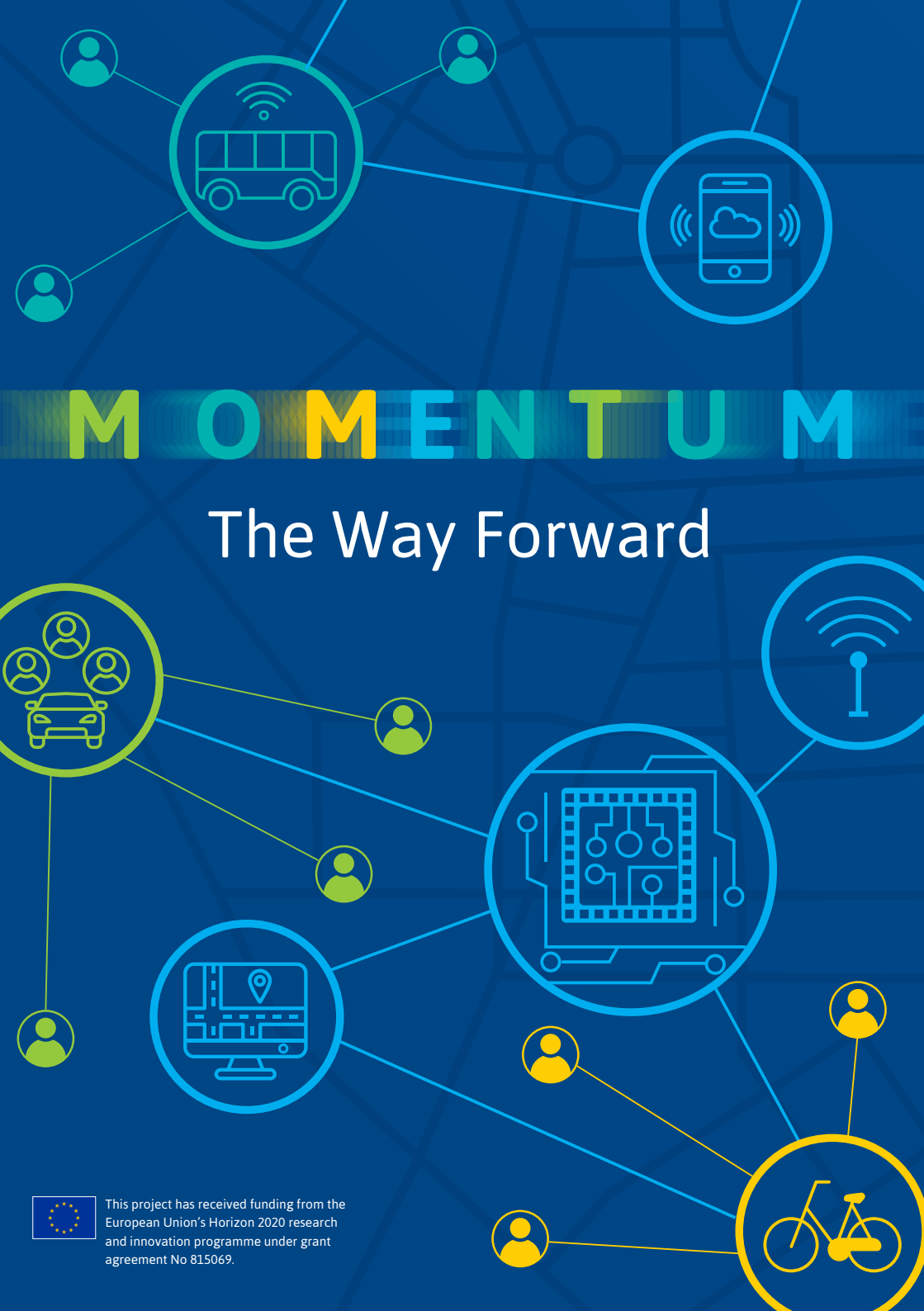

MOMENTUM

The Way Forward

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MOMENTUM

The Way Forward

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Introduction

Information and Communication Technologies (ICTs) and the spread of the shared economy has enabled the emergence of new mobility solutions. Shared micromobility services, demand-responsive transport (DRT) and other mobility innovations are potential cornerstones of future transport, which, if well-managed, could contribute to sustainable urban mobility. In order to exploit the full potential of these emerging mobility solutions, cities require tools able to properly assess the impacts on urban mobility.

The MOMENTUM project developed a set of new data analysis methods, transport models and planning support tools to capture the impact of emerging transport options on the urban mobility ecosystem. The tools and models that were developed by the MOMENTUM project were tested in the cities of Leuven (Belgium), Madrid (Spain), Regensburg (Germany) and Thessaloniki (Greece).

On the following pages, the reader will get an overview of the challenges emerging mobility solutions present in transport planning as identified by MOMENTUM. Data analysis methods, modelling tools, the Decision Support Tool (DST) developed by the project and how they were used in the participating cities will be presented. The brochure concludes with a set of key takeaways summarising the project's recommendations for cities that face decision-making processes on new mobility options.

In the following chapters, cross-references to MOMENTUM publications invite the reader to study the results of the project on a detailed level. The project consortium recommends following the results of the project by going to the project website at https://h2020-momentum.eu/ and having a look at the DST, which can be found at https://momentum.imet.gr.

What are Emerging Mobility Services?

A dynamic, wide range of new options

In recent times, many new alternatives to private vehicles have emerged. These mobility options rely on enhanced user connectivity and GPS fleet positioning and are heterogeneous in terms of vehicles, ownership models and market niches. The following services are part of this group of innovative solutions:

- **Shared vehicle services:**
  Including car, moped, bike and e-scooter sharing services, based on the provision of a fleet of vehicles that is made available to the public to meet their mobility needs.
- **Ride hailing services:**
  Based on mobile applications that match customer demand for a ride with private drivers or drivers of vehicles for hire through GPS tracking.
- **Demand Responsive Transport (DRT)**:
  Transport services operated by a company with professional drivers with dynamic routing (generally without fixed routes, schedules or stops. DRT serves multiple passengers as requested.
- **Urban Air Mobility**:
  Which intends to use unmanned aerial systems and electric propulsion for operating an on-demand service for urban air transportation.

The maturity of these alternatives is different from one to another, but the context is very dynamic. For example, e-scooter sharing services significantly developed during the lifespan of the MOMENTUM project (2019-2022) and covered many more cities at the end of the project than at the beginning. Moreover, new technology and business model concepts such as Cooperative, Connected and Automated Mobility (CCAM) and Mobility-as-a-Service (MaaS) shape the way these services operate and provide attractive transport options.

Opportunities and risks

Expectations about emerging mobility solutions are high, as they hold great promise for **reducing emissions, pollution and traffic congestion** in cities and offer potential opportunities:

- **An attractive alternative to private car use and ownership**:
  Emerging mobility options are often low- or zero-emission and can attract private car users whose needs are not met by existing alternatives.
- **A complement to public transport services**:
  Shared mobility and DRT systems can increase the competitiveness of fixed-route public transport services (e.g., bus, metro, commuter railway, etc.) by providing a solution for the first- and last-mile, cutting door-to-door travel times for those users that depart from or need to reach destinations beyond the proximity of the service area and stations. These systems also offer flexible schedules, which can be very beneficial in low-demand areas where high-frequency public transport services are not viable.
- **A way to test new mobility behaviours and technologies**:
  The availability of shared vehicle fleets offers citizens the possibility of trying new options to meet their mobility needs. This has the potential of fostering the adoption of active mobility habits such as through the availability of bike sharing and to test new technologies, such as electric vehicles.

At the same time, emerging mobility solutions bear some **risks that need to be addressed** to ensure that they contribute to urban sustainability:

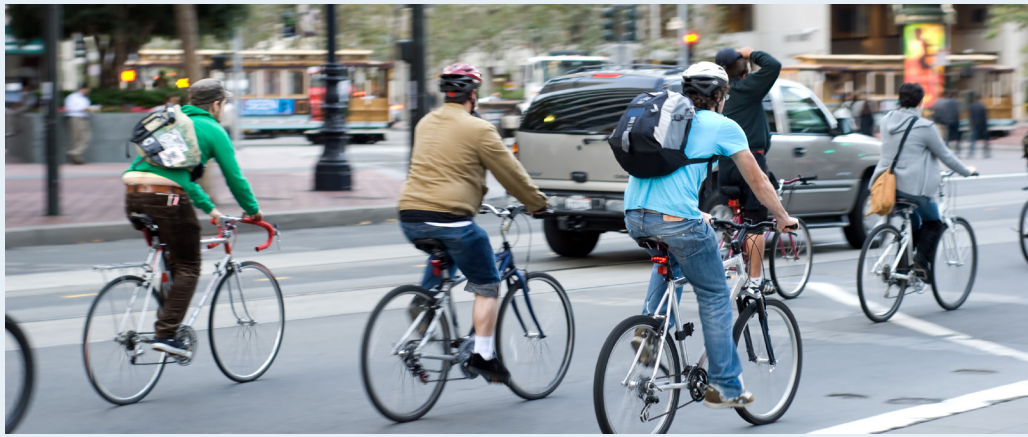
- **A potential competitor to active mobility and public transport**:
  If shared mobility services are restricted to central areas of large cities where public transport supply is often good and active mobility rates are already high, the potential for attracting users of shared cars remains a challenge.
- **Additional pressure on public spaces**:
  The availability of shared vehicles on the streets offers great flexibility to satisfy users' mobility needs but may compromise pedestrian mobility if parking regulations are unclear or no dedicated spaces are provided.
- **Growing complexity in mobility governance**:
  Emerging mobility solutions are provided by a mix of public and private service operators. Cities that want to leverage the benefits of these options often need to manage the inclusion of private stakeholders in the mobility ecosystem. They have to establish robust collaboration frameworks that ensure data availability for transport planning and service viability, among other aspects.

Short-lived hype or sensible transport alternatives?

The relevance of these opportunities and risks for cities depends on how service providers evolve in the future. Quick conclusions on market developments are difficult to draw. Mergers, acquisitions, and app integrations shape an ever-changing mobility landscape. For example, several mobility providers analysed during the beginning of the project had already disappeared by the end of the project.

The analyses conducted in the MOMENTUM cities show that emerging mobility solutions can provide complementary solutions to existing transport systems. DRT helps extend Thessaloniki public transport options to less-densely populated areas in the outskirts of the city, and bike sharing in Madrid is working as a last-mile solution for commuter railway services. Nevertheless, solutions must remain affordable, accessible, and easy to use. It remains important to consider and assess the full impact on all demographics, such as the elderly and people with specific mobility needs. Adoption analyses show that these new solutions are being used mostly by the educated male middle-class, suggesting that these services do not fulfil the specific mobility requirements of all segments of the population.

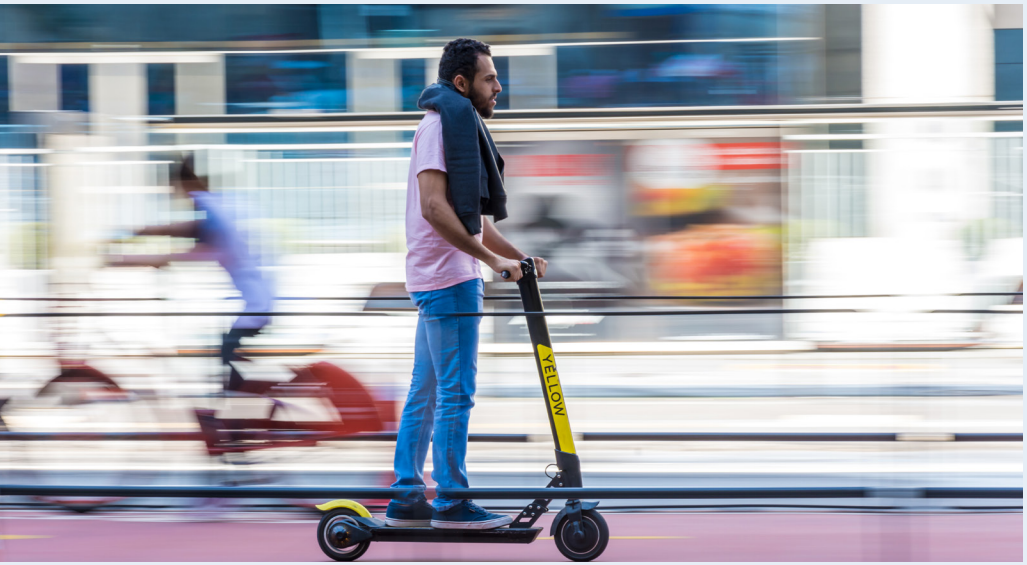
MOMENTUM started by shedding light on the future of emerging mobility solutions. The workshops and a Delphi poll engaging transport experts revealed that if the remaining challenges are properly addressed, shared mobility modal share in large cities with more than one million inhabitants can reach between 14% and 33% by 2050. Many cities and operators may support this, as rapid urbanisation and ambitious climate targets put pressure on cities to find low- or zero-emission transport solutions.



A challenge for current transport planning tools and techniques

In order to leverage the opportunities and address the risks brought about by emerging mobility solutions, transport planners need tailored tools and techniques. There is a broad consensus that the current data analytics and modelling methods applicable to traditional transport modes are not fully adapted to the characteristics of new mobility options. The dynamic nature of urban mobility and the fast-changing characteristics of new transport services make it difficult to know how transport planning tools and techniques need to be adapted. At the same time, the range of potential innovations in data analytics and modelling is broad.

Many experts consider shared mobility an element that should already be included in strategic transport models and that it will be essential if the modal share rises above 5%. Data availability, disaggregated data fusion techniques and agent-based modelling (simulates the behaviour and activities of travellers) were considered as priorities for adapting transport planning tools for the new era. Further detailed information concerning this consultation process is available in the MOMENTUM deliverable 'Challenges and opportunities for transport planning and modelling'.



MOMENTUM Data Analytics and Modelling Developments

Data fusion techniques for analysing emerging mobility options

Evidence-based policies with impact on urban transport systems require reliable information about mobility patterns and travel demand. The traditional approach to the collection of travel demand data is based on travel surveys that provide information on mobility patterns and the underlying behavioural drivers. During the last decade, new data sources have appeared which increase mobility monitoring capabilities, such as vehicular sensors, mobile network data and data from service operators.

MOMENTUM collected a wide variety of data sources from the four cities participating in the project. Relevant data was processed through various methods of data fusion and artificial intelligence techniques developed to analyse mobility patterns and travel behaviour. In total, more than 80 data sources were collected in MOMENTUM with quality standards in the following five categories applied:

- **Reliability:**
  Extent to which the data can be trusted in terms of accuracy and precision.
- **Geographical and temporal scope:**
  Geographical area and range of dates for which the data was available.
- **Geographical and temporal granularity:**
  Minimum level of aggregation of the data in terms of time and geographical area.
- **Accessibility:**
  Whether access to the data was public or private.
- **Usability:**
  Ddegree of usability of the data source within the project, given its characteristics in terms of data quality.

Further detailed information concerning data collection and assessment is available in the MOMENTUM publication 'Data Inventory and Quality Assessment'. The data analysis techniques developed to utilise disaggregated data sources and extract indicators on the use and adoption of new mobility services are described in the MOMENTUM publication 'Methodologies and Algorithms for Mobility Data Analysis'.

Modelling techniques used in the four MOMENTUM Cities

Madrid
A household survey, service operation data from a public station-based bike sharing service (*BiciMAD)* and a private free-floating moped sharing service (*Muving*) was used. Moped sharing showed a higher bias towards high income users than bike sharing. Additionally, the survey showed that shared mobility users (67%) have a private vehicle available when they perform a shared mobility trip. This suggested that shared mobility services could be attractive enough to prevent people from using their private vehicles. *BiciMAD* and Muving were used for short and medium trips, with an average distance of less than 3km. 22% of *BiciMAD* trips were taken in combination with public transport. This indicates that BiciMAD is used as a last mile service that supports public transport use.

Leuven
The adoption of shared mobility services was studied using microdata from a survey in the Belgian city. Results showed that people living in households with at least one car sharing subscription were mostly young women. This conclusion was the exact opposite of the results drawn from Madrid and Regensburg. Results showed that those already participating in car sharing are mostly young, highly educated and employed women, of which nearly 20% were students.

Regensburg
Microdata from a mobility survey was used to measure the adoption rate of electric car sharing services. Most users of car sharing services were young, employed, highly educated males, who otherwise prefer the use of active mobility and public transport. Therefore, car sharing is a great solution for the few times a private passenger vehicle is needed. Assessing the data of the trips with shared electric cars showed that these services were mostly used for medium and long trips, with an average travel distance of between 25 kilometres (starting from a sharing station in the city centre) and 45 kilometres (sharing station in the rural area). The length of the trips, rental patterns and booking and reservation data suggests rather spontaneous and sporadic usage.

Thessaloniki
Data from the dock-based bike sharing service *ThessBike* was assessed, concluding that most of the registered users were middle-aged and highly educated. However, unlike the cities examined in the project, no biases were observed in terms of gender and income. The user survey showed that approximately 80% owned private cars and 40% owned a private bicycle.

Modelling techniques to anticipate new mobility impacts

While data can help analyse the impacts of current systems, models are required if policymakers want to test policy alternatives to facilitate the implementation of emerging mobility solutions. MOMENTUM made significant efforts to expand current transport modelling capabilities, which are largely based on the traditional four-step approach to travel demand modelling that include:

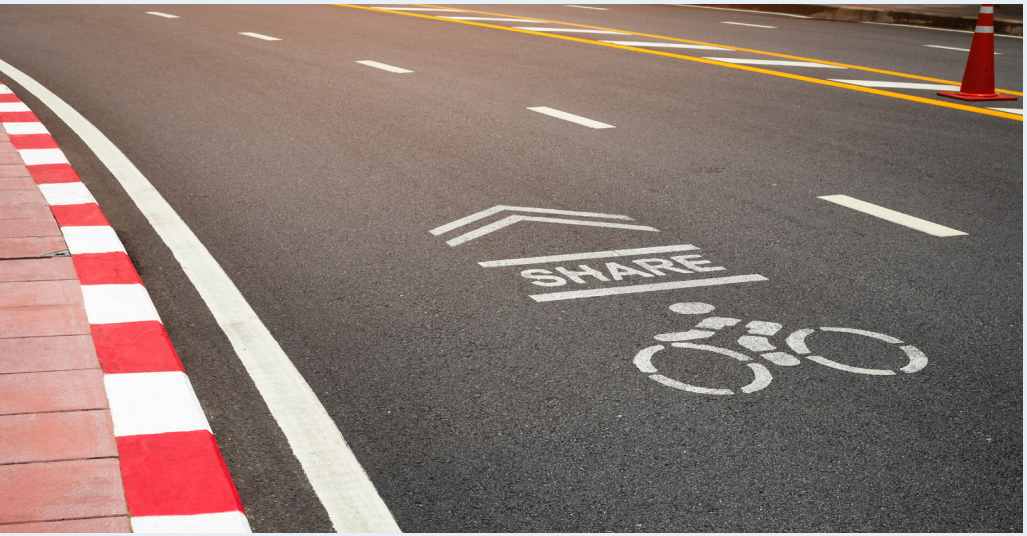
- Trip generation models, which estimate the number of trips made by different segments of the population according to household size, income and other factors.
- Trip distribution models, which estimate how many trips are made between city zones, depending on the attractiveness of each zone to perform activities and the travel costs between areas.
- Mode choice models, which estimate how many trips are made in each mode between city zones, depending on the travel times and costs, as well as on the profile of travellers.
- Route assignment models, which estimate how many trips are chosen along routes in transport sub-networks (roads for car trips, public transport lines).

Some aspects of new mobility services, such as the supply-demand interaction (i.e., the available supply depends on the demand patterns of the service), require major adaptations to the standard ways to operate with these models. Rather than substituting the four-step approach, MOMENTUM developed an '**intermediate modelling framework**'. This consists of enriching the four-step approach with additional modules based on new modelling techniques (e.g., agent-based modelling) and on the opportunities raised by new data sources, which are able to address the modelling challenges posed by new mobility solutions.

This facilitates compatibility with strategic transport models already available to many cities that are based on the four-step approach. A detailed review of the models developed can be found in the MOMENTUM publication 'New Transport Modelling approaches for Emerging Mobility Solutions'. The modelling algorithms are available as open-source scripts in the MOMENTUM GitHub repository (https://github.com/h2020-momentum). The guidelines for the use of this repository can be found in the MOMENTUM publication 'Open Repository of Demand and Supply Models and Algorithms for Emerging Mobility Solutions'.

The algorithms developed cover different aspects of travel demand and mobility supply, as well as service impacts on cities:

- **Induced demand models** to understand the increases in the total number of trips that may be caused due to new mobility options.
- **Origin-destination matrix classification models** to unveil recurrent demand patterns between city zones depending on the day of the week and time of day, special events, weather conditions, etc.
- **Synthetic population models** to generate individual agents that reproduce the trip requests made by shared mobility services.
- **Mode choice models** to understand the drivers behind the choice of new mobility services and predict how shared mobility demand reacts to service expansions and other policy interventions.
- **Car ownership models** to analyse the variables that explain car purchases among households and if emerging mobility services can have an impact on such variables.
- **Traffic assignment models** to better capture route choice patterns in local networks.
- **Service optimisation models** to align service supply characteristics (e.g., number of vehicles, location of stops, vehicle rebalancing, etc.) with demand patterns.
- **Service simulation models** to understand the impact of different service layout and demand levels on the overall mobility system.
- **Emission models** to assess the contribution of emerging mobility services on the carbon footprint of urban transport.



MOMENTUM Decision Support Tool

Integrating the project's developments into a policy-making oriented framework

Evidence-based policymaking requires that the technical developments concerning the indicators and assessments are attainable by policymakers. MOMENTUM took this as a guiding principle and developed a Decision Support Tool (DST) that offers a user-friendly interface for the data analysis and modelling algorithms provided by the project. The DST supports cities in the implementation of new mobility services in line with their policy objectives and Sustainable Urban Mobility Plans (SUMPs). The tool is available at https://momentum.imet.gr.

A tool adaptable to cities' needs

The DST is adapted to the data availability and analysis needs of each city, offering a three-level framework that meets the interests of transport planners.

Level	Input data requirements	Analysis capabilities
Level 1	**Low**: demographics + socioeconomic data	**Analytical**: preliminary transportation design
Level 2	**Medium**: mobility data	**Extensive**: data-driven decision-system
Level 3	**High**: full information using transport simulation tools	**Comprehensive** transport planning including passenger-oriented indicators

Level 1
This level requires a small amount of input data, including basic information, such as number of inhabitants, size of the analysis area and the selection of the desired service that should be deployed. The selection includes bike sharing, on-demand taxi sharing, free-floating e-scooters and DRT solutions. Due to the limited amount of necessary input data, assumptions will be made so that decision-makers can receive an initial estimation that can be used for a SUMP or planning process.

Level 2
This level requires more comprehensive input data and users need to perform data preparation to import transportation data in the applicable format. The higher granularity of input data allows a detailed analysis of the selected modes of transport (DRT, dock-based bicycle sharing, free-floating e-scooters and taxi ride sharing). The output information on the potential bicycle networks and public transport stops will be more accurate. Level 2 utilises spatially distributed data from trips or Origin/Destination (O/D) to support the decision-making process for the deployment of services. The user can define the desired characteristics of the service, such as expected demand, number of stations, the maximum acceptable walking distance to stations and other parameters.

In the next step, users provide values of demand in the examined area, the road network and constraints such as the availability of bicycle networks and public transport stops. Based on those criteria the planning module can return the optimal number, location, and capacity of stops or docks. Thanks to the feedback of the MOMENTUM cities, features to visualise and present results were added to this level of the tool.

Level 3
Level 3 is based on the investigation and extension of city transport models to enable the strategic planning and evaluation of shared mobility services. The implementation of Level 3 needs to be completed offline and then the visualisation and analytical tools of the online version can be used to assess the newly created KPIs.

Changes are required to incorporate emerging mobility solutions into strategic transportation models, both in terms of supply and demand. Level 3 models can capture and mimic user interaction and behaviour with emerging mobility services in strategic transport models, both in terms of supply and demand.

Furthermore, the simulation platform Aimsun Ride is used to evaluate the potential of shared mobility services such as Demand Responsive Transport (DRT), car sharing, bike sharing and carpooling. The platform was designed as a plug-in for the commercial software Aimsun Next and has been improved and extended for the scope of the MOMENTUM project.

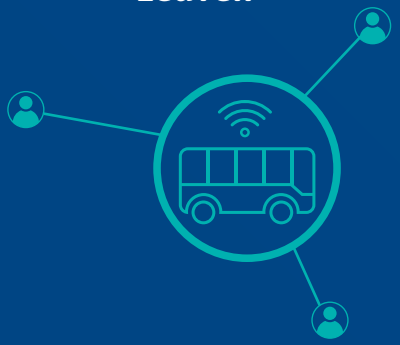
Implementation of the tool
For further details on the input and output data of each level and for a detailed description of the DST, a summary of the DST functions can be watched here and details of the implementation of the DST in the four MOMENTUM cities can be found in the publication of D5.3 Implementation of the MOMENTUM Decision Support Toolset in Madrid, Thessaloniki, Leuven and Regensburg.

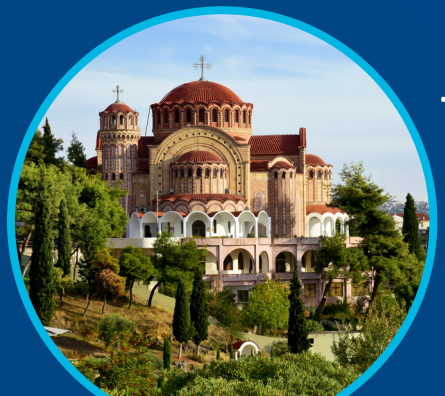
Madrid

Stories from MOMENTUM Cities

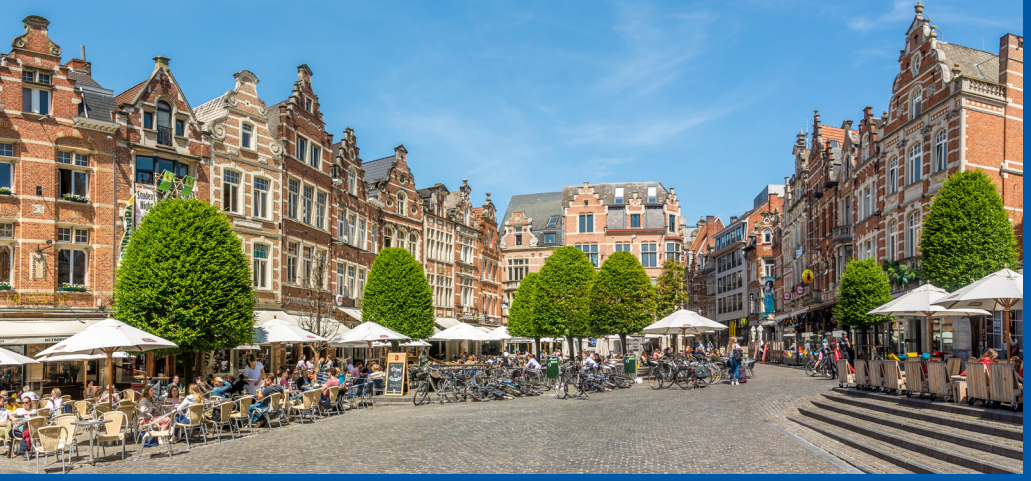
Regensburg

Leuven





Thessaloniki



Leuven

Key facts:

- Leuven is a Belgian university city with more than 100.000 inhabitants and 55.000 students.
- The city is part of the suburban area under the sphere of influence of Brussels
- Thanks to the unique role of the university, various spin-off companies in technology and research are created, which significantly contribute to the local economy.
- The city has over 30.000 bicycle parking spaces, cycling streets, and even cycling highways that provide a connection to Brussels.
- More than 4000 people in Leuven utilise the local car sharing services which includes a fleet of more than 200 cars.

Mobility challenges

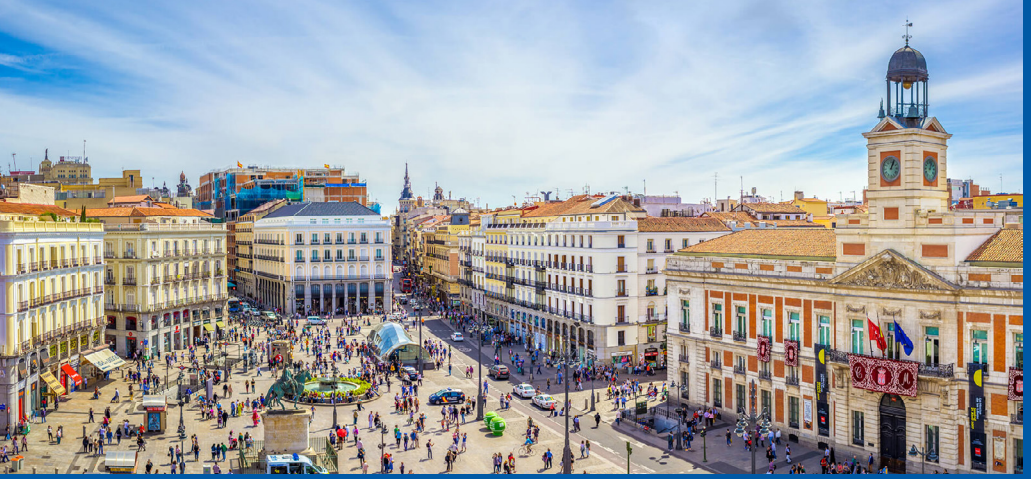
- The car remains an important mode of transport, especially in the outer districts which are still organised in a very car-centric way. In recent years however, the car is losing ground, and has actually been overtaken by the bike as the preferred transport mode for commuters.
- Since Leuven is a regional hub, a significant amount of traffic is generated by commuters from the hinterland that enter the city with passenger cars. Leuven takes significant steps to reduce congestion and improve accessibility of the city centre by promoting the modal shift to public transport and active mobility.
- Bike sharing has had limited success. The national train company operates a sharing system with only one hub at the central station in Leuven, which serves 2.000 to 3.000 people a year. This service successfully reaches a specific audience, namely irregular visitors of Leuven who combine interregional train trips with a shared bike. One potential reason for the 'limited success' is the fact that bike ownership is quite high in Leuven.

Main successes

The city of Leuven has acquired experience with data-driven policymaking thanks to the developments made in MOMENTUM. A new traffic model including MOMENTUM developments was included in the SUMP process, and many relevant stakeholders acknowledged that this facilitates the collaboration between transport authorities, operators and citizens in understanding the mobility solutions that better fit their needs. Since shared mobility is still on a relatively low level in Leuven, new investments need to be made and new planning tools will be necessary to increase the efforts. Additionally, the effectiveness of the tools will improve as more data is obtained.

Recommendations for cities

- **Invest in data collection and in-house expertise on transport modelling:** Although some entry level tools require very little data and expert knowledge, their usefulness is consequently limited. The added value of more complex tools, which require more data and expertise, is substantial.
- **Transport modelling needs to be embedded in a larger plan or SUMP:** MOMENTUM was essential to convince the city of Leuven to expand shared mobility services, as it demonstrated the need to approach this from a wider perspective. Besides the focus on the uptake of services, the following aspects should be included: use of public space, impact on local residential areas as well as the complementarity with public transport and parking.



Madrid

Key facts:

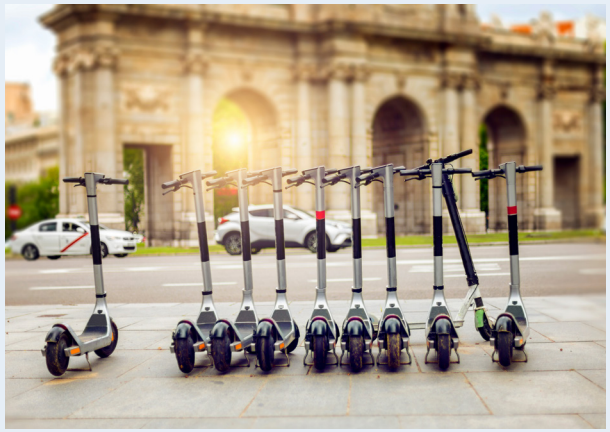
- Madrid has three million inhabitants and twice as many in the metropolitan area
- The cycling network includes about 350km of dedicated cycling lanes
- Madrid has a large public transport network that covers the whole region, including a metro system (13 lines & 236 stations), an urban bus network operated by EMT Madrid (212 lines & 4100 stops), a metropolitan bus network (450 lines & more than 8000 stops) and a commuter railway network (9 lines & 94 stations).
- In terms of shared mobility options, Madrid offers a vast array of services. This includes several e-scooter operators, a public bike sharing system operated by EMT Madrid (3000 electric bikes), five moped sharing providers (more than 3000 vehicles combined) and five car sharing operators (more than 3000 cars combined).

Mobility challenges

- Street space management is challenging due to the increased number of shared electric vehicles (especially e-scooters).
- Air pollution and traffic congestion remains a significant challenge. Shared cycle lanes (sharrows), an LEZ (Low Emission Zone) and a holistic 'Madrid 360' sustainability strategy aim to tackle this problem. Additionally, the municipality is promoting new parking facilities and Park and Ride schemes.
- The rapid evolution of shared mobility systems, constantly changing, make it difficult to interpret the demand data they collect. A closer monitoring of shared mobility services would allow better quantification of the relation between supply (number of docks, number of vehicles, etc.) and demand.

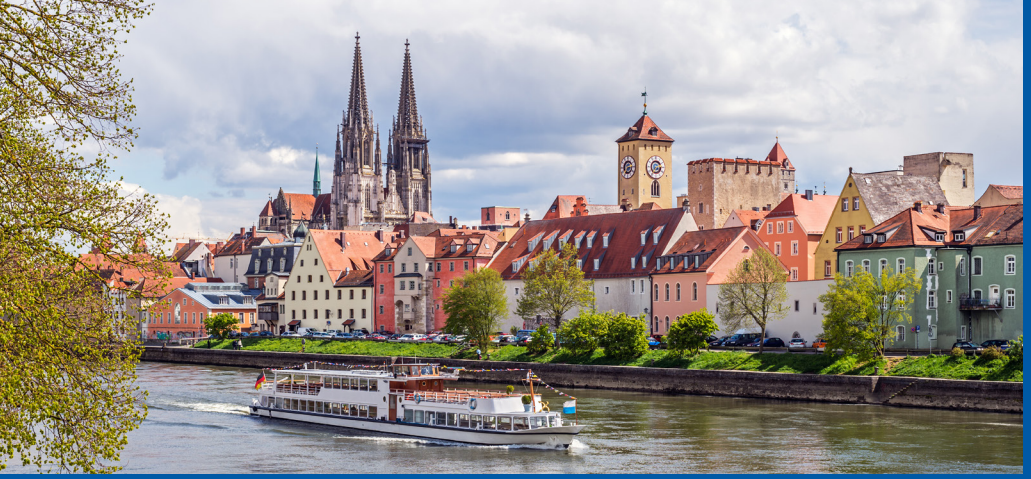
Main successes

The data analytics techniques developed in MOMENTUM have provided a deeper knowledge on the mobility patterns of bike sharing users and moped sharing users, shedding light on the adoption drivers of these services (e.g., bike sharing has less bias towards high-income people than moped sharing) and the role of shared mobility as an attractive alternative to private car use. Knowledge on the use and adoption of bike sharing has been used to coordinate the expansion of the public bike sharing system to the whole city through use of the MOMENTUM DST.



Recommendations for cities

- **Facilitate the entrance of new shared mobility options:**
  The inclusion of new options needs to be led by the public sector to assure collective public transport remains the backbone of the system.
- **Close cooperation with all mobility operators and other agents involved is vital:**
  A "Community of Practice" (CoP), which is a stakeholder group that includes representatives from citizens' organisations, local businesses, transport providers and other partners, can be an ideal platform that can foster exchange and be vital to gain broad support for the transport modelling exercises.



Regensburg

Key facts:

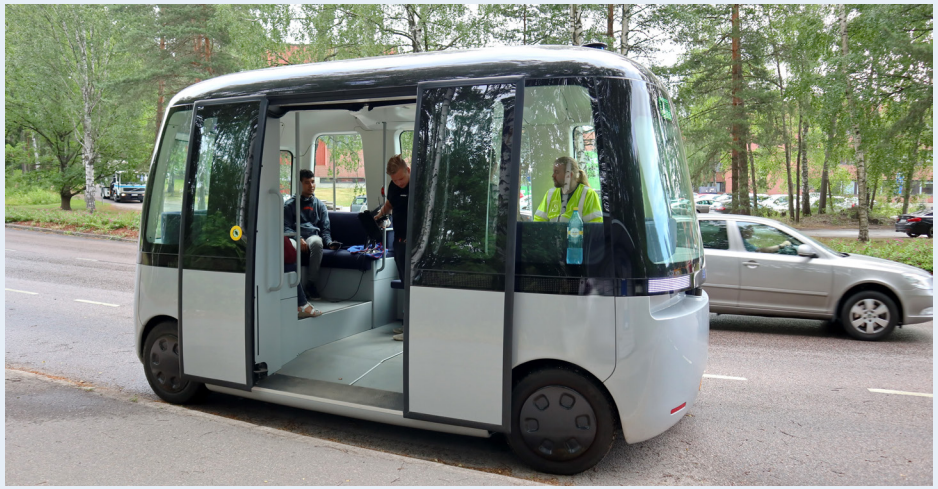
- More than 150.000 inhabitants
- Important economic and academic centre in the South of Germany
- The city has deployed an Autonomous People Mover (autonomous shuttle) in a peripheral commercial area as a pilot. It has been identified that this solution can play a role in the old town, given the narrow alleyways that characterise this area.
- The existing car sharing system is being developed on a very small scale and the bike sharing system could not yet be implemented for financial reasons.

Mobility Challenges

- Thanks to its historic city centre, which is listed as a UNESCO World Heritage Site, Regensburg is a significant tourist destination, which creates an additional burden on the existing modes of transport.
- Since the local economy is profiting from passenger car production, the local mentality and transport policies are often car centred.
- Commuters are a significant challenge that increase the overall traffic volume.
- Efforts are being made to electrify and modernise the bus fleet and a feasibility study for a tram system is being carried out.

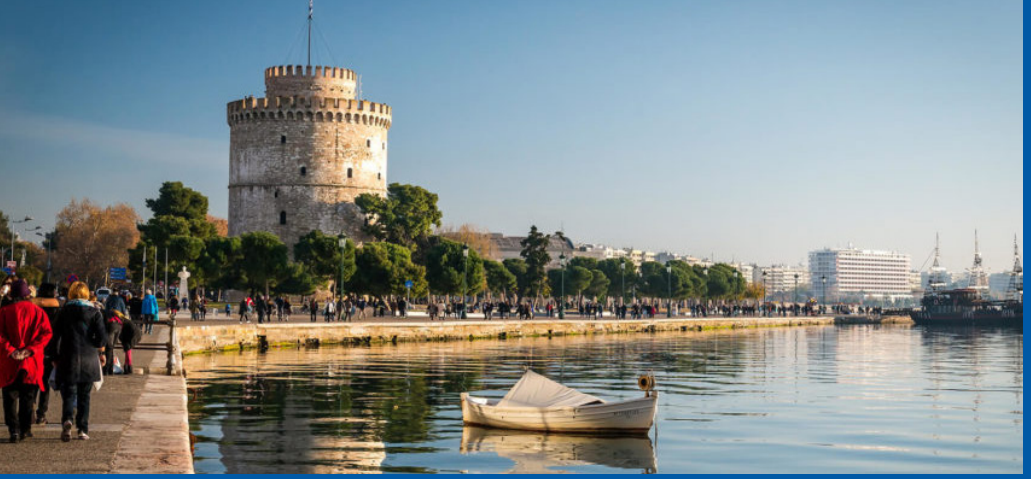
Main successes

The main success of Regensburg, besides the testing of various mobility solutions, is the funding of cargo bicycles. The purchase of a cargo bike is subsidised with 25% of the net purchase price up to a maximum of 1000€. Requirements for this subsidy are proof of residency and a contract with an energy provider that offers electricity from renewable energy sources. This subsidy has caused a remarkable number of cargo bicycles to circulate in the city. It is expected that the tools developed by MOMENTUM will further help Regensburg to accelerate shared mobility implementation.



Recommendations for cities

- **Actively support the integration process of emerging mobility solutions to increase the mobility options:**
  Thanks to MOMENTUM, Regensburg gained experience in transport modelling and can draw conclusions on user behaviour in connection with emerging mobility solutions. These experiences on the small scale will be used for a larger roll-out of solutions in the future.
- **Gathering external support, especially if you are a small city:**
  Regensburg cannot invest in an in-house team for transport modelling. The Technical University of Munich cooperated with the city to do this and help promote the concept of transport modelling.



Thessaloniki

Key facts:

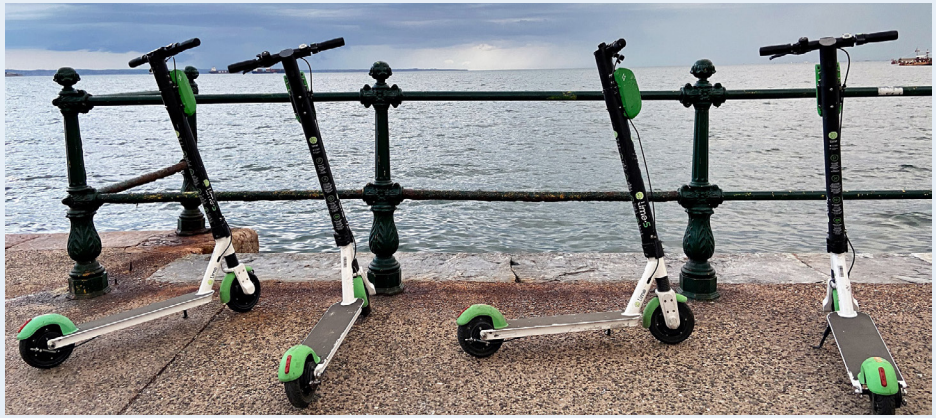
- Metropolitan area with more than one million inhabitants
- Important hub for commerce and culture
- Significant transport hub (port, airport and regional centre)
- Flat landscape, wide seafront and mild winters that favour micromobility adoption
- City invests in cycling infrastructure and shared mobility, as well as in DRT services. DRT systems are expected to play a critical role in the surrounding areas where the population density is low.
- In the framework of the EU-funded GALILEO4MOBILITY project in 2019, taxi sharing services were established, which helps commuters from suburban and peri-urban areas access the city centre.

Mobility challenges

- Until the completion of the metro, the bus service is the only available public transport solution in the city.
- Most trips are completed by private passenger cars, as the local bus service is currently inefficient.
- The new emerging mobility solutions of Thessaloniki (DRT, micromobility, bicycle & ride sharing) will complement existing mobility solutions and will hopefully cater as a feeder for the public transport systems or serve door to door trips.

Main successes

The design and test of the multilevel MOMENTUM DST in cooperation with CERTH/HIT was a significant success that was a win-win situation for Thessaloniki and the research centre. The tool paves the way towards giving decision makers all the required information, both operational and financial, to design and implement emerging mobility solutions. The evaluation of current and planned bike sharing schemes was performed through the MOMENTUM DST, which included fleet size, bike sharing models (dock or dockless) as well as distribution and rebalancing operations. The Municipality of Thessaloniki also aims to shift from a dockless to a dock-based scooter sharing system to improve urban space. The DST provided insights on the optimal number of stations, optimal locations and the number of docks each station should have.



Recommendations for cities

- **Use the MOMENTUM Decision Support Tool:**
  The DST is a great tool to improve the decision-making process, which is a difficult and demanding procedure for every city. The tool is even useful if only basic data is available. Through the first level of the tool any city can have an initial identification of the applicable urban mobility interventions and the impact of their implementation by simply entering geospatial and cost data. Proceeding to the following levels, the city can explore and study the principal strengths and weaknesses of the suggested solutions.
- **Involve private and public transport operators holistically:**
  It is critical to involve the private and public transport operators, technology providers and citizens in every step of the decision-making process in order to build solutions as responsive as possible to the real needs of the ecosystem.

MOMENTUM Key Takeaways

The conclusions of the MOMENTUM project cover both lessons learned on the role of emerging mobility services in cities and on how data analytics and transport modelling can help cities implement new mobility solutions in a way that contributes to a safe and sustainable urban environment.

- **Emerging mobility options are an opportunity for sustainable mobility - but details matter:**
  The four cities participating in the project as case studies consider that the implementation of new mobility offers such as shared mobility services or DRT schemes can be very beneficial to help reach their goals. The research conducted during the project shows that the detailed configuration of the services (such as the service operating area, location of vehicle pick-up and drop-off points, service fares, etc.) determine the ability to reduce emissions, pollution, and traffic congestion. Properly configured systems can attract private car users and reduce car ownership levels without competing with active transport and public transport services.

- **Multi-actor cooperation and citizen involvement is essential:**
  The collaboration between transport planners, decision-makers from public authorities and mobility service providers from the private sector enables a successful implementation of emerging mobility options, as it leads to services able to contribute to cities' sustainability goals and the ability of operators to be financially viable. The cooperation that was established amongst stakeholders in the four MOMENTUM cities provides a good example of the growing interest to reach agreements in a holistic way. At the same time, the involvement of citizens in the decision-making process on new mobility options is still very challenging. While the tools developed in the project helped citizens to understand the impacts of emerging mobility options, more research needs to be done in terms of how to bridge the gaps (i.e., languages, technical knowledge, interests) between transport-related stakeholders and the general public.

- **The user base of emerging mobility options needs to be broadened:**
  MOMENTUM analysed the user profiles of a wide variety of emerging mobility services across the four cities participating in the project. The results show that these services are mostly used by specific groups, e.g., young and with high education levels. Several factors contribute to this: the early deployments in inner core areas of cities where this demographic has a large presence, as well as the need to adapt vehicles/fleets to the mobility needs of families and the elderly. Shared mobility growth will depend on the capacity of the services to attract broader segments of the population.

- **Piloting needs to be complemented by simulations:**
  Trial-and-error processes have dominated the early stage of emerging mobility services across European cities, given the lack of tools to anticipate their impacts. While piloting is useful for gathering user input and testing new mobility concepts in real life, it is also necessary to increase cities' capabilities to understand the effects of such concepts. The tools provided by MOMENTUM help cities simulate different alternatives for how these new systems may operate. This should help them define regulation schemes and tendering processes for service providers, as well as refine pilot programmes if necessary.

- **A fast-changing market requires close monitoring:**
  The rapid evolution of shared mobility services, DRT solutions and other innovative transport options is a challenge for data analysis. Several providers of emerging mobility solutions that were assessed during the beginning of the MOMENTUM project have either merged, vanished or changed their business model throughout the relatively short duration of the project. Supply and demand baselines are very dynamic, given fleet expansions, merging of service providers and the integration of services into different apps. Cities require tools to monitor these new services, to better quantify the relation between supply and demand and the impact of measures towards the integration of new services with public transport networks.

- **Data sharing is not enough: standardisation and fusion with other sources is key:**
  One of the main motivations for multi-actor cooperation is data sharing. Operations data from service providers is a valuable source of information for analysing the contribution of new mobility options to urban sustainability and for reaching agreements that are beneficial for all stakeholders. Momentum has shown that not all of the required information on the use and adoption of new mobility services can be extracted from operations data alone. Cities need tools to make the most of the data collected.

- **Data privacy is a requirement - and it is compatible with the need for fine-grained data:**
  MOMENTUM has developed techniques for mobility data analysis that help cities understand how the needs of each population group are covered by emerging mobility options. At the same time, data privacy needs to be ensured through all assessment procedures performed by cities and operators. Data anonymisation techniques, implemented as part of the design of the algorithms, can effectively cover this aspect. In addition, the provision of analytical tools that go beyond mere data collection help cities identify specific use cases that motivate the gathering and processing of data, as current regulations demand.

- **There is no 'one-size-fits-all-solution' for implementing emerging mobility options:**
  Implementations of mobility services can differ significantly from one city to another, so a single tool cannot cover all the needs of cities related to the wide variety of possible configurations and uses of these services. Any effort to improve cities' capabilities in terms of emerging mobility solution assessments has to acknowledge the variety of data availability situations and the skills and resources available among transport planners (e.g., the availability of a strategic transport model). MOMENTUM tools and techniques have been developed taking this into account, providing cities with the ability to analyse the impacts of emerging mobility solutions from adaptable starting points.

- **Cities need more expert support for enabling evidence-based decision making:**
  The use of the tools and techniques developed in MOMENTUM in the four case studies proved that cities would benefit from increased resources for expert support in transport modelling. This can be provided either from in-house staff or hired externally. The project has developed tools that cover the needs of cities that cannot have immediate access to such expert support, but the ability of performing more complex analysis would be beneficial for any city.

- **MOMENTUM provides a toolset for a seamless integration of emerging mobility options:**
  The MOMENTUM DST integrates the technical developments made by the project in terms of data analysis and modelling. It provides a modular framework based on three levels of analysis that is adapted to different scenarios and different levels of data availability.

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