] COVID-19 SUMP Practitioner Briefing, CIVITAS SATELLITE CSA, July 2020.
[46] Barriers to implementing Dynamic Kerbside Management, Per Solér, WSP Sweden, ReVeAL international workshop, October 2020.

- On institutional fragmentation, **foster systemic approaches and propose models for partnerships with public health** officials, departments, and NGOs, to obtain valuable perspectives and evidence-driven evaluation; **analyse responsibilities, strengthen interdisciplinary and cross-departmental cooperation, and support pilot projects to prioritise functions and need; conduct studies on streets' hierarchy and typology, to establish a system of street designations according to their primary purpose, and merge it with urban patterns and the demand for public spaces with a high quality of living.**

- On public acceptance, **communicate on the benefits achieved** and encourage public feedback collection and showcasing. Setting actions and involving stakeholders and the public (in living labs for example) is crucial for the creation of user-centred environments, to pave the way for awareness raising, to make changes tangible, and finally for public acceptance and societal transition.

- On data collection, **foster the development of new standards, support the digitisation and accessibility of already available data, connect data from different sources.**

- Lack of a common understanding within and across cities of what road space allocation means[47]. Past and present decisions about the allocation of urban road space are shaped by evolving demands in favour of or against accommodating specific modes and users. Adopting a holistic approach requires a consolidated and integrated agenda about the future of roads. Such an approach should include governing resources both within and outside the public sector, follow-through capacity from the design to the effective implementation of policies and measures, and ownership by politicians, technicians, and citizens. **These results and further outcomes of currently running projects must be promoted at EU level, and further pilots should be supported to increase understanding and exploitation in European cities.**

If reallocation of space is a well-studied topic with numerous use cases and examples, reallocation of use of infrastructure, amenities (such as charging points) or even vehicles (e.g., after hours sharing of public fleets) are more recent and less mature practices which require more exchange and communication. Trials and pilot projects are conducted with the support of the EU[48], and **their results must be fostered throughout the community of stakeholders at EU level.** The potential reallocation of infrastructure – or use of single infrastructure for different types of vehicles, different modes or for specific social groups, presents several advantages for the implementation NMS-related public policy goals:

- It improves public health with a better local air quality.
- It unlocks the potential of multimodal transport (this includes connections to public transport).
- It contributes to a more efficient use of the vehicles.
- It reduces the pressure on public space thanks reduced parking needs.
- It allows prioritising modes which have the smallest impact on the public domain (and environment).

[47] Charlotte Halpern (Sciences Po) and Jenny McArthur (UCL), "Road space re-allocation. Organizational, institutional and political dimensions", MORE Report, August 2019.
[48] The eHUBS project provides transport hubs based at a local level with different zero-emission (electric as well as non-electric) and shared transport modes available. It can be as small as only two (e-)bikes at a street corner or it can contain a combination of e-(cargo)bikes, light electric vehicles (such as e-scooters and e-cargo bikes), even electric car-sharing and/or public transport possibilities. Additional services such as ticketing facilities, waiting zones, (postal) lockers etcetera, can be considered available when located within a 10-minutes' walk. The Metamorphosis project aims to achieve creative break through innovations in the development, design, governance and planning procedures of urban districts and neighbourhoods, the central focus being put on the transformation of the car-oriented neighbourhoods into children-friendly neighbourhoods.

When considering the reallocation of space and infrastructure, the legacy of static public space design elements must be taken into account. **Solutions must be researched for the exploitation of legacy infrastructure and how it can contribute to the scaling of NMS when this is considered a positive intervention.** Design projects and trials (tactical urbanism) can help to better understand this space shift, and play an important role in the design, piloting, roll-out and assessment of NMS.

The position of current service providers and infrastructure managers in the urban space ecosystem (e.g., parking service providers) should be studied, to **understand how current players can contribute to NMS, increased multimodality, and integrated city logistics and citizens' mobility.** This research must include the definition and testing of business models to reorganise on-street parking places and integrate mobility hubs.

Traditional urban development processes have difficulties to design for complex and competing priorities. **Research on integrated transport and urban planning tools and methods is needed for the coordination between NMS and the design of future public realms to investigate the interrelations and impacts across different spatial and temporal scales.** These planning methods shall help decision makers to better understand unwanted effects and reallocation related impacts to reduce motorised individual transport, increase interoperability and enhance the spatial design to encourage active mobility.

6.2. Dynamic space management and use

Smart management of urban space and existing infrastructure includes their dynamic use, in particular when considering curb space, changing its role and function in time, depending on parameters, functions and needs in relation to commuting peak hours, deliveries, public transport priority, market days, nightlife, etc. Dynamic space management is already being explored in some cities and represents an opportunity for further integration in mobility plans with the support of smart technologies and Intelligent Transport Systems.

As the rise of ride hailing services and the growth in urban goods delivery (even more so with the recent exponential growth of e-commerce) are challenging traditional ways of managing curb space, new approaches are needed[49]. Research on a shift away from curb use focused on street parking to more a flexible and dynamic allocation that for example includes pick-up and drop-off zones for passengers and freight, has also shown the potential for new mobility services, and to decrease the pressure on traffic with an increased percentage of shared rides. To ensure the implementation of these new approaches, R&I could support by developing:

- **tools to monitor** user needs and transport activity, **and planning** flexible curb use accordingly.
- tools to analyse the **revenue impacts of shifting curb use** from car parking to passenger or goods pick-up and drop off.
- **guidelines** for legal settlement bodies **to manage diverse demand for curb space** in flexible ways and ultimately in real time.

On-street storage of vehicles and reserved parking places are an obstacle to dynamic use of public space and curbside. Off-street storage of vehicles and parking strategies must be developed to make it safer and more attractive, so as to release pressure on on-street space. Besides, **solutions proposed by recent studies on curbside adaptation to the use of multiple modes[50] must be shared at EU level and validated through tests and pilot projects.**

[49] Philippe Crist, Luis Martinez, "The Shared-Use City: Managing the Curb", OECD/ITF Report, 2018, available online, last consulted on April 17, 2021.
[50] Rachel Nadkarni: The Multimodal Future of On-Street Parking. A Strategic Approach to Curbside Management, Berlin 2020 (Difu-Sonderveröffentlichung).

Hybrid formats enabling the use of several types of vehicles in the same place and with the same infrastructure is investigated in the framework of infrastructure reallocation. **Tools to define the most efficient model for infrastructure use should be standardised and promoted across European cities.** The capacity-building and study efforts to install hubs at key places in cities[51] must be further conducted to apply to dynamically managed spaces.

6.3. Integrating suburban areas in strategic planning

One way in which NMS can support public policy goals is the connection of remote and car-dependent suburban or rural areas with city centres. However, a "Shared Mobility Desert Outside the Cities" can be observed: the business model of NMS is not viable anymore at a certain distance from the city centre[52]. Suburban areas are a challenge for transport authorities because their low density of population and limited public transport services can lead to isolation, and at the same time they represent an asset through large unoccupied spaces which can help release the pressure on urban traffic. With the growing urban sprawl and the "organisation" of wider metropolitan regions (where peri-urban and semi-rural areas are extremely important), **strategic planning needs to address much more complex, integrated mobility services, that are strongly intermodal, and dependent on multiple information layers and channels.**

The large-scale deployment of mass transit is not efficient in these areas, but the development of NMS can support the exploitation of this asset to improve (sub)urban mobility. For example, sensor-equipped drones can help to plan, maintain, and manage transport infrastructure and traffic flows more effectively[53], and demand-responsive transport can complement the public transport supply in certain low-density areas where demand is low, e.g. suburban or rural areas, industrial areas, etc[54]. However, NMS and MaaS platforms rely on internet availability and on dense population and critical mass, which may further widen the gap in mobility accessibility between connected and remote areas.

To enable the deployment of relevant NMS in suburban areas, studies must be conducted on space exploitation between city centres and periphery. Recent research about mobility in remote areas has been very much focused on good practices to make sustainable and innovative mobility services more accessible to people living in rural and low-density areas[55], but the interaction between urban and suburban areas, commuting times and places, causes for transport mode usages, and exploitable space characteristics were only partially covered by research which would require updates and upscaling.[56]

Research focused on how to exploit suburban space to ease pressure on mobility in city centres as well as reduce car-dependence in suburban areas is needed. This research should include aspects proposed in the table 3 below, which details the topics to be investigated and the type of research to conduct to obtain results.

[51] The eHubs project supports strategic localisation of hubs for zero-emission and shared transport modes.
[52] Clemens Rath (Mobility Excellence Consultancy), "Shared Mobility Desert Outside the Cities", Post on the Mobility-as-a-Service blog, May 31st 2020.
[53] Katja Schechtner, "(Un)certain Skies? Drones in the World of Tomorrow", OECD/ITF Report, 2018, available online, last consulted on April 17, 2021.
[54] Javier Burrieza (NOMMON), "New Mobility Options and Urban Mobility: Challenges and Opportunities for Transport Planning and Modelling", Report, MOMENTUM Project, 2019.
[55] The EU-funded projects SMARTA, INTERREG Peripheral Access and LAST MILE, and the European Network for Rural Development, are just some examples which can be quoted that aim to help rural communities be aware of and test new solutions to some of the fundamental challenges they face with regards to mobility.
[56] R. Mäe, D. Antov & I. Antso (Tallinn University of Technology), "Urban sprawl: mobility potentials in suburban areas of Tallinn", The Sustainable City VII, Vol. 2, May 2012.

Topic for research	Research methodology
Strategic spaces for infrastructure (parking places, warehouses for parcel storage before delivery, infrastructure for drones' take-off and landing and air mobility controllers, ...)	Sociological study on the use of space between city centres and periphery Geographical analysis of spaces around the city, pilots on space uses
Governance models for transport policy, land use and mobility planning in suburban areas	Institutional and legal research Exchange on good practices Pilots on new decision-making processes
Infrastructure needs for the development of NMS	Economic analysis of NMS models Sociological study on demographics and user needs and behaviour in remote areas

Table 6 – Priority research topics and methods for NMS support to urban-suburban connection in view of a better functioning urban mobility ecosystem

6.4. NMS' role in the 15-minute city concept

Beyond the smart use of space within the city and its periphery to support the deployment of modes and services which improve citizens' lives the most, **the role of NMS in the implementation of the 15-minute city concept must be investigated**.

The 15-minute city concept is an urban set-up where locals are able to access all of their basic essentials at distances that would not take them more than 15 minutes by foot or by bicycle[57]. It rides on the concept of "chrono-urbanism", which outlines that the quality of urban life is inversely proportional to the amount of time invested in transportation, more so through the use of automobiles. It aims at achieving six essential social functions (living, working, commerce, healthcare, education and entertainment), with the urban social fabric becoming more closely knitted and with residents made to interact and participate more in activities that ultimately strengthen their social bonds, building character and trust, which ultimately leads to the building of more healthy urban landscapes. It sets a priority on accessibility over mobility, and turns mobility into a different kind of activity – entertainment or healthcare instead of hassle. The concept addresses challenges like increasing energy demand, traffic issues, social inequality in housing and in provision of services like health, improves the economic status of residents, and confronts the challenge of sustainability.

Through the reduction of the number of cars inducing traffic, the division of costs and the social interaction implied when sharing vehicles, and the decrease of travel need to purchase items, new mobility services have a key role to play in the set-up of cities as foreseen in the 15-minute city concept. Since this concept also involves other sectors such as building, planning, construction, energy and water management, **investigations are required on how to integrate NMS with these other sectors to support the implementation of the 15-minute city concept and improve the quality of life of citizens.**

[57] Moreno, C.; Allam, Z.; Chabaud, D.; Gall, C.; Pratlong, F. Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. Smart Cities 2021, 4, 93–111. https://doi.org/10.3390/smartcities 4010006

To summarise the research needed for a smart urban space and physical infrastructure management, which enables the development of the desired services, awareness must be raised on the potential of this policy area to support urban mobility goals, and capacity-building must be provided to enable its exploitation towards the targeted outcomes. Methods and support for public acceptance are needed, as well as pilot projects on different management models and innovative uses. Community-building, supporting dissemination of results and networking for further tests, would also benefit smart management. Standardisation of innovative concepts is necessary. Economic, sociological and legal research is needed to launch action on newly addressed fields such as urban-suburban connections.

EU Research & Innovations needs with regards to urban space and physical infrastructure		
Reallocation of space and infrastructure	1.	Help overcome the challenges to the durable implementation of temporary space reallocation interventions introduced during the COVID-19 crisis
	2.	Promote the outcomes of currently running projects, and support further pilot projects to increase understanding and exploitation of the potential of road space allocation
	3.	Foster research results on reallocation of use of infrastructure, amenities, and vehicles throughout the community of stakeholders at EU level
	4.	Research solutions for the exploitation of legacy infrastructure and how it can contribute to the scaling of NMS
	5.	Survey the position of current service providers and infrastructure managers in the urban space ecosystem to understand how current players can contribute to NMS, increased multimodality, and integrated city logistics and citizens' mobility
	6.	Investigate integrated transport and urban planning tools and methods to coordinate NMS and the design of future public realms, to investigate their interrelations and impacts across different spatial and temporal scales
Dynamic space management and use	7.	Ensure the implementation of new approaches of curb use, resulting from investigations on a shift away from a focus on street parking to more flexible allocation including pick-up and drop-off zones for passengers and freight
	9.	Share at EU level and validate through tests and pilot projects solutions proposed by recent studies on curbside adaptation to the use of multiple modes
	10.	Standardise and promote tools to define the most efficient model for infrastructure across European cities

Integrating suburban areas in strategic planning	11.	Encourage the integration in strategic planning of more complex, integrated mobility services, that are strongly intermodal, and dependent on multiple information layers and channels
	12.	Stimulate research on how to exploit suburban space to ease pressure on mobility in city centres as well as reduce car-dependence in suburban areas
NMS's role in the 15-minute city concept	13.	Investigate how to integrate NMS with other sectors to support the implementation of the 15-minute city concept and improve the quality of life of citizens

Table 7 - Research recommendations on Urban space and physical infrastructure

7. List of tables

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