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Research and innovation in car sharing in Europe

An assessment based on the Transport Research and Innovation Monitoring and Information System (TRIMIS)

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Abstract

This report provides a comprehensive analysis of R&I related to car sharing in Europe. The assessment follows the methodology developed by the European Commission's Transport Research and Innovation Monitoring and Information System (TRIMIS). The report critically assesses research by thematic areas, highlighting recent technological and other developments and future needs. The projects were grouped according to six key thematic areas: Better understanding of impacts (economy, environmental); User behaviour and acceptance of car sharing schemes; Information Technology development: apps, websites, connected cars; Vehicle technology: electric vehicles, hybrid vehicles, ergonomics, automated vehicles; Development and implementation; and Others: stakeholder engagement, regulations, and policies. Three main findings arise. First, most of the projects target urban environment, which makes sense from the industry point of view and potential users. Second, there has been an increase in funding support for car sharing schemes in the recent years, especially through R&I projects focusing on the development of Information Technology (IT) solutions: apps, websites, connected cars, etc. Finally, countries with significant public investments in R&I and a substantial transport industry, as well as consultancy and IT related companies, appear well placed to adopt car sharing schemes.

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Executive summary

The Transport Research and Innovation Monitoring and Information System (TRIMIS) is the analytical support tool for the establishment and implementation of the Strategic Transport Research and Innovation Agenda (STRIA), and is the European Commission's (EC) instrument for mapping transport technology trends and research and innovation capacities. The EC's Joint Research Centre (JRC) has developed TRIMIS to support and monitor the implementation of STRIA.

Seven STRIA roadmaps have been developed covering various thematic areas, namely:

- Connected and automated transport (CAT)
- Transport electrification (ELT)
- Vehicle design and manufacturing (VDM)
- Low-emission alternative energy for transport (ALT)
- Network and traffic management systems (NTM)
- Smart mobility and services (SMO)
- Transport infrastructure (INF)

Policy context

In May 2017, the EC adopted STRIA as part of the 'Europe on the Move' package, which highlights main transport research and innovation (R&I) areas and priorities for clean, connected and competitive mobility to complement the 2015 Strategic Energy Technology Plan. The European Green Deal also highlights the European Union's (EU) commitment to accelerate the shift to sustainable and smart mobility, achieving climate neutrality by 2050.

The 2030 Climate target plan (European Commission, 2019a) establishes a 55% greenhouse gas (GHG) emissions reduction target by 2030 compared to 1990. It acknowledges that all transport sectors - road, rail, aviation and waterborne transport - will have to contribute to the 55% reduction effort. A greater use of sustainable transport modes, multi-modal solutions, digitalisation for smart traffic and mobility management can reduce GHG emissions address noise and air pollution.

In December 2020, the EU published the Sustainable and Smart Mobility Strategy (European Commission, 2020a). This notes that a comprehensive policy is required to stimulate demand for zero-emission vehicles, which includes new and innovative solutions for more sustainable and healthier urban mobility. The European Urban Mobility Framework (European Commission, 2021) also acknowledges that more decisive EU action on urban mobility is needed to shift from the current approach based on traffic flows to an approach based on moving people and goods more sustainably, with a stronger collective/public transport backbone, and better active mobility options. Public transport and shared mobility services should complement each other. Car-sharing schemes can contribute to this objective. Such schemes provide a membership-based self-service and short-term car access system with a network of vehicles for which members pay by time and/or distance. This involves accessing a car owned by another person or entity in exchange for an agreed monetary payment.

Main findings and conclusions

Based on this research and review, the following findings and conclusions arise:

- Limited availability of analyses and data in a standardised format together with a lack of a robust impact assessment methodology means that it is difficult to get a clear picture of the state of car sharing in Europe. This lack of data is partly because of companies unwilling to share what is considered commercially sensitive data. Where data are available they are often out-of-date.
- A standardised assessment approach that produces comparable results is needed to understand the impacts (i.e., benefits and costs) of car sharing for urban mobility. It is not the focus of this report to outline such an approach, but the literature review revealed recommendations to improve car sharing impact assessments ensuring transparency and replicability.
- Car sharing has several unique properties (e.g., the users have no responsibility for maintenance, booking on-line/on-demand) which are not seen with private car ownership or other forms of urban transport.

— Many car sharing schemes rely on wireless communication to provide users with access to the vehicle at a specified time. They are therefore vulnerable to an unexpected disruption to the communication network as well as cyberattacks having potential privacy issues for users.

— Currently, users experience many sharing schemes on a first come/first served basis according to a tariff structure that depends on car availability and traffic in the area. However, they can experience traffic congestion at the point of access to the car sharing vehicle. When there is a high demand, some users may not gain access to a vehicle. The introduction of pricing techniques can solve this issue, and at the same time shift usage of vehicles to off-peak hours.

— Two main findings arise from the literature review. First, car sharing is popular in European cities with many highly educated inhabitants or cities with a university, whilst that is not the case in cities with many car commuters. Moreover, habits play an important role and some users may not be willing to change their behaviour despite the arrival of new services like car sharing. Car sharing is still not seen as an alternative to car ownership but a means to complement and extend existing mobility options. In this sense, private companies have established car sharing schemes only in large metropolitan areas with good public transport and important traffic congestion problems. However, they reported financial losses in the last years and they only expect profitability in the long term, which might need further support from the municipalities. Second, each European city is different regarding geography, administrative structure and extent of traffic congestion and air quality issues. There is a variety of different car sharing schemes and business models that can be used to implement shared mobility in urban areas. Car sharing has the potential to contribute to improving urban air quality (e.g. by reducing car ownership and CO_2 emissions per person), especially in case of low-emission technologies and increasing accessibility as part of a multi-modal urban transport system that includes public transport, walking and cycling.

— The analysis of European R&I projects available in the TRIMIS database provides the following conclusions:

— First, most projects target the urban environment, which makes sense from the industry point of view and potential users. However, an additional effort might be needed to study their support for the decarbonisation of rural transport. In this sense, the European Urban Mobility Framework recommends that in particular in rural areas shared and on-demand mobility could become part of public transport.

— Second, there has been an increase in the funding support of car sharing schemes. This is particularly true for projects studying IT development: apps, websites, connected cars, etc.

— Third, countries with a long tradition of public investments in R&I, and a large transport industry, including consultancy and IT-related companies, appear well placed to adopt car sharing schemes.

Key recommendations

The following recommendations can be made to transport planners and policy makers:

— If car sharing is to be expanded across European cities, then it is clear that a standardised robust methodological approach is needed to better understand the extent and effects of car sharing on urban mobility. The adoption of a best practice methodology could provide a better understanding of the impacts of car sharing schemes, potentially further improving urban accessibility, mobility and air quality for all European citizens.

— Car sharing became more widespread in Europe relatively recently. It falls under the concept of sharing economy and has not been specifically addressed by European regulation as such. Sharing of best practice approaches and establishing guidelines at the European level might be needed. At the same time, common approaches should also allow flexibility for cities to suit their mobility needs.

— Before implementing any car sharing scheme, municipalities should conduct an ex-ante analysis to understand the travel patterns of potential users. Since transfers from public transport to car sharing schemes might partially offset the benefits of car sharing, it is key to assess overall externalities of the car sharing scheme. The ideal car for such schemes should be small, electric, connected, with a high degree of automation (or even fully automated in the future since they can improve urban mobility by increasing the efficiency and safety of the transport system, as stated in the CAT STRIA roadmap (Meyer, Blervaque and Haikkola, 2019)) and should have a high daily usage.

— Municipalities should ensure that car sharing schemes are integrated within the existing public transport system and are easily accessible and targeting specific demographic groups (e.g. non digital natives or

people with disabilities) to encourage them to use the service. See, for instance, the guidelines on Sustainable Urban Mobility Plans (SUMP Guidelines) on the Integration of Shared Mobility Approaches to SUMPs (Arndt et al., 2019). Cities can implement several measures to support such integration (e.g. journey planning information, payment, urban infrastructure, etc.), but the dimensions of the integration will depend on the context of the city, since not all cities have the same transport facilities and transport patterns. For instance, charging stations of car sharing electric vehicles should be allocated to complement public transport and increase their user base (e.g. car sharing is a very good option for the last mile of a multimodal trip). Also, the monitoring of the scheme is crucial, since car sharing services should contribute to reducing the overall externalities of the transport system. The focus should be on facilitating multimodal trips where these can reduce GHG emissions, as well as on enabling the substitution of trips made with privately owned cars with shared cars where public transport is not available.

Related and future JRC work

In 2017, the JRC has launched TRIMIS on behalf of the EC Directorate General for Mobility and Transport (DG MOVE) and the Directorate General for Research and Innovation (DG RTD) and has published several Science for Policy and Technical reports[1]. These reports directly support the STRIA process, the related roadmaps as well as other areas of EU transport policy. The Science for Policy report on Research and innovation in smart mobility and services in Europe provides a comprehensive analysis of R&I in smart mobility and services in Europe (Tsakalidis et al., 2020) critically assesses research by thematic area and technologies, highlighting recent developments and future needs. The Science for Policy report on Research and innovation capacity in smart mobility and services (van Balen et al., 2018) maps relevant R&I capacity and focuses on framework programmes, the geographical and organisational distribution of funds, as well as investments per Member State and per mode of transport.

Quick guide

This report is divided into four sections. After a brief introduction, Section 2 describes the background of car sharing in Europe from various perspectives, including EU policy initiatives and the main characteristics of car sharing schemes across Europe. Section 3 provides an analysis of the different R&I projects that have been publicly funded across Europe relating to car sharing, and how these are distributed across countries, organisations and transport modes. It also identifies key technologies researched as well as the level of their maturity. Finally, Section 4 outlines conclusions and policy considerations for the future.

[1] https://trimis.ec.europa.eu/archive/trimis/documents

1 Introduction

European cities are grappling with the challenge of enhancing mobility while improving air quality, road safety and reducing traffic congestion. In the European Union (EU), road transport accounts for almost 20% of the overall GHG emissions (European Environment Agency, 2021). Urban mobility accounts for 40% of all carbon dioxide (CO_2) emissions from road transport and up to 70% of other pollutants, such as nitrogen oxide (NO_X) and particulate matter (PM) (European Commission, 2017a; European Environment Agency, 2016, 2015). Today, almost 40% of EU citizens live in urban areas (Eurostat, 2020) with concentrations of NO_X and PM above legal limits, with over 379 000 premature deaths attributed to high concentrations of PM (European Environment Agency, 2020).

The European Commission (EC) has a commitment to reduce greenhouse gas (GHG) emissions by at least 55% by 2030 across the whole economy. To deliver this intermediate step towards climate neutrality in the EU by 2050 (European Commission, 2019b), the EC has adopted the Sustainable and Smart Mobility Strategy (European Commission, 2020b). This new strategy aims at making connected and automated multimodal mobility a reality, and reinforces the objectives of the former low-emission mobility strategy to increase the efficiency of the transport system, speed up the deployment of low energy transport alternatives, and move towards zero-emission vehicles (European Commission, 2016a). Cities play a key role in the strategy's delivery by encouraging a modal shift to active travel (e.g., walking and cycling), public transport and shared-mobility schemes (e.g., car sharing and bike-sharing) to reduce congestion and air pollution. The European Urban Mobility Framework (European Commission, 2021) highlights that to achieve a sustainable and multimodal transport, public transport and shared mobility services should complement each other.

The car continues to be the most common mode of transport in the EU for the most frequent trip. On average car users travel over 20 kilometres, have a journey time of 20 minutes and an occupancy rate of 1.7 persons/car (Fiorello and Zani, 2015). However, an increasing number of European cities are improving urban living by adopting shared-car-based mobility schemes to reduce car use, vehicle emissions, parking spaces and to promote greener transport modes (Saheen and Cohen, 2013).

Car sharing is a membership-based self-service, short-term car access system with a network of vehicles for which members pay by time and/or distance (Millard-Ball et al., 2005). This involves accessing a car owned by another person or entity in exchange for an agreed monetary payment (Le Vine et al, 2014a).

Advances in smart technologies such as mobile phones, mobile web applications and social media, combined with socio-demographic changes have facilitated a move towards mobility as a service[2], with a shift from "owning" to "using" means of transport. In 2018, the European car sharing fleet was about 370 000 vehicles although this still represents only 0.1% of all passenger cars in Europe (ING Economics Department, 2018). In fact, before the COVID-19 pandemic, the European car-sharing fleet was expected to grow a further 30% until the end of 2020 (Monitor Deloitte, 2017). Nevertheless, the pandemic's impact on car sharing has been enormous across Europe, with services reduction higher than 60%. On the other hand, the pandemic has increased the appetite for sustainable mobility in which car-sharing services play a vital role (Roblek et al, 2021). Car sharing schemes have reported benefits such as a reduction the new car sales (Intini and Percoco, 2021), including deferring purchases of a car (Cazzola and Crist, 2020), particularly for younger generations (Prieto et al., 2017), and reduction of cars per household since a shared car mostly replaces a second or third car, or lower CO_2 emissions per person (Nijland and van Meerkerk, 2017) (more information of the impact of car sharing is available on Table 4). The environmental benefits of car sharing have been widely acknowledged by several studies (see e.g. ITF, 2020). These benefits are multiplied when emissions for car production are considered (Akimoto et al., 2022; Amatuni et al. 2020). On the other hand, transfers from public transport could partially offset the benefits if cars relying on combustion engines are in use (Chicco and Diana, 2021) and the impact from car sharing on transport-related energy demands may vary depending on socio-demographic characteristics, technical infrastructure, car-sharing services and transport systems (Julsrud and Farstad, 2020). However, several barriers exist to its further adoption, which relate to user experience of car sharing schemes such as cost, reliability, convenience, ease of access to the vehicle, and include the development of car sharing platforms to improve user interaction.

It is becoming evident that technological drivers such as automation, connectivity and low-carbon technologies, coupled with new sharing trends are transforming the transport sector. Nevertheless, without the right policy framework, this may also have negative effects for most people in most cities (Alonso Raposo

[2] MaaS is mentioned here as concept, in which transport is a service considered as a whole and any of the perspectives mentioned are considered. The projects analysed in section 4 also study combinations of the integration of this service.

et al., 2019). Although there are many options for future research within this domain, car sharing is a relatively recent concept, with most of its growth occurring in the last decade. Car sharing will evolve according to relevant future policies, technological innovations and business strategies (Münzel et al., 2020). The convergence of electrification and automation is changing car sharing, leading to shared automated and electric vehicle (SAEV) fleets (Shaheen et al., 2019), which will further reduce carbon emissions per passenger compared to car sharing relying on latest generation combustion engines. Car sharing schemes that rely on electric fleets (e.g. in Madrid, Stuttgart and Amsterdam) therefore contribute to the ongoing transition towards low-carbon mobility (Sprei et al., 2019). Much of the assessment of car sharing has been based on North America. However, North American cities have different spatial patterns and levels of car dependency and public transport coverage than European cities.

Within this context, this report aims to assess the status and potential implications of car sharing in the European transport sector through a critical review of scientific literature. To identify the key trends and challenges in research and innovation (R&I) in shared mobility in Europe, an assessment of European R&I projects found in the European Commission's Transport Research and Innovation Monitoring and Information System (TRIMIS) is carried out. The report concludes with identifying the main barriers for car sharing uptake and provides recommendations to promote its appropriate deployment in Europe.

2 Background

This section describes the background of car sharing in Europe from various perspectives. It firstly reviews the milestones of EU policy initiatives. Secondly, it analyses the evolution from car ownership to car sharing. Then, it describes the main characteristics of car sharing schemes across Europe. It concludes with the main figures of car sharing across Europe as well as a discussion of its future evolution. For the last subsection, a review of the relevant international literature was undertaken using recently published peer-reviewed papers. The main literature databases, namely Web of Science, SCOPUS, Google Scholar, and TRID, were searched using keywords and combination of keywords: 'car sharing', 'carsharing', 'vehicle sharing', 'car club', 'shared-use vehicles', 'car-sharing', 'car sharing', 'practice', 'Europe', 'European', European Union', 'EU' plus the name of each EU member state.

2.1 Policy context of car sharing in Europe

On the policy side, in the EU, the Single Market Strategy was adopted in October 2015 to deliver a deeper and fairer Single Market that will benefit both consumers and businesses, while complementing other key EC initiatives such as the Investment Plan for Europe, the Capital Markets Union, the Digital Single Market, the Energy Union and Labour Mobility (European Commission, 2020b). Moreover, the Communication 'Upgrading the Single Market: more opportunities for people and business COM/2015/0550 final' announced that the EC would develop a European agenda for the collaborative economy, which would include specific guidance on how existing EU law applies to collaborative economy business models (European Commission, 2015a). The accompanying Commission staff working document (European Commission, 2015b) provided further analysis covering the collaborative economy and highlighting the example of car sharing as one of the five main collaborative economy sectors. In June 2016 (European Commission, 2016b), the EC highlighted that the collaborative economy can encourage more asset-sharing and more efficient use of resources thus potentially contributing to the EU sustainability agenda and to the transition to the circular economy. Furthermore, it provided guidance related to EU law application on collaborative economy business models and an assessment of possible regulatory gaps.

Specifically focusing on the transport domain, the 2011 'White Paper: Roadmap to a Single European Transport Area – Towards a Competitive and Resource Efficient Transport System COM/2011/0144 final' listed awareness raising of alternatives to individual conventional transport including car sharing under the goal of promoting sustainable behaviour (European Commission, 2011). Moreover, the European policy regarding ICT-based shared and on-demand mobility services has been embedded in a series of recent EU transport policy frameworks and programmes. For instance, the Low Emissions Mobility Strategy highlighted the importance of shared mobility schemes towards the mitigation of traffic congestion and pollution as part of a sustainable urban mobility planning (European Commission, 2016a). In the 2016 review of the implementation of the 2011 White Paper on Transport, the increased use of shared mobility services as part of a broader trend for collaborative economy was noted along with the application of big data and ICT tools to new business models of integrated and optimised mobility services (European Commission, 2016c). The CIVITAS initiative explores innovative ways to break car dependency including car sharing and promotes the spreading of successful strategies among cities, with several innovative mobility solutions having been tested and implemented in many European cities (CIVITAS, 2013).

The transport sector requires new technological developments to address current socio-economic challenges. This can be achieved through R&I that will support new quality standards for mobility to decarbonise transport and to back European competitiveness. Thus, in 2017, the EC adopted the Strategic Transport Research and Innovation Agenda (STRIA) as part of the 'Europe on the Move' package (European Commission, 2017). It highlighted the key transport research and innovation R&I areas and priorities for a clean, connected and competitive mobility, thus complementing the 2015 Strategic Energy Technology Plan (European Commission, 2015c). STRIA identified priority areas with specific actions for future R&I, outlined in seven roadmaps: connected and automated transport (CAT), transport electrification (ELT), vehicle design and manufacturing (VDM), low-emission alternative energy for transport (ALT), network and traffic management systems (NTM), transport infrastructure (INF), and smart mobility and services (SMO), with the latter covering also the area of shared mobility.

In a 2018 communication the EC set the policy framework for the take-up of connected and automated mobility, while research funds from the European framework programme Horizon 2020 (H2020) for 2018-2020 in this area focused on 5G connectivity, large scale demonstration pilot projects for passenger cars, freight transport operations and shared mobility services in urban areas (European Commission, 2018).

The latest policy developments point out the same direction: stricter emission objectives combined with further support of greener transport. The European Green Deal (European Commission, 2019b) highlights the EU's commitment to accelerate the shift to sustainable and smart mobility, achieving climate neutrality by 2050. The 2030 Climate target plan (European Commission, 2019a) establishes a GHG emissions reduction target by 2030 compared to 1990 of at least 55% including emissions and removals. It acknowledges that all transport sectors - road, rail, aviation and waterborne transport - will have to contribute to the 55% reduction effort. A greater use of sustainable transport modes, multi-modal solutions, digitalisation for smart traffic and mobility management can reduce GHG emissions address noise and air pollution. In December 2020, the EU published the Sustainable and Smart Mobility Strategy (European Commission, 2020a). This notes that a comprehensive policy is required to stimulate demand for zero-emission vehicles, which includes new and innovative solutions for a more sustainable and healthier urban mobility. Finally, the European Urban Mobility Framework (European Commission, 2021) also acknowledges that more decisive EU action on urban mobility is needed to shift from the current approach based on traffic flows to an approach based on moving people and goods more sustainably, with a stronger collective/public transport backbone, and better active mobility options. Public transport and shared mobility services should complement each other.

2.2 From car ownership to car sharing

The concept of a 'sharing economy' reflects growing consumer preference to pay for assets or services on-demand rather than owning them (Deloitte, 2016). In particular, the notion of 'shared-mobility' is gaining popularity in the European transport sector with the introduction of car sharing, bike sharing, carpooling, ridesharing and ridesplitting schemes. Such schemes are seen as being fairer, more environmentally friendly, participatory and socially connected (Schor, 2014).

The number of registered car sharing users in Europe have doubled from 5.1 million to 11.5 million in the period 2016-2018 (ING Economics Department, 2018). The expansion of digital platforms, web-based services, information and communication technology are facilitating this collaborative consumption, changing consumer preferences and providing the opportunity to reduce air pollutant emissions and move towards more sustainable cities (Boyko et al., 2017).

Traditional car rentals are designed for longer distances than those needed in the average trip in the urban context (e.g. rentals are for days instead of hours or minutes, the car has to be returned with some amount of fuel, higher prices than an urban public transport ticket, etc.). Unlike them, car sharing was developed as an innovative approach to address some of the urban transport problems. With the emergence of modern technology it has evolved to allow individuals to have access to a private car when needed without the costs and responsibilities of full car ownership (Shaheen et al., 1998).

The earliest European car sharing scheme was introduced in Zurich (Switzerland) in 1948; this was followed in the seventies by public car sharing experiments in Montpellier (France) and Amsterdam (The Netherlands). By the eighties car sharing organisations were being established in Denmark, France, Ireland, Italy, Norway, Sweden and the United Kingdom (UK). Car sharing complements urban mass-transit with European car sharing revenue equal to approximately €230 m (2015) (Finger et al., 2017), doubling its value in just two years to over EUR 460 million in 2017, and it is forecasted to reach EUR 3.5 billion by 2024 (Parikhit B, 2021).

In 2014, an estimated 2 206 884 individuals participated in European car sharing schemes compared to 212 124 in 2006 (based on one-way car sharing data). The number of car sharing vehicles in circulation equalled 57 947 or a member-vehicle ratio of 38:1. Public awareness of car sharing is increasing with 65% of people surveyed being aware of the shared mobility concept in those EU countries that have adopted car sharing schemes such as Austria, Denmark, France, Germany, Luxembourg and Portugal (Fiorello and Zani, 2015). There is increasing interest in car sharing in Europe, especially among non-car owners/public transport users, people living in metropolitan areas where parking spaces are limited and young people in countries with low incomes. According to a survey by ING (2018), 7% of Europeans with a driver's licence stated that they use car sharing, while 23.5% would consider using car sharing services over the following year. Despite the growth in car sharing, car ownership still dominates with the number of cars per inhabitant increasing in most European countries (ING Economics Department, 2018).

Münzel et al (2020) analysed the supply of car sharing across 177 cities in five Western European countries: Belgium, France, Germany, the Netherlands and the UK. They found that car sharing is popular in cities with many highly educated inhabitants or cities with a university, whilst that is not the case in cities with many car commuters. One potential explanation for this result can lay in the financial education of these users, which might lead them to choose a cheap and convenient option for certain urban trips. Ramos et al. (2020) studied attitudes of both users and non-users of car sharing in European cities regarding their travel patterns and

psychological aspects. They found that communication messages are key to reach different type of users and, must be tailored for each targeted group of travellers. Habits play an important role and some users may not be willing to change old routines despite the arrival of new services like car sharing. In other words, the mobility patterns of the cities (i.e., willingness to use public or alternative means of transport) and their socioeconomic conditions (i.e. percentage of inhabitants below 45 years old) seem to play a key role in the success of car sharing schemes.

2.3 Characteristics of car sharing schemes

European countries have adopted various car sharing schemes (see Table 1). This often requires users to go through a pre-qualification process for verification of identity and driving record to gain access to the shared-vehicle fleet. They can then use vehicles at various locations across a service or make reservations if needed. Vehicle usage is billed based on time or distance travelled (Le Vine et al., 2014a).

Table 1. Types of car sharing.

Type	Description
Peer-to-peer car sharing	This involves individuals renting their private car to others for a fee for a round-trip use.
Free floating car sharing	Also known as a flexible car sharing, it enables one-way journey within a specified geographic zone. This allows more trips to be captured and can be used for leisure, shopping and sporadic trips.
Round trip station-based car sharing	The user picks up a car from one parking station and returns it to the same station (round trip) or another (one way). Although this may make it easier for operators to plan stock, it is often inconvenient for users. However, the advantage from a round trip is that users know where it is possible to return the vehicle.

Source: Barth and Shaheen (2002); Jorge and Correia (2013); Le Vine et al. (2014a)

Table 2 presents the main characteristics of car sharing users (Jorge and Correia, 2013; Kent and Dowling, 2013; Laurino and Grimaldi, 2012; Le Vine et al., 2014b; National Academies of Sciences Engineering and Medicine, 2005; Shaheen et al., 1998; Shaheen and Cohen, 2013). The average user of European car sharing schemes tends to be young, single, well-educated males who live in locations with good public transport links. Generation Y (born between 1977-1994) want greater connectivity and convenience from the increasing range of transport options and are shaping on-demand service providers such as Uber, DriveNow and car2go. These providers are connecting drivers to passengers (taxis, carpooling) or passengers to cars (car sharing) and changing the way individuals move (Deloitte, 2016).

Table 2. Characteristics of car sharing users.

Characteristic	Sources
Men tend to use car sharing more than women	(Loose, 2011; National Academies of Sciences Engineering and Medicine, 2005; Steer Davis Gleave, 2015, Amat 2016a)
Average age of shared car users is 25-45 years old	(Huwer, 2004; Muhr, 2010; National Academies of Sciences Engineering and Medicine, 2005; Steer Davis Gleave, 2015, Amat 2016a)
Car sharing members tend to be single and/or live in small households	(Cervero and Tsai, 2004; Loose, 2011; National Academies of Sciences Engineering and Medicine, 2005; Steer Davis Gleave, 2015)
Car sharing members tend to be well-educated with average or high income, cost-sensitive and environmentally conscious	(Cervero and Tsai, 2004; National Academies of Sciences Engineering and Medicine, 2005; Synovate, 2007, Amat 2016b)
Users live in locations served by public transport with car sharing seen to increase individual mobility for recreational / social activities	(Haefeli et al., 2006; National Academies of Sciences Engineering and Medicine, 2005)

Source: Own elaboration based on Laurino and Grimaldi, 2012

Motivations for taking part in car sharing schemes range from personal convenience, social and environmental improvement to economic benefits derived from collaborative consumption (Shaheen et al., 1998). An examination of Autolib's point-to-point station-based service in Paris found users to be motivated primarily by economic considerations and convenience rather than environmental issues (Le Vine et al., 2014b). A survey of Carplus members in England and Wales found that the ability to hire cars on a short-term basis and to make trips that cannot be made by other modes were the main reasons for joining car clubs. This suggests that people joined car sharing schemes to increase their travel options, rather than as a direct replacement for travel by public transport (Steer Davis Gleave, 2015).

The results of the Autolib and Carplus surveys are reinforced by Fiorello and Zani (2015) who found that individuals in the EU28[3] that are aware of car sharing are not significantly inclined towards using such schemes. In fact, one third of those surveyed are not interested in car sharing, while half of those who are interested in car sharing do not see it as an alternative to car ownership. It is possible to conclude that car sharing is still not seen as an alternative to car ownership but a means to complement and extend existing mobility options.

Assessing the actual effects of car sharing is difficult since interpreting the impacts depends on the method used (Firnkorn and Müller, 2011). Graham-Rowe et al. (2011) found that out of 77 evaluations of measures to reduce car use only 12 were methodologically strong, and only half of these found that the examined intervention reduced car use. This methodological heterogeneity (Firnkorn, 2012) has implications for the justification and adoption of future car sharing schemes in European cities highlighting a need for a robust evidence base that provides reliable and comparable data on the environmental impacts of car sharing schemes.

The reported social and environmental benefits of car sharing schemes include lower GHG emissions, reduced vehicle ownership, vehicle kilometres travelled and a modal shift to walking, cycling and public transport (see Table 3) (Baptista et al., 2014; Fellows and Pitfield, 2000; Litman, 2000; Martin et al., 2010; Shaheen and Cohen, 2013; Steer Davis Gleave, 2015). An assessment of Car2Go schemes in five American cities found that car sharing resulted in a 6 to 16% reduction in vehicle miles travelled and a 4 to 18% reduction in GHG emissions per household with 1 to 11 cars removed per car sharing vehicle (Martin and Shaheen, 2016). The overall emissions reduction, including energy and resource savings due to less car production and less

[3] European Union with 28 Member States.

material used, was found to be around 10% in the Netherlands (Amatuni et al. 2020), whilst the worldwide emission reduction effects by 2050 could be up to 50% (Akimoto et al., 2022). European car sharing practice

Few relevant peer-reviewed studies were found to quantitatively address the actual impact of car sharing in Europe (Table 3). Where some form of impact assessment has been undertaken there was no agreement on the methodology. Studies vary from reporting actual impacts to modelling the potential of car sharing or developing specific methodologies to implement schemes.

Table 3. Social and environmental benefits of car sharing.

Characteristic	Sources
Reduction in vehicle ownership	(Martin et al., 2010; Martin and Shaheen, 2010; National Academies of Sciences Engineering and Medicine, 2005)
Savings in transport costs	(Cervero et al., 2007)
Reduction in vehicle kilometres travelled	(Cervero et al., 2007; Cervero and Tsai, 2004; Koch, 2001; National Academies of Sciences Engineering and Medicine, 2005, Shaheen and Cohen, 2007)
Increase in public transport use	(Koch, 2001; National Academies of Sciences Engineering and Medicine, 2005)
Reduction in pollutant emissions	(Martin and Shaheen, 2010)
Reduction in parking spaces	(Sullivan and Magid, 2007)

Source: Own elaboration

We cannot claim to have covered the entirety of published studies with relevance to European car sharing. The identified studies provide an indication of the low level of car sharing impact assessment, while at the same time, illustrating the poor, albeit increasing, availability of European car sharing information.

Rodenbach et al. (2018) analysed 168 car sharing services in 25 EU countries and found that Western European countries (i.e., Austria, Belgium, France, Germany, Luxembourg and the Netherlands) have the largest number of car sharing schemes representing 60% of EU car sharing services. They are followed by Southern Europe (i.e., Croatia, Greece, Italy, Malta, Portugal, Slovenia and Spain) at 18%, Northern Europe (i.e., Denmark, Estonia, Finland, Latvia, Lithuania, Sweden and the UK at 15% and Central and Eastern Europe (i.e., Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovakia) at 8%.

An analysis (Boldrini et al., 2019) of web-based data about the available of free-floating car sharing in 10 European cities (Amsterdam, Berlin, Florence, Copenhagen, Milan, Munich, Rome, Stockholm, Turin and Vienna) found that car sharing success and modal split in these cities were the same. Car sharing demand was found to be positively correlated with high educational attainment and nightlife activities but negatively correlated with the percentage of people commuting outside the municipality.

Roblek et al. (2021) used an automated content analysis to identify 314 articles published in peer-reviewed journals from the Scopus database. They found seven areas of research relating to the status of car sharing in Europe: sharing, economy, model, systems, electrical car sharing, policy and travel. As we will see later, this classification is complementary to the categories shown in the next section.

European car sharing is the second largest carsharing market and accounts for 21.2% of worldwide membership and 30.6% of global fleets in operation (Shaheen and Cohen, 2020). . Berg Insight estimated that the total number of car sharing members worldwide reached 50.4 million at the end of 2018 (Berg Insight, 2020). Some examples of this huge increase of car sharing schemes can be found across different European cities. In Madrid, for instance, the first car sharing company started in November 2015 (Car2Go). As of the end of 2020 there were five car sharing companies (emov, Wible, City, Sharenow – former Car2Go –, and Wishilife) accounting about 300 000 regular users and 1,3 million people who downloaded some of the

five apps. Table 4 presents the range of internationally reported impacts of car sharing from low- to high-impact for several key indicators (Chen and Kockelman, 2016).

Table 4. Reported impacts of car sharing on selected indicators.

Indicator	Low	Medium	High
Car sharing market potential (% of United States adult population)	3% [a]	10% [b]	26% [c]
% Reduction in private vehicles owned	10% [d]	21% [e]	49% [f]
Private vehicle replacement rate for each car sharing vehicle	1 [g]	15 [h i]	23 [i]
% Reduction in vehicle kilometres travelled	27% [j]	31% [h]	67% [d]
% Fuel efficiency improvement	17% [k]	24% [l]	43% [h]
% Reduction in public parking demand	26% [l]	38% [m]	50% [n]
% Increase in rail transit use	0% [h]	8% [o i]	36% [l]
% Increase in cycling	7% [h]	9% [o i]	14% [l]
% Increase in walking	2% [h]	19% [i]	25% [o]

a Schuster et al., (2005) b Shaheen et al., (2006) c Duncan, (2011) d Cervero et al., (2007) e Zhou and Kockelman, (2011) f Martin and Shaheen, (2011a) g Martin and Shaheen, (2016) h Frost and Sullivan Research Service, (2010) i Lane, (2005) j Martin and Shaheen, (2011b) k Rydén and Morin, (2005) l Meijkamp, (1998) h Martin and Shaheen, (2011c)l Stasko et al., (2013) m Department for Transport, (2004) n Engel-Yan and Passmore, (2013) o Cooper et al., (2000)

Source: adapted from Chen and Kockelman (2016)

Avis Budget group's *Zipcar*, Daimler's *Car2Go* and BMW's *Drivenow* have been the largest players in the private car sharing market (see Table 6) (Clark, 2014). In fact, in 2019 Car2Go and Drivenow merged into one single company (ShareNow) which operates in 30 European cities. *Zipcar* offers hybrids, PHEV (electric vehicles, plug-in hybrid electric vehicles) diesel and petrol cars and operates in Austria, Belgium, France, Germany, Spain and the UK, while *Car2Go* has 1.4 million members across five European countries (Austria, Germany, Italy, Netherlands and Spain (Car2go, 2017). All these companies are however still in financial deficit. For instance, the Spanish division of emov, operating in Spain and Portugal, registered €2.6 m and €1.5 m in 2018 and 2017 respectively. Its competitors in Spain (Zity, ShareNow, Respiro and Wible) also registered a financial deficit, and one of them, Respiro, does not operate any longer. These recent financial losses posted by various service providers worldwide, worsened by the lockdown and lack of traffic in 2020, have raised concerns about the capability of car sharing schemes to further penetrate the market, as well as about their economic sustainability. In fact, the increasing operating costs due to service maintenance and the low daily revenue have prompted providers to shut down part of the services they offer (Glon, 2019).This suggests operators want to take advantage of the schemes to test new electric vehicles and their user's acceptance, but they could only expect profitability in the long term, which might be subject to further support from the municipalities. An example of this closure is Paris' Autolib, which was originally supposed to make a profit of 56 million by 2023 but had a financial debt by 2018. The service providers of Autolib, attributed this fail to several reasons such strong competition with the arrival, of ride-hailing apps like Uber, the poor and dirty conditions when the cars were parked, and also its own success that left many potential users frustrated without other alternative. Altogether, the subscribers reached its peak at the end of 2016, but started a steady decline in 2017[4]. The most successful city across Europe in terms of kilometres driven and rentals per car per day is Madrid, with 100 km and 11 respectively (Giordano et al., 2021). Preliminary results from a medium-size city in Germany suggests that several factors influence usage intentions, namely mode of drive,

[4] https://www.thelocal.fr/20180601/whats-gone-wrong-with-the-much-lauded-paris-car-sharing-scheme/

pickup and drop-off mode, service level, price model, availability, and type of market mediation (Hahn et al., 2020)

3 European R&I projects

TRIMIS contains an open-access, searchable database of projects and programmes that to date contains approximately 9 000 projects that have been financed by EU research Framework Programmes, EU Member States and other countries. A search was undertaken using six keywords based on a survey of literature (*car sharing, shared mobility, vehicle sharing, shared-use vehicles, shared economy, ride sharing*) to select applicable projects relevant to car sharing in Europe.

If a project contained the keyword in its description, it would appear in the search (i.e., a single keyword search). After carefully reading the background, the project would then be included in the research or classified as non-applicable and discarded. To classify the projects, the description, method and results of each project were reviewed. Following the definition of car sharing previously given in the former section, it is important to remind that only those projects strongly connected to the topic of car sharing apply. Using this approach, more than 2 000 projects appeared in the search, but only 155 projects were relevant to car sharing. In addition, a new feature was added to the characteristics of each project. This new feature created for this study identifies whether the project addresses one or more of the six key topics from the literature review:

- Better understanding of impacts (economy, environmental)
- User behaviour and acceptance of car sharing schemes
- Information Technology Development: Apps, websites, connected cars
- Vehicle technology: Electric vehicles, hybrid vehicles, ergonomics, automated vehicles
- Development and implementation
- Others: Stakeholder engagement, regulations, policies

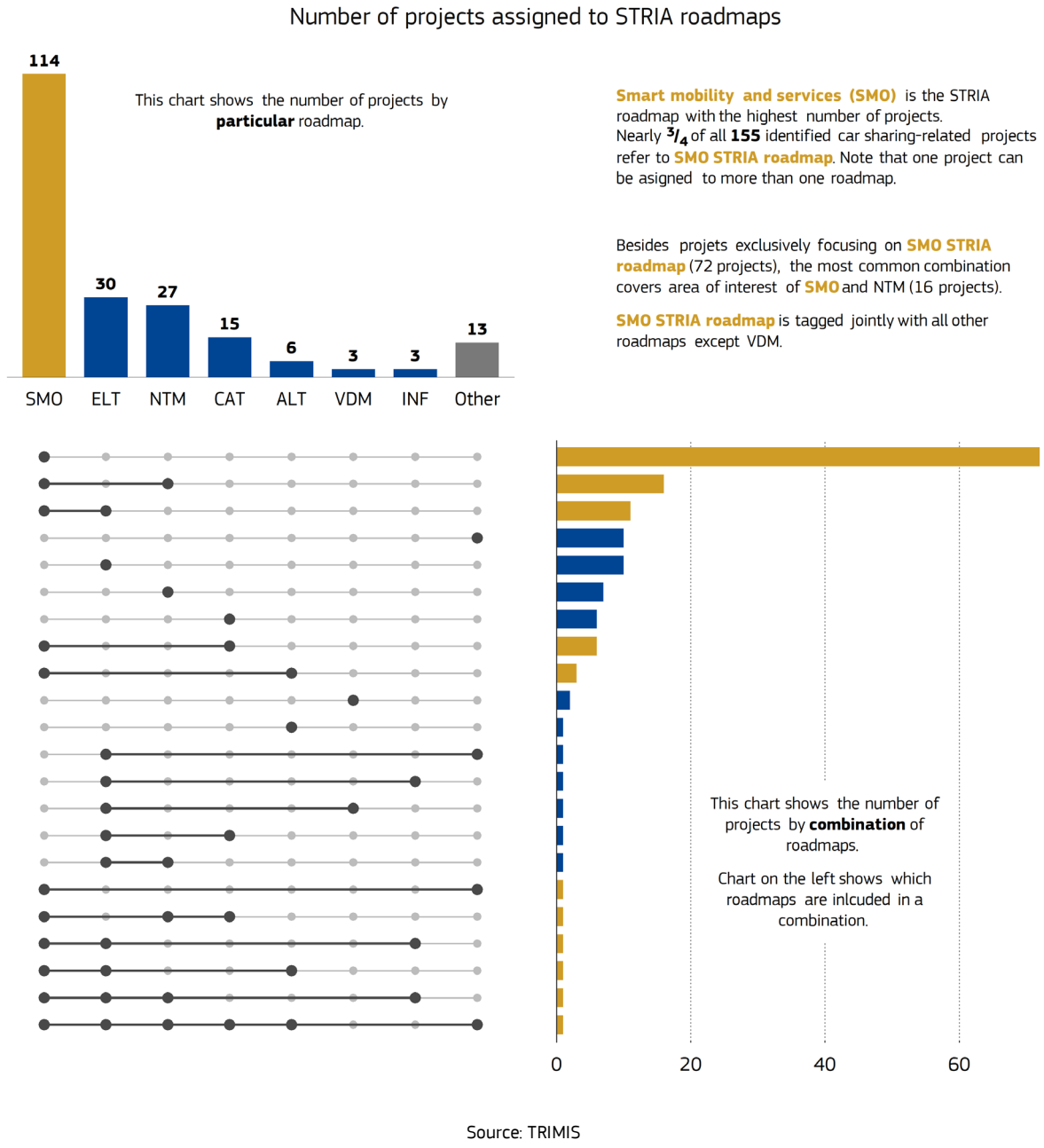
Projects in TRIMIS are by default marked with additional information regarding the STRIA roadmaps, as well as the relevant transport policy that they address.

Since a given project can address more than one roadmap, policy and topic, in the subsequent analyses there will be more tags than projects. Since some projects have more than once tick in the categories, the total number of ticks or tags will be greater than the number of projects studied. Annex 1 shows the list of projects considered in this report as well as the key topics assigned to them.

Regarding the funding origin, the distribution shows that 96 projects (62% of the projects) were supported by European framework programmes such as H2020 or the 7th Framework Programme (FP7), whilst Member States (MSs) supported the remaining 59 projects (38% of the sample). In addition, there is no significant difference between MSs and the EU in the topics studied.

Classification according to the seven STRIA roadmaps shows that the 155 projects have 211 tags. SMO is undoubtedly the roadmap with the highest number of projects with 114 projects falling within that category. Thirty projects are linked to the STRIA roadmap ELT and 27 projects are linked to NTM roadmap. The remaining roadmaps have fewer projects. This result is entirely logical, since the SMO roadmap aims to assess emerging new technologies such as multi-modal, electric and autonomous vehicles, drone technology and on-demand mobility services. Figure 1 shows the distribution of the tags per roadmap.

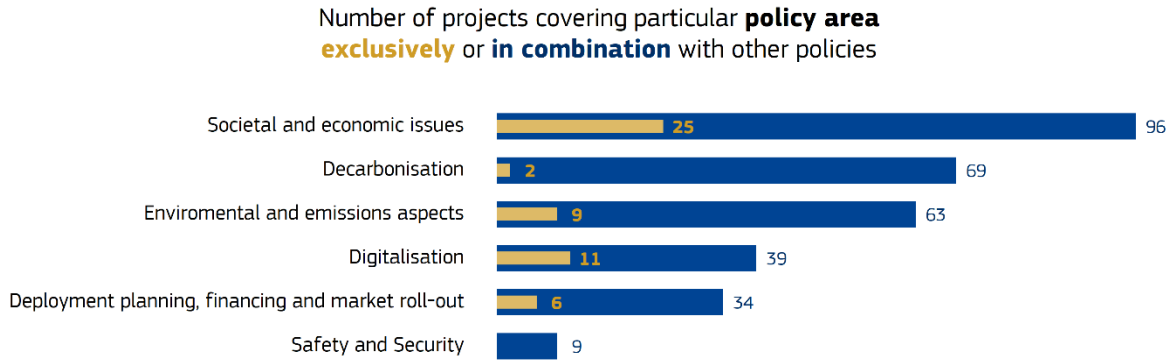
Figure 1. Projects distribution by roadmap.



Source: TRIMIS

Regarding the STRIA policy, the 155 projects have 310 tags. 96 projects fall under societal/economic issues, 69 analyse the decarbonisation of the transport sector, 63 projects belong to environmental issues, and 39 study the digitalisation of the transport sector. Figure 2 presents how the 310 tags are distributed across the different STRIA policies.

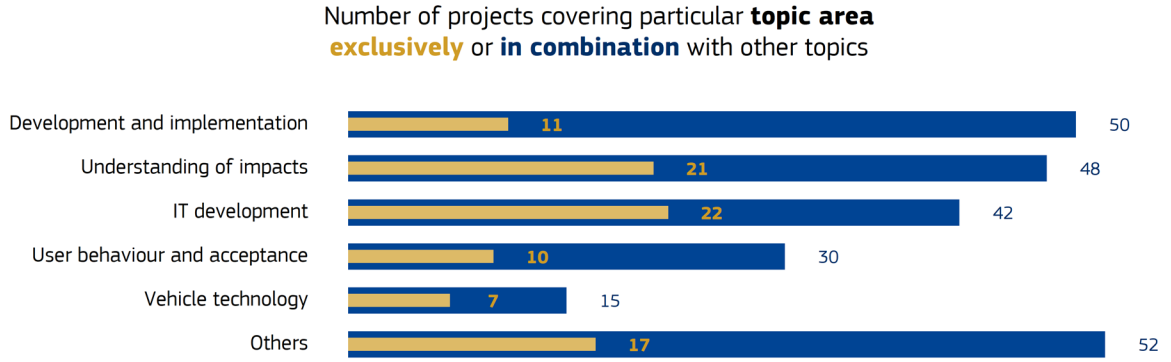
Figure 2. Projects distribution by policy.



Source: TRIMIS

A more in-depth analysis of the topics shows that 52 projects examine the category others (e.g., stakeholder engagement, regulation, etc.), while 50 projects study the development and put in practice of car sharing schemes, 48 projects focused on better understanding of impacts (economy, environmental, etc.) and 42 projects belong to the category Information Technologies (IT) Development: Apps, websites, connected cars, etc. By contrast, 29 projects analysed user behaviour and acceptance, and only 14 projects addressed vehicle technology. Figure 3 shows how the 235 tags are shared across the six transport issues.

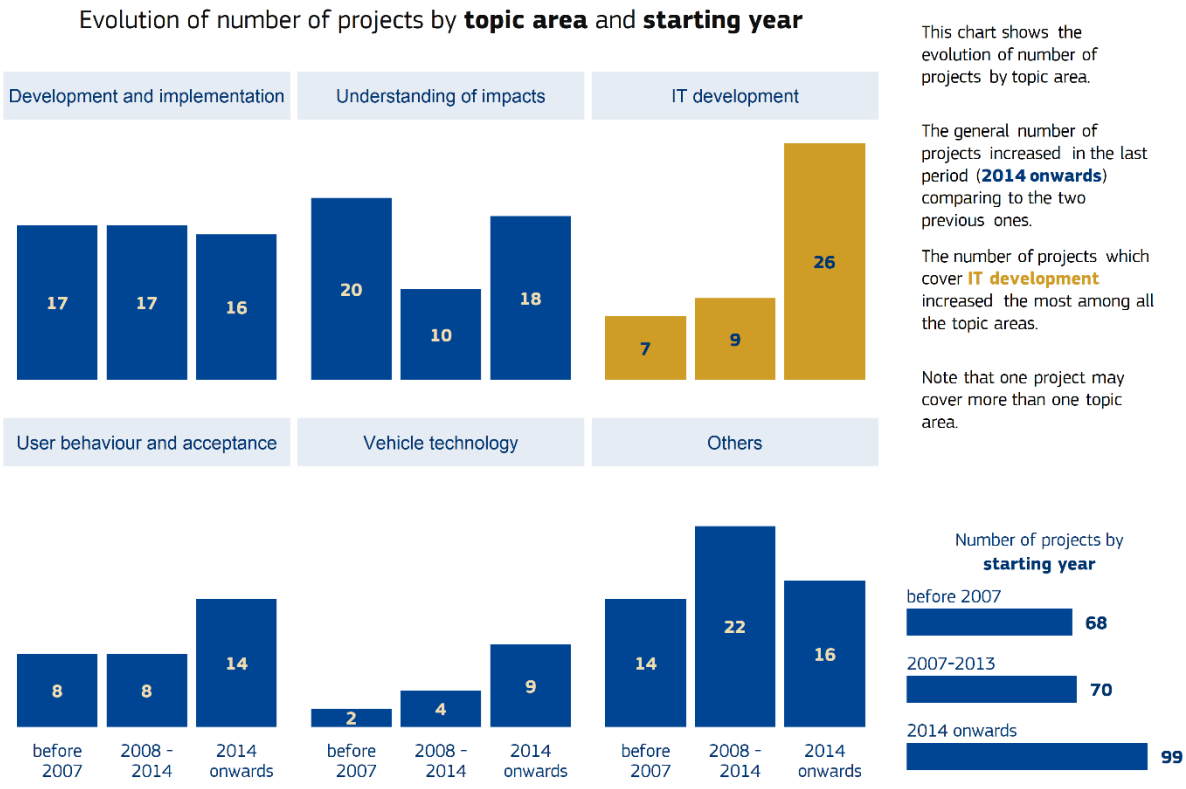
Figure 3. Projects distribution by topic.



Source: TRIMIS

It is also interesting to analyse how these topics are distributed across the years. Figure 4 shows the evolution of all projects (i.e., regardless of their funding origin) in three periods: before 2007, 2007-2013, covering the period of FP7 and from 2014 onwards, which also overlaps the period of H2020. Some conclusions arise from figure 4. First, 50 projects accounting €294 m were awarded before 2007, 39 projects with a total cost of €72 m in the period 2007-2013 were granted and, 66 projects with a budget of €356 m from 2014 onwards have been conducted. Second, development and put in practice has been constantly studied throughout the years. Third, there is a huge increase in the number of projects studying IT Development: Apps, websites, connected cars, etc.; from 7 before 2007 and 9 between 2007-2013, to 26 from 2014 onwards. Car sharing schemes became popular in significant metropolitan areas relatively recent. Following this increase in users' number, the car sharing companies needed to adapt their information technologies to ever-growing demand.

Figure 4. Evolution of topics per parent programme.

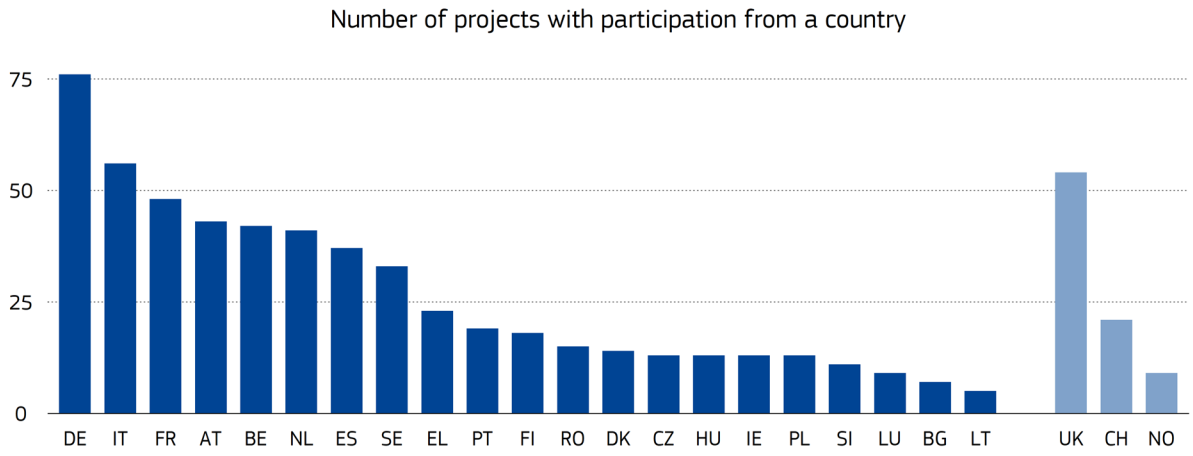


Source: TRIMIS

Figure 5 shows the participation of EU MSs, other European countries and third countries in the 155 R&I projects analysed[5]. For the sake of clarity, only countries with more than five projects are considered in the figure. Germany, Italy and the UK have the highest number of R&I projects with 76, 56 and 54, respectively. There is a link between the size of the country, its economy and the number of projects. However, countries with a long tradition of public investments in R&I, and a large transport industry, including consultancy and IT-related companies, also appear well located. Austria (43 projects), the Netherlands (41 projects) and Belgium (42 projects) are the best examples since the size of their economy does not justify their position. The ratio of projects per capita is at least three times higher in the latter group of countries when compared to the first group. Germany is the country with most projects funded by national authorities with 18, followed by Austria with 12 projects funded and Switzerland with 7 projects funded. The case of Germany is a good example of the trade-off between car sharing and electric vehicles: 12 of their national funded projects are connected to electromobility, which suggests a big support for this type of vehicle in the urban environment. Looking at the overall picture seems that two factors explain the success in number of projects awarded: national R&I investment and location. Germany and Austria use the first factor, whereas the Netherlands and Belgium take advantage of their short distance to European headquarters of companies and have economy of scale benefits.

[5] AT-Austria, BE-Belgium, BG-Bulgaria, CH-Switzerland, CZ-Czechia, DE-Germany, DK-Denmark, EL-Greece, ES-Spain, FI-Finland, FR-France, HU-Hungary, IE-Ireland, IT-Italy, LT-Lithuania, LU-Luxembourg, NL-The Netherlands, NO-Norway, PL-Poland, PT-Portugal, RO-Romania, SE-Sweden, SI-Slovenia, UK-United Kingdom.

Figure 5. Country participation.



Note that Croatia, Cyprus, Estonia, Latvia, Slovakia and Malta has no registered car sharing projects and they are not present on the chart

Source: TRIMIS

4 Research and Innovation assessment

This chapter summarises the main results of research and innovation projects related to car sharing, clustered according to the six key topic areas identified for the purposes of this report. It is based on 23 projects that were considered the most relevant for the analysis. These projects are funded through European programmes such as H2020, and have good information available on their websites (e.g. they were just finished or are close to their end) It is important to note that many projects fall under more than one cluster, and to avoid duplication of information they are therefore analysed only once in this report. For instance, projects Cities-4-People or MaaS4EU are included and presented in detail under key topic 6, *Other*, whilst they also fall under key topic 5, *Development and implementation*.

4.1 Key topic 1 – Better understanding of impacts

This topic focuses on better understanding of impacts of car sharing. These include environmental and economy impacts of car sharing schemes or the effect of these schemes on traffic, society and land use.

4.1.1 Overall direction of R&I

R&I in this area focuses on understanding the differences between expected and actual impact of car sharing schemes across Europe. It aims to investigate the impacts in terms of congestion mitigation, shifting vehicles to outside peak times and diversion to avoid the most congested areas and routes, environmental footprints and social inclusion.

4.1.2 R&I activities

48 projects were assigned to this topic, funded by European and national programmes, as shown in Table 5.

Table 5. Key topic 1 research by funding origin summary.

Funding origin	Number of Projects	Total project value	Total EU contribution
European	29	€ 187 364 080	€ 93 219 154
National	19	n.a.	n.a.
Total	48	€ 187 364 080	€ 93 219 154

Source: Own elaboration from TRIMIS

The **STARS (Shared mobility opporTunities And challenges foR European citieS, 2017-2020)** project partners aimed to close the gap between the potential benefits of shared vehicle services, and their real impacts in terms of congestion mitigation, environmental footprints and social inclusion. They **assessed the role of car sharing in improving mobility in European urban areas**, including new business opportunities to the automotive sector as well as the impact of car sharing on other travel modes (public transport, active means, private cars). They studied two scenarios: business as usual and rupture mobility.

The main objective of **EMPOWER (EMPOWERING a reduction in use of conventionally fuelled vehicles using Positive Policy Measures, 2015-2018**) was to substantially reduce the use of conventionally fuelled vehicles in cities by influencing the mobility behaviour of drivers and users. EMPOWER **aimed at reducing the use of cars by shifting trips to other modes (e.g. public transport) and other vehicle types (e.g. electric vehicles), promoting sharing (e.g. car sharing schemes) and self-organisation and reducing demand overall (e.g. through remote access to services)**. EMPOWER also studied shifting vehicles to outside peak times and diversion to avoid the most congested areas and routes. Finally, it followed a multidisciplinary approach, involving social science research with the public, living lab experiments and city demonstrators.

In the context of the **C2ART (Towards a Connected, Coordinated and Automated Road Transport system, 2016 – 2019) project, the Joint Research Centre (JRC) investigated the impacts of Connected and Automated Vehicle (CAV) technologies through a combined approach based on traffic modelling and simulation, desk research and stakeholders' consultation**. These new

technologies are particularly important in the paradigm shift in transport and mobility, with vehicles becoming increasingly connected, electrified and automated, and with new mobility trends (e.g. shared mobility) are increasingly emerging.

MERLIN (Multimodal electrified infrastructure planning, 2018 – 2022) project aims at developing a platform to investigate the impact of different mobility solutions for Luxembourg, whose inhabitants spent more than 33 hours in congestion per year and head. Multimodality, shared and electro-mobility are the central elements considered in MERLIN. More specifically, the goal is to provide a decision support tool for the government and for the info-mobility operator, to assess the impact of different policies and measures.

4.1.3 Achievements

In a first step, the STARS project identified six different profiles of car sharing systems unevenly distributed across Europe: while most roundtrip station-based car sharing services were found in Western Europe and many peer-to-peer services in Northern Europe, free-floating services were concentrated in Southern Europe and were quickly growing in the Eastern Europe. In a second step, the project partners studied the influence of car sharing on the wider automotive market and industry. Finally, the project investigated the influence of individual, social, political, environmental and economic variables in driving the behavioural change towards shared mobility by comparing car sharing users and non-users identifying different profiles between these two groups. The outcomes of individual-users analyses conducted in Belgium, Germany and Italy showed the most effective car-sharing schemes in reducing car ownership. Two simulations in Turin and Milan with fully electric car-sharing fleets found a 3.6% reduction of daily costs for society deriving from the emissions of CO_2 and air pollutants. Moreover, free-floating car sharing might reduce the parking demand in areas where the mobility attractors are concentrated, such as the city centre. However, car sharing was still too small and polarised to have a real impact on the car industry.

To achieve its objectives, EMPOWER has created a set of tools for industry, policy makers and employers. These improved the understanding of 'positive' evidence-based and cost-effective policy interventions based on innovative mobility services, considering existing infrastructure, policy and measures. The main achievements of EMPOWER were classified as follows:

1. New mobility services to provide innovative positive policy measures (positive incentives)
2. EMPOWER Toolkit to support a range of stakeholders
3. Evidence of the impact of positive incentives on behaviours related to conventional vehicles fuel use
4. New and improved organisational models for successful implementation of positive policy measures (Business models)
5. Innovation in the evaluation method for new mobility services

According to the findings of the exploratory research conducted in the C2ART project, connected and automated vehicles promise to reduce road accidents, traffic congestion, traffic pollution and energy use, as well as to increase productivity, comfort and accessibility. However, the road transport system is complex, and the potential impacts of these technologies could contribute to change vehicle use paradigm, increasing uncertainty and could even have undesirable consequences. In particular, the study showed two main scenarios based on the expected socio-economic impacts of automated and connected vehicles in two timeframes. By 2030, AVs would account for a small percentage of vehicle fleet and would coexist with conventionally driven vehicles. Big safety risks would remain. By 2050, would represent a substantial portion of road transport, almost achieving a 100% penetration rate. Road transport demand increases significantly in this scenario. Road capacity would also increase but, at times, might not outweigh the impact of increased demand on the overall network, particularly in certain stretches of it.

The main results of MERLIN are new dynamic mode choice models that account for trip chaining and activity patterns, new visualisation and support tools for guiding policy decisions. Specifically, these models will allow estimating and modelling current and future mobility patterns, in terms of demand flows. They will also allow assessing the environmental impact of the proposed planning and management solutions through the coupling of transport and energy consumption modelling approaches. Finally, they will provide a decision support expert system able to suggest how to redesign the future public transport network, considering the urban dynamics and the major infrastructure changes.

4.1.4 Implications for future research

The STARS project clarified how car sharing influences personal long-term mobility choices and their impact on different travel modes and everyday mobility decisions: car-sharing members tend to own fewer cars, more public transport passes and bike-sharing membership than non-users. Round trip services have a much deeper impact in decreasing car ownership that free-floating, but the latter are more appealing for larger population segments. The main predictors of car sharing usage were perception of the usefulness of car-sharing schemes for commuting and a social network with positive attitudes towards car sharing. Car sharing has shown potential as an efficient transport solution to establish a new mobility culture, adapted to current economic and ecological demands.

The innovation outputs of EMPOWER included an EMPOWER Toolkit to support industry, policy makers and employers to understand, choose and implement positive policy interventions. The Toolkit added: new mobility services to provide innovative positive policy measures, new evidence on behavioural responses and impacts from positive incentives, improved organisational models for successful implementation of positive policy measures and innovation in the evaluation methodology for new mobility services.

In the light of the findings of C2ART project, the JRC will analyse the possible effects of new technologies and mobility paradigms in the future management of the road transport system, considering the different rates of connected, automated and traffic mix. The scenarios arising from having different rates of these vehicles will be analysed from multiple perspectives, specifically covering users, system performance, security, data governance and protection, and traffic management, while, smart mobility solutions will be tested in Living Lab conditions[6].

These systematic changes observed in the transport and mobility systems in MERLIN project, and, on a broader perspective, in the land use developments of the country, create major challenges for the future planning of transport networks. The complex urban dynamics caused by the population growth, the workplace relocation of major firms to the outskirts of the capital city, as well as the strong development and implementation of innovative transport and mobility services make any forecasting model based on past trends inaccurate. Therefore, urban and transport planners should use new and more sophisticated modelling approaches which make use of all possible types of data, such as those being collected and, for a large part, offered by the government in an open legacy framework.

4.1.5 Implications for future policy development

Increases in a car sharing service market penetration reduces its customers‘ car ownership, thus the aggregate impacts of different schemes could be of the same order of magnitude. The various types of car-sharing schemes did not compete with each other for users; therefore, a policy indication arising from STARS is to promote both as much as possible. In other words, users of round-trip and free floating services use it differently and have a different experience with car sharing services. The future for car sharing is more significant than its market shares, because both the existing automotive industry and disruptive new entrants are searching for the right ‘formula’ of revenue streams in the transition to the transport by car of the future. In addition to investments in car sharing fleets, the automotive sector should also consider mobility solutions in which several “mobility providers” work together to satisfy the users’ requests. Modal switch models applied in trip-level analyses showed that free-floating car sharing has the potential to cover up to almost 10% of the daily travel demand, when appropriately leveraging both the car sharing and private car costs. The final project output of STARS is a toolbox offering key results to decision-makers to understand the various types of car sharing and their effects. All results were prepared in a compact and clear form such that decision-makers can find the relevant decision criteria for their respective cities.

The EMPOWER concept can be used in practice by: City stakeholders being able (through a software tool) to choose positive policy options based on their expected impacts and deliver incentives and social network sharing schemes to individuals using software.

The increased road transport demand observed in the C2ART project, may exceed the available road capacity, thereby potentially leading to congestion peaks, with severe consequences. The role of transport authorities in managing transport automation in real time can become crucial.

[6] Smart Mobility portfolio (JRC annual work programme 2021-2022) https://ec.europa.eu/jrc/en/news/jrc-s-work-programme-2021-2022-adopted

MERLIN project is the only one that considers the trade-off between land use and transport. It will help local authorities with the replacement of conventionally fuelled Public Transport services with electrified systems by using big data and indicating where to locate charging points.

Annex 1 provides an overview of the projects undertaken in the field of better understanding of impacts.

4.2 Key topic 2 – User behaviour and acceptance of car sharing schemes

This topic focuses on studying user behaviour and acceptance of car sharing schemes. These include mobility behaviour before and after car sharing schemes or the acceptance and use of these schemes across Europe.

4.2.1 Overall direction of R&I

Several areas of research have emerged that focus on user behaviour and acceptance of car sharing schemes. Projects investigating this topic were funded mostly from H2020.

One of the main research areas has been into the development and test of theories and models of transport network with many options available for the end-user. The preferences, opinions and user's perceptions expectations have been also studied, with the goal of adapting the technological advancements in the field and replicate schemes to boost ownership or sharing by urban travellers and light delivery companies.

4.2.2 R&I activities

30 projects were assigned to this topic, funded by European and national programmes, as shown in Table 6.

Table 6. Key topic 2 research by funding origin summary.

Funding origin	Number of Projects	Total project value	Total EU contribution
European	10	€ 43 592 737	€ 32 799 203
National	19	n.a.	n.a.
Total	30	€ 43 592 737	n.a.

Source: Own elaboration from TRIMIS

The shared economy changes urban mobility by reshaping the traditional division between private and public transport, shifting from an ownership model to Mobility as a Service (MaaS). Current theories and models of travel behaviour, transport network and operations cannot explain the behavioural dynamics, interactions and evolution of both supply-side and demand-side of these new transport interactions. **The main objective of CriticalMaaS (Concepts, theories and models for planning, operating and evaluating the dynamics of Mobility as a Service, 2019 – 2023) project is to develop and test theories and models of transport network in this complex mobility context.**

The **INCIT-EV (Large demonstratIoN of user CentrIc urban and long-range charging solutions to boosT an engaging deployment of Electric Vehicles in Europe, 2020-2023)** project partners aim to demonstrate an innovative set of charging infrastructures, technologies and its associated business models, ready to improve users experience of Electric Vehicles, and therefore, fostering penetration rate on electric vehicles in the EU. The project **will seek the emergence of electric vehicles users' unconscious preferences relying on l**atest neuroscience techniques to adapt the technological developments to the users' subjective expectations. The consortium of the project has 33 partners, including charging technology providers, public authorities, ICT companies, and a car sharing Services Company among others.

The main objective of the **ELVITEN (Electrified L-category Vehicles Integrated into Transport and Electricity Networks, 2017-2020**) project was to **study all issues hindering the take-up of electric L-category vehicles such as motorcycles, mopeds, quads, and minicars**. The project partners proposed replicable usage schemes to boost ownership or sharing by urban travellers and light delivery companies. In addition, the project analysed these vehicles' actual driving and charging patterns, reported issues encountered, and travellers' opinions and perceptions. In conclusion, ELVITEN set out to raise awareness about the benefits of these vehicles and to explore how best to integrate them into transport and electricity networks.

4.2.3 Achievements

The CriticalMaas project will produce a set of new behavioural models for analysing supply- and demand-side transport dynamics. These models will study emerging patterns, transition phases and critical mass concepts by testing the conditions for generating economies of scale in market adoption and evolution of MaaS. In order to do so, the project will use a series of surveys, choice experiments, laboratory experiments, observed behavioural data from on-demand services, focus groups and interviews.

The INCIT-EV project will use seven case studies to analyse slow and superfast bidirectional charging of electric vehicles as well as the acceptance of these services across car-sharing schemes (e.g., innovative dynamic and static wireless charging for electric vehicles in urban environment). The main achievements of this project divide as follows:

1. To deepen the knowledge about users' expectations and concerns regarding electric vehicles adoption and charging infrastructure
2. To design a set of innovative and interoperable charging solutions in urban, peri-urban and extra-urban areas following the users' expectations and looking for their seamless integration in the existing infrastructures (transport, energy grids, ICT and civil ones)
3. To develop a Platform integrating a Decision Support System for mobility planners and a set of Applications to improve the EV user charging and driving experience.
4. To carry out a full demonstration campaign reaching TRL 8 at five demonstration environments involving seven use cases and validate the INCIT-EV Platform at two follower locations.
5. To promote the investment in charging infrastructure through attractive business models together with recommendations to solve regulatory and standardisation bottlenecks.

The project partners (Kyburz and S3T) of ELVITEN supplied 225 L-category electric vehicles across six European cities – Trikala, Rome, Bari, Genoa, Malaga and Berlin. The mix of electric vehicle types were freely available for both short- and long-term renting, from a few hours up to several weeks. The vehicles were also equipped with ICT tools and services. Drivers and fleet managers had access to the Unifying App with a range of ICT tools (e.g., eco-friendly driving tips, a booking system, parking and charging locations), and loyalty rewards. Based on the databank of the 41 275 trips made and the results of 9 820 questionnaires, the project partners identified three main factors impeding the market penetration of L-category electric vehicles. First, the users' low awareness of the use of such vehicles, partially based on their limited direct experience with them. The second factor relates to user's concerns about their high cost and the feeling of uncertainty as regards range anxiety. The third factor identified was a lack of consistent knowledge by planning authorities to prepare an integrated charge infrastructure in the transport and electricity networks.

Result of the ELVITEN pilot show a positive shift in attitudes towards L-category electric vehicles use, since 74.5% of the users would use these vehicles more frequently than four days per week and 20.0% would use them at least once per week, whereas only 16.18% were regular users and 45.18% had used them rarely before. Significant benefits arose from the emission and noise savings: 22% reduction of NO_x and 21% reduction of $PM_{2.5}$ can be achieved if L-category electric vehicles replace 30% of combustion vehicles' activity gradually by 2050. Together with the achieved increase of users' acceptance, this finding could contribute to a better quality of life in the future.

4.2.4 Implications for future research

The CriticalMaas project aims to establish new behavioural models of traveller and supplier trends to study emerging practices, transition steps and critical mass concepts. The proposed research efforts will result with several theoretical and methodological breakthroughs in the field of transport modelling. In addition, the research program will make methodological and empirical contributions to the field of travel behaviour as well as insights into the dynamics of a two-sided mobility environment. Future research in this area will therefore focus on improvements in transport modelling considering findings from CriticalMaas.

Future research of INCIT-EV project will include identifying how electric vehicles penetration level, charging points location and technologies and grid constraints affect mobility and traffic, allowing the development of coupling solutions for optimal scheduling and real-time operation of electrical grid and traffic. These points are critical for the successful acceptance of car-sharing schemes.

ELVITEN project partners found positive perceptions of speed, comfort, safety and green credentials across users. However, there were cost concerns affecting mainly ownership, whilst sharing schemes would equally benefit from the system. Traffic data collected during and after first COVID lockdown suggest that the car sharing market will grow quickly after the pandemic. One potential explanation is that they are open-air single-person vehicles. The project partners such as Kyburz and the City of Rome, alongside the wider automotive industry and related services, local authorities and policymakers, can use all the findings and tools from the project. The benefits from the emission savings will be higher in cities with lower air quality and higher urban population density. Comparing the monetized benefits with the costs associated shows that, shifting to small electric vehicles is a justifiable investment. Further research will look at the long-term perceptions of car sharing schemes using electric vehicles, particularly in big metropolitan areas.

4.2.5 Implications for future policy development

Future car-sharing policies might potentially consider new behavioural models developed by CriticalMaas project. These models will be crucial to understand user behaviour and acceptance of car-sharing schemes in an ever-growing complex transport system.

The INCIT-EV project will design, develop and demonstrate a set of charging solutions to respond to electric vehicle user's needs in seven representative use cases with high replicability potential across Europe. These needs include requirements from a car-sharing service provider as well. The platform will cover two main needs. First, a decision support system orientated to help Mobility planners and Policy makers on the development of ad-hoc action plans to boost the penetration of electric vehicles in their area through the deployment of user-centric charging infrastructure. Second, a set of applications, including parking reservation, payment and smart charging, will focus on the improvement of drivers' experience, providing them with relevant information.

ELVITEN's findings prove the importance of incentives to reduce the price of vehicles, develop a roust network of infrastructure charging points and avoid maintenance concerns. Public-private partnerships might be a good approach for the development of such measures. Activities to raise public awareness (e.g., workshops or open days) on car sharing and electromobility will also help its development. Authorities of different countries should also develop a standardised regulatory framework

Annex 1 provides an overview of the projects undertaken in the field of better understanding of impacts.

4.3 Key topic 3 – IT Development: Apps, websites, connected cars, etc.

This topic focuses on studying how to develop IT solutions for car sharing schemes, such Apps, websites, the communication of cars with the former, etc.

4.3.1 Overall direction of R&I

Several areas of research and innovation emerge for this key topic. These include the development of an IoT open vehicle platform and an IoT architecture based on existing and forthcoming standards, open platforms to leverage car-captured data, integrating connected traffic management and multimodal services, etc.

4.3.2 R&I activities

42 projects were assigned to this topic, funded by European and national programmes, as shown in Table 7.

Table 7. Key topic 3 research by funding origin summary.

Funding origin	Number of Projects	Total project value	Total EU contribution
European	28	€ 181 746 015	€ 111 995 535
National	14	n.a.	n.a.
Total	42	€ 181 746 015	n.a.

Source: Own elaboration from TRIMIS

AUTOPILOT (AUTOmated driving Progressed by Internet Of Things, 2017-2020) aims at bringing Internet of Things (IoT) into the automotive world in order to transform connected vehicles into highly and fully automated ones. It **comprises the development of an IoT open vehicle platform and an IoT architecture based on existing and forthcoming standards, along with open source and vendor solutions**. Moreover, it includes the development of new services on top of IoT to involve autonomous driving vehicles, like autonomous car sharing, automated parking, or enhanced digital dynamic maps, while IoT-enabled autonomous driving cars were be tested, in real conditions, thus allowing multi-criteria evaluations of the impact of IoT on AD.

5GMETA (Monetizing car & mobility data for new Entrants, Technologies and Actors, 2020-2023) project is developing an **open platform to leverage car-captured data to stimulate and facilitate innovative products and services**. It will empower the automotive ecosystem, from industry players to new entrants such as small and medium-sized enterprises and high-tech start-ups. Granting access to data from relevant geographical regions, the project will create new opportunities and business models from valuable services where data liability and billing will rely on an accountability dashboard of data-flow subscription and volume consumption.

The aim of **InCoMMune (Incentivizing Collaborative Mobility by means of Multimodal Sharing Services, 2014-2018)** was to achieve an understanding of the contemporary transport needs within a complex activity-travel context towards the development of collaborative solutions that can provide a flexibility and comfort comparable to privately owned cars. Travel behaviour models were developed to quantify the impact of these services in the whole activity-travel chain, also facilitating the design and long-term assessment of different service layouts and policies, which aim at optimizing the use of collective transport modes. These along with new travel information support systems were tested in two pilots around the campus of the University of Luxembourg.

MyCorridor (Mobility as a Service in a multimodal European cross-border corridor, 2017-2020) aimed at **facilitating sustainable travel in urban and interurban areas and across borders using mobility as a service solutions instead of private cars within an integrated and multimodal MaaS chain**. This is done through the provision of an innovative platform, based on mature ITS technology, integrating connected traffic management and multimodal services. It proposed a technological and business MaaS solution in order to enable modal shift, through interoperability, open data sharing between service providers, as well as tackling the legislative, business related and travel-behaviour adaptation barriers enabling the emergence of a mobility services aggregator and cross border pilots in a corridor of 6 EU countries.

4.3.3 Achievements

In the first phase of the project, AUTOPILOT partners developed and integrated the IoT platforms in vehicles and other devices, while developing and adapting AD functions for the IoT-progressed AD uses cases. Moreover, an open IoT service platform was set up; a federation of several vendor-IoT platforms provided by the project partners and interconnected through an open oneM2M standard IoT platform. A common approach to evaluation based on the FESTA methodology was developed allowing multi-criteria evaluations covering technical, business, quality of life, user acceptance and legal issues. In the second phase of the project, the focus was on testing and evaluating AUTOPILOT's IoT-enabled AD use cases. To this aim, IoT-enabled automated cars were tested with various services in real conditions at six permanent large scale pilot sites internationally, covering four distinct modes i.e., 1) Automated Valet Parking (AVP) 2) Urban Driving applications 3) Highway Pilot and 4) Platooning. The test results were used for multi-criteria evaluations (i.e., technical, business, quality of life, user acceptance and legal issues) to assess the impact of IoT towards higher level of driving automation.

5GMETA open platform aims to leverage car-captured data to stimulate, facilitate and feed with them innovative products and services. Due to its recent launch, the project has not reported results so far. The result of 5GMETA will empower the automotive ecosystem from industry players to new entrants, such as SMEs and high-tech start-ups granting access to interoperable car-captured data according to data licenses. The access to data coming from relevant geographical regions will catalyse the generation of new opportunities and business models coming from valuable services, where data liability and billing will rely on accountability dashboard of dataflow subscription and volume consumption.

The project InCoMMune allowed the study of the university relocation from Luxembourg City to the new campus located 25km southwest of the country, allowing the collection of mobility data that were being

observed even before the relocation started. Various corporate transport services for work-related activities were tested to facilitate the modal shift towards public transport for the commuters. This allowed a series of activities, namely: 1) Activity-travel patterns and mobility analysis, through extensive data collection and analysis that were used combined with analytical models to assess the impact of new modes of transport 2) Information & feedback mechanisms for adaptive collaborative services, including Go2Uni, a Platform-as-a-Service developed to provide a unique point of information for the services offered during the pilot tests, and a tool for estimating and predicting activity location and duration, allowing user profiling via an index for collaborative services 3) Pilots, which allowed an extensive data collection for research in travel behaviour and mobility services analysis 4) Dissemination through dedicated dissemination and outreach activities.

MyCorridor main achievement was the development of a one-stop-shop standards abiding MaaS platform, which allows users to experience a series of mobility, info-mobility, traffic management and added value services, and trip planners while enabling service providers and MaaS aggregators to interface their services at cross-border level. The technical solution is supported by novel business roles and relations, promotion and incentivisation policies. It has been shown that MyCorridor has the potential: 1) to reduce the overall number of trips up to 55% compared to the baseline; 2) support a modal shift in favour of bus and cycling by 15% and 10% respectively; 3) to increase multimodal trips by 6% compared to the baseline; achieve a positive acceptance change towards shared mobility on the basis of Likert-type questions to travellers. MyCorridor also demonstrated a reduction of 23% in CO_2 emissions from road-based transport activity. MaaS in the rural context appeared more challenging, particularly for private MaaS, while there were benefits found in terms of inclusiveness and equity. The importance of data standards and regulations and of niche business models and roles was highlighted, while the necessary technology appears already mature.

4.3.4 Implications for future research

The use cases and the vehicle IoT platforms developed within the AUTOPILOT context, underlined the role of IoT sensor data collection and the use the vehicle as an IoT device, allowing increased data driving data collection and their use a s a means for improving the driving environment perception, paving the wat to higher levels of automation. A common data model was developed through assessing and addressing the needs to implement interoperable vehicle and cloud IoT platforms, along with heterogenic IoT sensor devices. It was carried out jointly with the SENSORIS platform, which was responsible to provide standards for the vehicle to cloud data, while relevant standards have also been presented to oneM2M. AUTOPILOT's Platooning and Automated Valet Parking use cases are used as references in the ETSI Technical Report "SAREF extension investigation: Requirements for Automotive". Smart Appliances REFerence ontology (SAREF) intends to enable interoperability between solutions from different providers and among various activity sectors in the IoT domain and is an essential standardisation work to ensure intra-domain and x-domain interoperability. AUTOPILOT Open Data assists standardisation organisations and researchers to define a common data model for the automotive sector. Finally, the FESTA methodology has been enhanced, in the frame of the evaluation, for including the IoT data.

Forecasting models are limited in capturing the transport dynamics related to the relocation and a classical multinomial logit model was used to predict the modal shifts in the project InCoMMune. A relation was found between commuters' stated satisfaction (a proxy for remembered utility) and the Logsum function of the commuting utility (Decision Utility). In addition, determinants of commuting satisfaction have been related to residential factors. There is a correlation between the complexity of activity-travel patterns and mode choice, in particular car use. The PLS-SEM technique was used for the first time for travel behaviour analysis and appears more robust than the more traditional Covariance-based SEM. Moreover, GIS-based techniques appear to quantify the impact of workplace relocation on the spatial redistribution of daily activities of people.

The research results of MyCorridor can be used either as a digital service case or as a software product sales case, with the main one being the one-stop-shop B2B2C MaaS platform and its front-end mobile applications that can be exploited in several ways. An integrated and efficient MaaS solution – in this case backed an advanced traffic management functionality (i.e., TM2.0), can provide benefits to both citizens and participating organisations and support the mitigation of transport externalities. The current lack of robust, extensive evidence for both types of users require new knowledge in the field of MaaS, which will used as a basis to increase awareness, uptake and political commitment. MyCorridor demonstrated positive effects in terms of reducing trips, increased modal shift, multimodality and a positive attitude towards shared mobility also facilitated through the advanced traffic management features, within a context of EU restrictions due to the recent pandemic, thus affecting pilots and mobility behaviour data collection, generating a lower-than-expected acceptability/use of shared mobility. A more extensive collection of data on the socio-economic characteristics of users will be a critical element to consider as part as future research on MaaS, while the

availability of a larger number of services will support more informed and sustainable mobility and further evidence in uptake and benefits for service providers.

4.3.5 Implications for future policy development

AUTOPILOT highlighted a series of advantages related to safer and more comfortable journeys through the demonstration of technical innovations and business cases around new mobility services utilising IoT-assisted automation. IoT sensors and systems allow for enhanced data collection that enabling a higher perception of the driving environment by the vehicle, allowing increased driving ranges and with less sudden manoeuvring while in autonomous mode. Smoother riders also result in less pollutants and harmful emissions. Through IoT, vehicle users can enjoy enhanced route-optimisation and the comforts of shared mobility services, as with car sharing, while supporting Mobility-as-a-Service and Smart Mobility in general. Furthermore, AUTOPILOT's role is important in validating the role of the automotive sector in the digital marketplace since its use cases, especially the highway pilot, can be used to further the EC's agenda on cross-border societal challenges as prioritised in the CEF2 agenda.

The main scientific objectives of the project InCoMMune inter alia were: 1) to gain insights into the complexity of activity-travel patterns of individuals and of transport users of multimodal sharing services 2) to design and organise collaborative mobility services based on sharing concepts 3) to develop new information and feedback mechanisms, through the design and testing of web-based and smartphone apps. Furthermore, InCoMMune enabled the understanding and exploitation of the specificities of the Luxembourgish context. The research and pilot applications were framed within a real transport policy initiative of the university, to meet both research objectives and university practical needs, while implementing the mission of a Marie-Curie Career Integration Grant in providing solid foundations for enduring research and collaboration within and beyond the university walls. InCoMMune aims to bring together the advantages of travel sharing solutions, whose take up critically depends on how efficient these systems are in relation to the mobility needs of the travellers, and those offered by new information sharing technologies, which can facilitate the closing of the loop between flexible design and organization of sharing systems and the users' activity-travel choices. In essence, by closing this loop, we here introduce the concept of collaborative mobility, where users and service providers continuously collaborate by sharing information on mobility needs and by constantly adapting the services to these needs.

One of the main issues raised through the research conducted under MyCorridor was data sharing and interoperability combined with a lack of national and local political support. The development of adequate policies to enable equitable data sharing, common data sharing standards and a regulatory body to ensure adequate data sharing will be important. MaaS can act as a facilitator in view of the post-COVID-19 recovery through the provision of novel services and information as in the cases of crowding or social distancing. Moreover, the pandemic provides an opportunity to reconsider travel behaviour an opportunity for MaaS to enter and reshape travel. Meanwhile, other impact criteria were considered as less important, mostly because of their relevance to specific contexts, with revenue being more important to private MaaS deployment, and passenger volumes being more relevant to policymakers and to the public setting, mostly at urban level. The key recommendations deriving from the project include, inter alia, the inclusion of advanced traffic management features into MaaS planning, the establishment of data sharing protocols and fair business rules to prevent unfair competition.

Annex 1 provides an overview of the projects undertaken in the field of IT development.

4.4 Key topic 4- Vehicle technology: Electric vehicles, hybrid vehicles, ergonomics, automated vehicles, etc.

This topic focuses on new vehicle technologies aimed at developing car sharing, including electric vehicles for car sharing schemes, hybrid vehicles, ergonomics and automated vehicles.

4.4.1 Overall direction of R&I

R&I in this area focuses on efficient and economically viable electric and automated car sharing, understanding customer and operator needs. It aims at developing generally applicable methods for optimised planning and operation and identifying opportunities for transport planners and urban decision makers.

4.4.2 R&I activities

15 projects were assigned to this topic, funded by European and national programmes, as shown in Table 8.

Table 8. Key topic 4 research by funding origin summary.

Funding origin	Number of Projects	Total project value	Total EU contribution
European	11	€ 46 442 513	€ 30 806 003
National	4	n.a.	n.a.
Total	15	€ 46 442 513	n.a.

Source: Own elaboration from TRIMIS

E4-Share (Models for ecological, economical, efficient, electric car sharing, 2014-2017) aimed at laying the foundations for **efficient and economically viable electric car sharing, understanding customer and operator needs, developing generally applicable methods for optimised planning and operation, and identifying opportunities for urban decision makers**. The methodology applied was based on the extensive examination and mathematical formalisation of the arising optimisation problems, on active stakeholder dialogue and on the development of novel numerical methods for planning and operating electric car sharing systems.

NedraEV (A lightweight, fast charging, EV platform to be utilised on Car Share and Urban Mobility Systems, 2016 - 2016) aimed at creating a family of novel, lightweight EVs, through an EU-based organisation co-ordinating design, manufacture, supply and support service infrastructure. The project objective is **to enable zero-emission urban mobility for sharing schemes, transportation networks, taxi services or private transport**.

UP-Drive (Automated Urban Parking and Driving) aims to address the technological transport-related challenges through the development of an automated valet urban parking service, contributing further to higher levels of vehicle automation and collaboration, thus allowing higher levels of transport safety, inclusiveness and affordability. UP-Drive targets technological progress in all levels of automation ranging from driver assistance to future full automation. Thanks to the better coordination of vehicles, traffic would become more efficient, which might have a crucial impact on car sharing services. For instance, via a virtual chauffeur and pick-up at the doorstep service, car-sharing will become more attractive, full individual mobility could become more affordable, mobility for the elderly or citizens with handicaps will be drastically improved, and the delivery of goods on the last mile could be effectively and innovatively approached.

BICAR (The definitive 100% energy autonomous, CO_2-free and recyclable last mile solution, 2018-2018) aimed at the **development of an individual yet eco-friendly sharing mobility system to serve current urban mobility needs**. It. The BICAR is an all-in-one emission-free and sustainable micro mobility solution intended to support cities towards replacing fossil-fuel vehicles by public transport and sharing systems, through the introduction of smart and sustainable solutions.

4.4.3 Achievements

E4-share laid the foundations for efficient and economically viable electric car sharing systems through studying and solving their design and operational optimisation problems and provided fundamental recommendations to improve urban mobility systems. The project has a two-fold target audience covering both the operators and the city administration: The recommendations provided aim at reducing additional traffic by optimising the operators' maintenance or management efforts, providing the optimal opportunities for customers and eventually regulating regulate the market. On the policy side, the project provides recommendations on how to setup a framework for sharing operators and the integration of shared services in urban mobility.

Nedra has been formed specifically to capitalise on car sharing emerging opportunities through an Electric Vehicle (EV) platform where Product Specification and New Product Development processes are optimised to match exactly the market needs and the mantra "just enough" is applied. The Nedra product range features a

combination of lightweight, low cost, longer range and rapid charge platform that is not currently met by any single existing product. The purpose of this feasibility study is to confirm some of the assumptions regarding the market, identify further key suppliers and partners, and establish the product legislative and compliance needs. The NEDRA project sets out to design and deliver to market an adaptable, three-wheeled, EV platform that can be cleverly configured to produce a range of bespoke transport solutions that give low carbon urban passenger mobility and goods movement with the flexibility of a cycle and the practicality of a car.

UP-Drive focused on advancing technologies in the fields of 360° object detection and tracking using low-level spatio-temporal association, tracking and fusion mechanisms; accurate metric localisation and distributed geometrically consistent mapping in large-scale, semi-structured areas; representations and mechanisms for efficient and cost-effective long-term data management across devices; scene understanding, including semantic features detection, object classification to be used as a basis towards behaviour analysis and intent prediction. The project resulted in a fully integrated system able to perform automated drives in urban environments. After 48 months of activity, the autonomous system was demonstrated, showing that the technology developed during the course lend itself to a higher market uptake of relevant urban transport services, including car sharing services.

BICAR produced a functional prototype demonstrated in a relevant environment (TRL6) capable of supporting multimodal behaviour and to be integrated into the Smart City concept. At the time of its development, it presented the smallest (1.2 m2 footprint) and lightest (80 kg) three-wheel vehicle on the market, featuring a series of novel integrated characteristics in a three-wheeler: a tilting mechanism, solar roof, swappable batteries, while it is made from sustainable materials. The vehicle can be linked to a mobile app, through which drivers can geo-locate, make reservations, lock/unlock, navigate and pay for use. BICAR is an efficient first and last mile solution suitable for urban applications and sharing schemes that can complement public transport systems. The BICAR project included the development process moving from the conceptual idea towards the commercialization of the vehicle and its market uptake.

4.4.4 Implications for future research

Electric vehicle sharing schemes can have positive effects at various levels. Their introduction come along a series of challenges among which is the introduction and placement of the appropriate recharging infrastructure that needs to be planned based on the appropriate traffic and usage forecasting. Users have different characteristics and the individual probability of accepting an incentive is determined by their perceived availability of time, their implicit valuation of time, the previous experience with car sharing services, income and educational level. Knowing more about the various types of users can support the adjustment of the services and incentives provided in order to improve market uptake. To this aim, big data and mathematics-based decision support should be utilised and E4-share showed that common and recurring operators' problems can be numerically solved, and fleet operation can be optimised based on mathematical models. Facing these challenges and optimising the system can have a significantly positive impact on the system, and the developed mathematical formalisations and optimization algorithms are sufficiently generic allowing a wide range of application Finally, a toolbox incorporating the findings can further ease market access for prospective service providers avoiding extra extensive costs.

The NEDRA project studied the framework of changing urban transport systems and user needs. Further, it defined a market opportunity between cycle and car-sharing schemes and with last-mile cargo delivery groups where no other companies and products are currently operating.

The technical developments implemented in the BICAR project to meet the safety and environmental requirements to comply with EU Directive 2007/46/EC for motor vehicles were identified with the support of TÜV-SÜD. The commercial feasibility was assessed through an analysis of the micro mobility market, shifting the target group to business fleet operators or sharing mobility providers as prospective direct customers, offering a sustainable, electric and safe micro-mobility solution directly to B2C and to B2B for urban areas. In order to achieve financial viability, a sale and price strategy was developed along with an initial commercialization targeting B2B and then, starting from year 2 of commercialization, private citizens (B2C) with direct sales.

4.4.5 Implications for future policy development

Establishing clear regulations for shared mobility service providers can maximise their benefits for the city (e.g. less externalities, regain public space) and complement existing public transport systems. Shared systems should fulfil its role in favour of the citizens balancing interests, the administration must negotiate

parking regulations and land use with the operators and define the rules for sharing services. Establishing the required legal framework and standardisation is necessary to promote the interoperability between the various providers regarding information, planning and payment. Moreover, sharing services should be included into digital MaaS platform in order to ensure an effective integration in the existing transport system. Replacing ICE vehicles with electric vehicles cars can effectively contribute to reducing GHG and pollutant emissions. The shift to EVs entails also challenges as in the case of the need for recharging infrastructures installation and optimal positioning that requires investments and coordination between city and stakeholders is required to balance interests. Policy incentives intend to increase the acceptance of the population, encourage the change to use electric cars and facilitate specific parking spaces for car sharing vehicles, user incentives tend to reduce maintenance and management costs on the operator side. Constant data collection can enable the monitoring of sharing schemes and allow adjustment measures if need be.

The NEDRA project identified two barriers to the lightweight electric quadricycle uptake. The first one relates to the commercial nature of the project, since it exceeds the required performance and efficiency needs whilst maintaining low cost and legislative compliance. The second is the perception that, due to the current lack of a widespread electric vehicle-charging infrastructure, vehicle users will be unable to recharge whilst 'on the go'. Further policies and promotional campaigns can help address those two issues.

The BICAR is a cost-effective individual mobility solution which integrates itself into a Smart and Sustainable City concept and multimodal system complementing the public transport with comfort and safety, relieving the inner-city congestion, and solving the "first and last mile" issue. The Feasibility Study shows the need for very careful IPR management especially of any new technical development that may arise and need to be regulated.

4.5 Key topic 5 – Development and implementation

This topic focuses on studying development and implementation of car sharing schemes. These include analysing best practice approaches for car sharing schemes.

4.5.1 Overall direction of R&I

Several areas of research and innovation have become focal points in the development and implementation of car sharing schemes. Some of these involve creating the conditions for the take up of smart e-mobility in cities as well as compare the effectiveness of innovative sustainable mobility solutions in cities with different characteristics but with common challenges.

4.5.2 R&I activities

50 projects were assigned to this topic, funded by European and national programmes, as shown in Table 9.

Table 9. Key topic 5 research by funding origin summary.

Funding origin	Number of Projects	Total project value	Total EU contribution
European	34	€ 475 732 446	€ 215 847 346
National	16	n.a.	n.a.
Total	50	€ 475 732 446	n.a.

Source: Own elaboration from TRIMIS

The project partners of **MEISTER (Mobility Environmentally friendly, Integrated and economically Sustainable Through innovative Electromobility Recharging infrastructure and new business models, 2018-2021**), aim at **creating the conditions for the take up of smart e-mobility in cities**. They want to change the paradigm in the electromobility market by providing interoperable platforms and services for easy, convenient, and barrier-free access to charging, billing and smart grid service, whilst also increasing the use of renewable energy sources and self-generation methods to power electric vehicles. One of their core tasks is to integrate Electric Vehicles within sustainable urban planning, including the establishment of car sharing schemes and the inclusion of electric vehicles within Mobility as a Service framework.

In the context of **DESTINATIONS (CIVITAS DESTINATIONS, 2016-2021)**, six European cities have developed an innovative holistic approach to building sustainable urban mobility systems focusing on both residents and tourists. Participating cities are Elba, Las Palmas de Gran Canaria, Limassol, Madeira, Rethymno, and the Valletta Region. The main objective of DESTINATIONS was to **demonstrate and evaluate the effectiveness of innovative sustainable mobility solutions in cities with different characteristics but with common challenges**. DESTINATIONS aimed at changing the point of view of all stakeholders involved in providing effective mobility and transport solutions in an integrated way.

MEGA-E (Metropolitan Greater Areas – Electric, 2017-2023) it is a CEF project aimed at **installing 322 ultra-charging (UC) stations in 20 European countries**. It also foresees the deployment of 202 UC stations (up to 350 kW) in 30 greater metropolitan areas within 13 countries. MEGA-E also encompasses the introduction of 39 multi-modal e-hubs in 10 major cities (park & ride facilities and intermodal nodes, such as train stations and bus terminals), allowing UC and/or intermodality with e-taxi, e-car sharing, e-logistics or e-buses.

SHOW (SHared automation Operating models for Worldwide adoption, 2020-2023) aims to **estimate and evaluate the role of autonomous vehicles (AVs) in making urban transport more effective, sustainable and user friendly**. The project will put in practice real-life urban demonstrations in five Mega, six Satellite and three Follower Pilots in 20 cities across Europe. The SHOW project partners will analyse the following measures: shared, connected, cooperative, electrified fleets of autonomous vehicles in coordinated Public Transport, Demand Responsive Transport (DRT), Mobility as a Service (MaaS) and Logistics as a Service (LaaS) operational chains.

4.5.3 Achievements

MEISTER project partners plan to develop and put in practice integrated approaches, smart solutions and innovative, sustainable business models, in three urban areas in Southern, Central and Northern Europe: Malaga (Spain), Berlin (Germany), and Gothenburg (Sweden). These three cities have been selected due to their leadership in the field of e-mobility, their complementary contexts and their common vision on electric vehicles deployment. Since MEISTER project is still ongoing, only preliminary results are available. The project has progressed according to the timetable until month 18. The project achieved the following milestones so far:

1. Definition of the user requirements and necessities
2. Specification of the MEISTER platform
3. Intermediate software prototypes developed
4. Integrated MEISTER platform ready
5. eSUMPS knowledge base software operational

In addition to it, four of the five forecasted products are already finished: P2-MEISTER Intelligent Billing & Accounting Platform, P3-MEISTER Integrated Real-Time Information & Booking Services, P4-MEISTER European eMobility Expertise Centre (EeMEC) and eSUMPS knowledge base, and P5-MEISTER Smart Charging and Storage Platform.

For almost five years, the six selected cities of DESTINATIONS applied a set of uniform methodologies, and developed and implemented sustainable mobility measures. The actions have helped reduce the tourism-derived pressure on transport systems across the project sites and relevant stakeholders have committed to a shift towards more sustainable modes. Specifically, the DESTINATIONS cities have conducted the following actions:

1. Developed Sustainable Urban Mobility and Logistics Plans (SUMPs and SULPS);
2. Created attractive and accessible public spaces;
3. Fostered behavioural change towards shared mobility and e-mobility (including by providing new infrastructure);
4. Managed mobility demand and re-allocated urban space in favour of sustainable modes;
5. Raised awareness on the worth of sustainable mobility; and,
6. Fostered attractive, efficient and accessible public transport.

The MEGA-E project will contribute to expand the coverage of ultra-charging stations across the EU. Results and lessons obtained from such installation and practice might be easily transferable to the deployment of faster charging stations among European cities.

SHOW project will deploy a fleet of 74 AVs of all types including buses, taxis, MaaS connected automated cars and cargo vehicles for all transport users in both mixed traffic and dedicated lines. These vehicles will operate under traffic speeds ranging from 18 to over 50km/h and will cover all urban automated mobility needs of the stakeholders. The project pilots will last at least one year in each city, and will transport over 1 500 000 passengers and 350 000 units of goods.

4.5.4 Implications for future research

The three MEISTER pilots expect to involve over 50 000 users, 1 000 electric vehicles and 660 charging points. The project will also evaluate reductions of emissions and environmental sustainability. One the main implications for future research will be conditions for increasing the demand of electric vehicles as well as reducing installation costs of charging points.

The deployments made by DESTINATIONS cities showed that tourism and transport sectors could cooperate, and that sustainable mobility is a highly touristic service (e.g. other holiday destinations could opt for a green mobility offer to become friendlier for tourists influencing positively in the city). It would contribute to better social cohesion attracting further investments. Following the onset of the COVID-19 pandemic, DESTINATIONS also supported touristic cities to rethink tourism in times of travel restrictions. Further research will be needed to fully capture the new mobility and tourism trends after the pandemic.

The assessments carried by SHOW project will analyse the impact of shared automated cooperative and electric fleets at city level. The demonstration fleets, infrastructure elements and connected services (DRT, MaaS, LaaS, etc.) for all travellers in real urban and peri-urban traffic environments across Europe and through a vast international collaboration at global level will allow such analysis. The evaluation will cover all urban automated mobility needs and all stakeholders' demands. In this way, there will be room for further studies of urban traffic, which is a crucial challenge if European cities aim to achieve carbon neutrality. SHOW will seek effective and sustainable urban transport through technical solutions, business models and priority scenarios

4.5.5 Implications for future policy development

The MEISTER project will develop and demonstrate useful business models and public-private partnership frameworks. These guidelines and lessons can facilitate trans-European transferability and increase the impact of car sharing schemes.

Smaller tourist destinations that cannot afford urban transport services all around the year will benefit from DESTINATIONS policy lessons. Across these cities, mobility is highly car dependent, and congestion and other harmful mobility impacts are growing, particularly in the peak summer season. This generates exceptional demands and trade-offs that must be addressed by local administrations, with different offices and competences for coping with tourist and residents' mobility needs. The lack of well-established private-public collaboration schemes and business models prevent the provision of a seamless offer in many tourist destinations at the present. The integrated innovative solutions implemented and put in practice in DESTINATIONS will help transport planners and policymakers of these areas.

The results derived from SHOW project will be a unique opportunity for a fundamental change in urban mobility by integrating AVs into public transport networks. Shared and connected fleets of AVs could drastically decrease the number of cars on the road by reaching people and places it was too difficult to before, plugging first/last-mile gaps and feeding into public transport trunk lines.

Annex 1 provides an overview of the projects undertaken in the field of implementation and put in practice.

4.6 Key topic 6 – Others: Stakeholder engagement, regulations, policies, etc.

This topic focuses on studying other remaining topics not analysed previous. These include stakeholder engagement, better regulations and policies aimed at increasing the use of car sharing vehicles, etc.

4.6.1 Overall direction of R&I

The main area of focus has been on harnessing synergies between a wide range of stakeholders to develop better regulations and policies. These include ride-sharing platforms, crowd-sensing system installed car-mounted smartphones to estimate road conditions, including leading industries, renowned research institutions, transport authorities, car sharing operators and end users.

4.6.2 R&I activities

Fifty-two projects were assigned to this topic, funded by European and national programmes, as shown in Table 10.

Table 10. Key topic 6 research funding origin summary.

Funding origin	Number of Projects	Total project value	Total EU contribution
European	34	€ 172 766 964	€ 98 375 596
National	18	n.a.	n.a.
Total	50	€ 172 766 964	n.a.

Source: Own elaboration from TRIMIS

Delays in maintenance of roads can have an important cost for the society: road safety, road intervention cost, the running cost of the vehicles as well as emissions are negatively affected. The **CROWD4ROADS (CROWD sensing and ride sharing FOR ROAD Sustainability, 2016-2019)** project is aimed at **exploiting synergies between BlaBlaCar, the largest trusted ride sharing community worldwide, and SmartRoadSense, a crowd sensing system that uses of the accelerometers of car-mounted smartphones to estimate the roughness of road surface**. These synergies will provide a sizeable impact in terms of car occupancy rate, road monitoring, and end-user engagement in road maintenance and transport sustainability. The CROWD4ROADS project therefore combines trip sharing and crowd-sensing initiatives, harnessing collective intelligence to address sustainability issues of road passenger transport, by increasing the car occupancy rate and by engaging drivers and passengers in road monitoring. The project will put into practice large-scale pilots to address scalability issues both from a technical and from a social point of view.

Cities-4-People (New approaches for community-driven sustainable mobility innovations at neighbourhood and urban district level, 2017-2020) project partners bring together a multidisciplinary consortium to introduce a community-driven People Oriented Transport and Mobility (POTM) framework. The scheme incorporates **collective awareness and open innovation to understand the real needs of EU citizens and co-create new mobility solutions with them, exploiting digital and social innovation**. The framework co-developed concepts and endorsed concrete solutions inspired by growing mobility trends (e.g., shared mobility and connected mobility). The best solutions were tested thorough pilot and scale up program in 5 different EU urban areas with rich diversity in terms of size, population density and socio-economic context. Cities-4-People also included an open process to set definitions, metrics, indicators and methods to guide POTM impact assessment and add the citizen into this process.

The **MaaS4EU (End-to-End Approach for Mobility-as-a-Service tools, business models, enabling framework and evidence for European seamless mobility, 2017 – 2020)** project aims at **providing quantifiable evidence, frameworks and tools, to remove the barriers and enable a cooperative and interconnected EU single transport market for the MaaS concept**, by addressing challenges at four levels: Business, end users, technology and policy. The project partners provided quantifiable evidence about MaaS costs and benefits in three complementary pilot studies in Greater Manchester, Budapest and Luxembourg. The consortium had all necessary skills and was able to handle all tasks involved in the project, consisting of 17 partners from nine countries, including leading industries, renowned research institutions, transport authorities and operators, consultants and one ministry of transport.

The main objective of **SOLUTIONSplus (Integrated Urban Electric Mobility Solutions in the Context of the Paris Agreement, the Sustainable Development Goals and the New Urban Agenda, 2020 –**

2023) project is to develop an innovative and highly effective approach to urban e-mobility that will lead mobility systems to meet sustainable development goals and address the New Urban Agenda. SOLUTIONSplus aims to set up a **global platform for shared, public and commercial e-mobility solutions, and to kick-start the transition towards low-carbon urban mobility**. The project work-plan encompasses city level demonstrations to test different types of innovative and integrated e-mobility solutions, vehicle and user-level demonstrations complemented by scaling up and replication activities.

4.6.3 Achievements

The most important specific achievements of CROW4ROADS project linked to car sharing are the following:

- The development of a scalable and inclusive crowd sensing CROW4ROADS platform linked to carpooling and car sharing communities. The platform allows end users to contribute anonymous open data on road quality, while being rewarded both for the data they provide and for the sustainable habits that they adopt.
- The development of real-world pilots at urban, regional, and national scale. The platform is active in seven countries (Italy, Romania, UK, Greece, Portugal, Denmark, Hungary) and ready to be activated further across cities and communities with enough critical mass of users.
- The collection of accurate up-to-date open datasets on road surface conditions, covering more than 64 000 kms of roads across seven European countries.
- The development of gamification techniques designed to engage car drivers in passenger transport sustainability.
- The design of a general-purpose rewarding platform that provides policy makers and stakeholders an instrument to raise awareness and incentivize common-good initiatives, driving user engagement.
- The empowerment of citizens as active community members able to adopt more sustainable usage habits and contribute to road transport sustainability.

Through a people-oriented approach, the Cities-4-People project worked to improve transportation and increase urban sustainability. Commuters usually face various problems associated with convenience, access to live information and infrastructure. The project partners studied these issues to improve mobility experience across Europe and make cities a better place to live. Cities-4-People project developed an up-to-date knowledge base of relevant frameworks and models with a strong application potential to the specificities of neighbourhood-level, urban-district level or peri-urban mobility measures and policies. The project partners also identified five profiles that have grounded all the activities that followed. The main achievements can be categorised according to three packages of measures and policies. First, measures aimed at including citizens in urban mobility design. Second, interventions to improve mobility network in European cities such transport services on demand or the design of transport hub that includes e-cars, scooters and bikes. Finally, measures to improve European city infrastructure, for example, expanding the bike infrastructure or providing electric scooters for citizens with mobility impairment to move around the centre of the city.

The main goals of MaaS4EU project were achieved by defining sustainable business models that support the cooperation across transport stakeholders, understanding user needs and choices, implementing a MaaS mobility hub and identifying the enabling policy and regulatory frameworks. More specifically, the project accomplished the following objectives:

- The project partners studied three different organizational structures, focusing on the point of view of MaaS operator to understand which model suits best of each city. Business models were developed and the respective MaaS4EU products demonstrated in the pilots were designed, priced and positioned.
- The partners analysed the diversity of private-public collaborations in the proof-of-concepts demonstrations, including the in-depth understanding of the dynamics between partnerships in different levels (operational, business, regulatory and technological). They also developed use cases to describe the processes and actors involved in the technological approach for the MaaS4EU platform.
- State of the art literature review to understand personal and extrinsic factors influencing users' mobility behaviour as well as assess future potential behaviour changes.
- Development of the Maas4EU platform, which includes generic but also pilot specific functionality, based on the requirements of the operators, integrated in each city. MaaS4EU also defined and implemented

the City Aware MaaS Plans Designer, a web-based dashboard that supports MaaS operators to select MaaS plans that make sense to travellers and potentially have the greatest acceptance, relying on city characteristics that affect the use of mobility modes by its inhabitants.

Due to its recent launch, the SOLUTIONSplus project has not reported any relevant result yet. The project partners will conduct city level displays to test diverse innovative e-mobility solutions and engage a wide range of highly committed actors such as cities, industries, research and implementing institutions and finance partners. To maximise its impact, SOLUTIONSplus brings together highly committed cities, industry, research, implementing organisations and finance partners.

4.6.4 Implications for future research

The impact of CROW4ROADS is twofold. Direct impacts include continuous collaborative monitoring of road quality and more sustainable car usage habits adopted by community members, whilst indirect impacts include the emergence of crowd sensing and gamification as feasible means to empower and engage end users in sustainability challenges. The progress beyond the state of the art achieved has created an ecosystem integrating: mobile crowd-sensing, carpooling and car sharing, gamification, rewards, and open data. Future research in this area will include cooperation agreements with several institutions and public administrations for further validation and evaluation of project results, understanding the applicability of the lessons elsewhere.

Cities-4-People project created knowledge base that provides access to a variety of concepts in different fields, and tested co-creative, participatory methods. Based on the intervention results, the partners measured the concrete impact on the pilot cities. In terms of societal impact, this also means more awareness that positively affects inclusion (e.g. accessibility to people with disabilities), safety and improves quality of life and environmental standards. The project built a solid knowledge base that offers a set of mobility-related interventions and guidelines to other cities that want to implement similar approaches Further research is therefore needed in the impacts of specific measures and policies on transport related social issues.

In the context of MaaS4EU project, the MaaS operator was an intermediary between transport operators and users. Travellers could configure and buy a set of services that are at the same time composed of different transport modes. The operator could propose the best trip combination for each user. The research work was clustered in research directions that interact with each other, namely: Transport Business Models, Travel Surveys and Travel Behavior Models, Data fusion and ITS interoperability, Dynamic Travel services and finally, Personalization for Adaptive Travel Services. Further research will require a better understanding of the interaction between these packages to support car sharing as better alternative to private car.

4.6.5 Implications for future policy development

The CROWD4ROADS project analysed the socio-economic framework and the sustainability threats of passenger road transportation that can be addressed by means of crowd-sensing and ride sharing. The project partners studied the direct and indirect effects of car occupancy rate and road maintenance. The critical mass and the adoption rate required to trigger positive externalities and network effects were also estimated, together with the effectiveness of the cooperation incentives that might contribute to reach it. The practical guidelines on how to exploit the results of the project outside the pilots are of interest for urban planners and policy makers.

Cities-4-People project proved the importance of engaging citizens in the co-creation process, especially when it comes to neighbourhood mobility. To raise awareness of this fact, project partners collaborated with other projects (Metamorphosis, SUNRISE, and Looper) to produce a 'Big Messages' brochure to encourage citizen participation in the urban planning of their neighbourhood. The developed methodology should help with standardising practices to evaluate mobility interventions and provide a more inclusive and encompassing evaluation method that considers quality of life indicators for all citizens.

The MaaS4EU project drafted a MaaS Policy Framework that included a review of current EU regulation and evidence on regulatory issues and policy implications from the real-world activities carried within the project. The project partners also identified the impact of the introduction of MaaS services on short-term travel decisions (i.e., travel patterns) and on mid-term travel decisions (i.e., car ownership) in Greater Manchester. The impact of MaaS4EU app demonstration on attitudes towards MaaS services as well as the impact of COVID-19 on short-term and medium-term travel decisions were analysed. Of particular interest is the stronger demand for private means of transport such as car and bicycle, which does not require the

individuals to share the means of transport with unknown people. These findings and lessons can be considered for future car sharing policies.

Annex 1 provides an overview of the projects undertaken in the field of Others: Stakeholder engagement, regulations, policies, etc. Below, Table 11, provides the main lessons learned from all the reviewed projects.

Table 11. Main lesson learned from the reviewed projects.

Key topic	Lesson
Better understanding of impacts	Free-floating car sharing has the potential to cover up to almost 10% of the daily travel demand, A toolbox offering key results to decision-makers to understand the various types of car sharing and their effects is also very useful. Trade-off between land use and transport, and big data to better locate charging stations should be considered.
User behaviour and acceptance of car sharing schemes	Future car-sharing policies might potentially consider new behavioural models which will be crucial to understand user behaviour and acceptance of car-sharing schemes in an ever-growing complex transport system. Activities to raise public awareness (e.g., workshops or open days) on car sharing and electromobility will also help its development.
IT Development: Apps, websites, connected cars, etc.	IoT sensors and systems allow for enhanced data collection that enabling a higher perception of the driving environment by the vehicle, allowing increased driving ranges and with less sudden manoeuvring while in autonomous mode. Smoother riders also result in less pollutants and harmful emissions. Through IoT, vehicle users can enjoy enhanced route-optimisation and the comforts of shared mobility services, as with car sharing, while supporting Mobility-as-a-Service and Smart Mobility in general. The development of adequate policies to enable data sharing standards and a regulatory body to ensure adequate data sharing will be important.
Vehicle technology: Electric vehicles, hybrid vehicles, ergonomics, automated vehicles, etc.	Replacing ICE vehicles with electric vehicles cars can effectively contribute to reducing GHG and pollutant emissions. The shift to EVs entails also challenges as in the case of the need for recharging infrastructures installation and optimal positioning that requires investments and coordination between city and stakeholders is required to balance interests.
Development and implementation	Shared and connected fleets of AVs could drastically decrease the number of cars on the road by reaching people and places it was too difficult to before, plugging first/last-mile gaps and feeding into public transport trunk lines.
Others: Stakeholder engagement, regulations, policies, etc.	Establishing clear regulations for shared mobility service providers can maximise their benefits for the city (e.g. less externalities, regain public space) and complement existing public transport systems. Shared systems should fulfil its role in favour of the citizens balancing interests, the administration must negotiate parking regulations and land use with the operators and define the rules for sharing services. The development of practical guidelines on how to exploit the results of lessons outside the pilots are of interest for urban planners and policy makers.

Source: Own elaboration

5 Conclusions

This report analyses car sharing schemes across the EU, including European transport R&I activities in the field, and how European research supports the development of such schemes. It first reviewed the European regulation on mobility and transport as well as sharing economy. Second, it explained the concept and gave examples of the European practice. Third, it reviewed publicly funded R&I projects available in the TRIMIS database. Based on this research, the following conclusions arise:

- Limited availability of analyses and data in a standardised format together with a lack of a robust impact assessment methodology means that it is difficult to get a clear picture of the state of car sharing in Europe. This lack of data is partly because of companies unwilling to share what is considered commercially sensitive data. Where data are available, they are often out-of-date.
- A standardised assessment approach that produces comparable results is needed to understand the impacts (i.e., benefits and costs) of car sharing for urban mobility. It is not the focus of this report to outline such an approach, but the literature review revealed recommendations to improve car sharing impact assessments ensuring transparency and replicability.
- Car sharing has several unique properties (e.g., the users have no responsibility for maintenance, booking on-line/on-demand) which are not seen with private car ownership or other forms of urban transport.
- Many car sharing schemes rely on wireless communication to provide users with access to the vehicle at a specified time. They are therefore vulnerable to an unexpected disruption to the communication network as well as cyberattacks having potential privacy issues for users.
- Currently, users experience many sharing schemes on a first come/first served basis according to a tariff structure that depends on car availability and traffic in the area. However, they can experience traffic congestion at the point of access to the car sharing vehicle. When there is a high demand, some users may not gain access to a vehicle. The introduction of pricing techniques can solve this issue, and at the same time shift usage of vehicles to off-peak hours.
- Two main findings arise from the literature review. First, car sharing is popular in European cities with many highly educated inhabitants or cities with a university, whilst that is not the case in cities with many car commuters. Moreover, habits play an important role and some users may not be willing to change their behaviour despite the arrival of new services like car sharing. Car sharing is still not seen as an alternative to car ownership but a means to complement and extend existing mobility options. In this sense, private companies have established car sharing schemes only in large metropolitan areas with good public transport and important traffic congestion problems. However, they reported financial losses in the last years and they only expect profitability in the long term, which might need further support from the municipalities. Second, each European city is different regarding geography, administrative structure and extent of traffic congestion and air quality issues. There is a variety of different car sharing schemes and business models that can be used to implement shared mobility in urban areas. Car sharing has the potential to contribute to improving urban air quality (e.g. by reducing car ownership and CO_2 emissions per person), especially in case of low-emission technologies and increasing accessibility as part of a multi-modal urban transport system that includes public transport, walking and cycling.
- The analysis of European R&I projects available in the TRIMIS database provides the following conclusions:
- First, most projects target the urban environment, which makes sense from the industry point of view and potential users. However, an additional effort might be needed to study their support for the decarbonisation of rural transport. In this sense, the European Urban Mobility Framework recommends that in particular in rural areas shared and on-demand mobility could become part of public transport.
- Second, there has been an increase in the funding support of car sharing schemes. This is particularly true for projects studying IT development: apps, websites, connected cars, etc.

Third, countries with a long tradition of public investments in R&I, and a large transport industry, including consultancy and IT-related companies, appear well placed to adopt car sharing schemes.

Based on the above conclusions, the following recommendations can be made to transport planners and policy makers:

- If car sharing is to be expanded across European cities, then it is clear that a standardised robust methodological approach is needed to better understand the extent and effects of car sharing on urban

mobility. The adoption of a best practice methodology could provide a better understanding of the impacts of car sharing schemes, potentially further improving urban accessibility, mobility and air quality for all European citizens.

— Car sharing became more widespread in Europe relatively recently. It falls under the concept of sharing economy and has not been specifically addressed by European regulation as such. Sharing of best practice approaches and establishing guidelines at the European level might be needed. At the same time, common approaches should also allow flexibility for cities to suit their mobility needs.

— Before implementing any car sharing scheme, municipalities should conduct an ex-ante analysis to understand the travel patterns of potential users. Since transfers from public transport to car sharing schemes might partially offset the benefits of car sharing, it is key to assess overall externalities of the car sharing scheme. The ideal car for such schemes should be small, electric, connected, with a high degree of automation (or even fully automated in the future since they can improve urban mobility by increasing the efficiency and safety of the transport system, as stated in the CAT STRIA roadmap (Meyer, Blervaque and Haikkola, 2019) and should have a high daily usage.

— Municipalities should ensure that car sharing schemes are integrated within the existing public transport system and are easily accessible and targeting specific demographic groups (e.g. non digital natives or people with disabilities) to encourage them to use the service. See, for instance, the guidelines on Sustainable Urban Mobility Plans (SUMP Guidelines) on the Integration of Shared Mobility Approaches to SUMPs (Arndt et al., 2019). Cities can implement several measures to support such integration (e.g. journey planning information, payment, urban infrastructure, etc.), but the dimensions of the integration will depend on the context of the city, since not all cities have the same transport facilities and transport patterns. For instance, charging stations of car sharing electric vehicles should be allocated to complement public transport and increase their user base (e.g. car sharing is a very good option for the last mile of a multimodal trip). Also, the monitoring of the scheme is crucial, since car sharing services should contribute to reducing the overall externalities of the transport system. The focus should be on facilitating multimodal trips where these can reduce GHG emissions, as well as on enabling the substitution of trips made with privately owned cars with shared cars where public transport is not available.

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List of abbreviations and definitions

ALT	Low-emission Alternative Energy for Transport
AT	Austria
BE	Belgium
BG	Bulgaria
CAV	Connected and Automated Transport
CH	Switzerland
CO_2	Carbon Dioxide
CZ	Czech Republic
DE	Germany
DG MOVE	Directorate-General for Mobility and Transport
DG RTD	Directorate-General for Research and Innovation
DK	Denmark
EC	European Commission
EL	Greece
ELT	Transport Electrification
ES	Spain
eSUMPS	Electromobility Sustainable Urban Mobility Plans
EU	European Union
EU28	European Union with 28 Member States
FI	Finland
FP7	7th Framework Programme for Research
FR	France
GHG	Greenhouse Gas
H2020	Horizon 2020 Framework Programme for Research and Innovation
HU	Hungary
IE	Ireland
INF	Transport Infrastructure
ITAL	Italy
IT	Information Technologies
LT	Latvia
LU	Lithuania
MS	Member State
NL	Netherlands
NO	Norway
NO_x	Nitrogen Oxide
NTM	Network and Traffic Management Systems
PL	Poland
PM	Particulate Matter

PT	Portugal
R&I	Research and Innovation
RO	Romania
SE	Sweden
SI	Slovenia
SMO	Smart Mobility Systems and Services
STRIA	Strategic Transport Research and Innovation Agenda
TRIMIS	Transport Research and Innovation Monitoring and Information System
UK	United Kingdom
VDM	Vehicle Design and Manufacturing

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Annex 1. List of projects considered in this report.

Acronym	Name	Start–End	Funding sponsor	TOPIC					
				Better understanding of impacts	User Behaviour/ acceptance	IT Development	Vehicle technology	Development and put in practice	Others
EUROPEAN FUNDED PROJECTS									
MOMO CAR-SHARING	More Options for Energy Efficient Mobility through Car-Sharing	10/08 - 09/11	European		Y			Y	Y
TOSCA	Technological and operational support for car sharing	09/00 - 02/02	European (5th RTD Framework Programme)			Y		Y	Y
mobiCS	Disrupting the Car-Sharing Market in Smart Cities through a Unified Cross-Border Platform	07/16 - 12/16	European (H2020)			Y			
P2PCS	Peer-2-peer Car Sharing	06/17 - 11/17	European (H2020)			Y			
E4-Share	Models for ecological, economical, efficient, electric car sharing	10/14 - 10/17	European				Y		Y
MoVe LIFE94 ENV/D/000030	Integrated transport models with emphasis on car-sharing	10/94 - 09/97	European			Y			

NedraEV	A lightweight, fast charging, EV platform to be utilised on Car Share and Urban Mobility Systems	04/16 - 08/16	European (H2020)				Y		
iShare	iShare - a disruptive approach to vehicle sharing	03/17 - 08/17	European (H2020)			Y	Y		
CROWD4ROADS	CROWD sensing and ride sharing FOR ROAD Sustainability	01/16 - 03/19	European (H2020)			Y			Y
STARS	Shared mobility opporTunities And challenges foR European citieS	10/17 - 03/20	European (H2020)	Y					
SHOTL	A shared mobility On-Demand Service	12/16 - 05/17	European (H2020)			y			
MOSES	Mobility services for urban sustainability	05/01 - 10/04	European (5th RTD Framework Programme)						y
OUITAXI	OUITAXI (or WETAXI) a taxi on demand and taxi sharing service	02/17 - 07/17	European (H2020)					Y	
SMASH	SMASH, SMArt SHaring device for mobility	05/15 - 11/15	European (H2020)			Y			
INTERCEPT	Intermodal Concepts in European Passenger Transport	12/98 - 11/00	European (4th RTD Framework Programme)		Y			Y	

TELLUS (Results 6 - PF6: LCL - New Forms of Ve...)	Transport and Environment Alliance for Urban Sustainability	02/02 - 01/06	European (5th RTD Framework Programme)					Y	Y
ECO²Mobility	Mobility for Economy, Mobility for Environment	01/13 - 12/14	European		Y				
eBRIDGE	Empowering E-Fleets for Business and Private Purposes in Cities	04/13 - 03/16	European				Y	Y	Y
CyberCars	Cybernetic technologies for the car in the city	08/01 - 07/04	European (5th RTD Framework Programme)				Y		
ADD HOME	Mobility Management for housing areas - from car-dependency to free choice	12/06 - 11/09	European						Y
TAG	Crowd-Sourcing technology to change how people and cars move in cities	10/15 - 03/17	European (H2020)			Y			
VIVALDI	VIsionary and Vibrant Actions through Local transport Demonstration Initiatives	02/02 - 01/06	European (5th RTD Framework Programme)	Y		Y			
Mobile together	Mobile together	01/13 - 04/15	European	Y				Y	Y
LIFE97 ENV/D/000469	Realisation of the Sustainable Model City, District Vauban	05/97 - 11/98	European						Y

MOBILE LIFE97 ENV/A/000394	Innovative mobility concept for a medium sized European city to improve the quality of living and of the environment.	01/97 - 12/99	European					Y	
MEGA-E	Metropolitan Greater Areas - Electric	08/17 - 12/21	European					Y	
ITRACT	Improving Transport and Accessibility through new Communication Technologies	01/12 - 12/14	European			Y			
CONNECT	Developing and disseminating excellent mobility management measures for young people	10/07 - 09/10	European		Y				
TRASCOM	Traveller Assistance for Combined Mobility in regional areas	03/02 - 02/04	European (5th RTD Framework Programme)			Y			
AUTOPILOT	AUTOmated driving Progressed by Internet Of Things	01/17 - 02/20	European (H2020)			Y			
CIVITAS DYN@MO	CIVITAS DYN@MO	03/12 - 11/16	European (7th RTD Framework Programme)			Y			Y
CARAVEL	Travelling Towards a New Mobility	02/05 - 02/09	European (6th RTD Framework Programme)	Y				Y	

MIDAS	Measures to Influence transport Demand to Achieve Sustainability	01/06 - 12/08	European	Y					Y
DECOMOBIL	Support action to contribute to the preparation of future community research programme in user centered Design for ECO-multimodal MOBILity	10/11 - 09/14	European (7th RTD Framework Programme)	Y		Y			
SMILE LIFE00 ENV/F/000640	Sustainable Mobility Initiative for Local Environment	08/01 - 01/04	European		Y				
SMILE	Sustainable Urban Transport for the Europe of Tomorrow	02/05 - 01/09	European (6th RTD Framework Programme)	Y				Y	
AENEAS	Attaining Energy Efficient Mobility in an Ageing Society	08/08 - 05/11	European						Y
LEDA	Legal and Regulatory Measures for Sustainable Transport in Cities	01/98 - 09/99	European (4th RTD Framework Programme)						Y
MOBILIS	Mobility Initiatives for Local Integration and Sustainability	01/05 - 01/09	European (6th RTD Framework Programme)	Y				Y	
PRO.MOTION	Creating liveable neighbourhoods while lowering transport energy consumption	11/07 - 02/10	European		Y				Y

EUROMOS	European Road Mobility Scenarios	01/98 - 03/99	European (4th RTD Framework Programme)	Y					
TSG NETWORK	Traffic Snake Game Network	02/14 - 02/17	European						Y
PICAV	Personal Intelligent City Accessible Vehicle System	08/09 - 07/12	European (7th RTD Framework Programme)				Y		
SmartCEM	Smart Connected Electro Mobility	01/12 - 12/14	European					Y	
RTS	Rural Transport Solutions 4.5	01/09 - 08/12	European			Y			
GUARD	Specific Support Action for CIVITAS II	01/05 - 12/09	European (6th RTD Framework Programme)					Y	
ELMOS	Introducing electric mobility as intermodal transport mean in small & medium sized cities of the South Baltic area	10/11 - 04/15	European					Y	Y
UP-Drive	UP-Drive : Automated Urban Parking and Driving	01/16 - 12/19	European (H2020)				Y		
CARE-North	Carbon Responsible Transport Strategies for the North Sea Region	08/09 - 08/12	European	Y					

CARE-North+	Carbon responsible transport strategies for the North Sea Area - CARE-North plus	01/13 - 02/15	European	Y					
METEOR	Monitoring and Evaluation of Transport and Energy Oriented Radical strategies for clean urban transport	01/02 - 03/06	European (5th RTD Framework Programme)	Y					
SUCCESS	Smaller Urban Communities in Civitas for Environmentally Sustainable Solutions	02/05 - 02/09	European (6th RTD Framework Programme)			Y		Y	
PROGRESS	Pricing ROad use for Greater Responsibility, Efficiency and Sustainability in citieS	06/00 - 06/04	European (5th RTD Framework Programme)	Y					
MOVE TOGETHER	Raising Citizens Awareness and Appreciation of EU Research on Sustainable Transport in the Urban Environment	01/08 - 12/09	European (7th RTD Framework Programme)						Y
MOBIEUROPE	Integrated and Interoperable ICT Applications for Electro-Mobility in Europe	01/12 - 12/14	European			Y	Y		
AUTOPILOT	AUTOmated driving Progressed by Internet Of Things	01/17 - 02/20	European (H2020)			Y			
CITYMOBIL2	Cities demonstrating cybernetic mobility	09/12 - 08/16	European (7th RTD Framework Programme)					Y	Y

SPRITE	Separating the Intensity of Transport from Economic Growth	04/00 - 06/01	European (5th RTD Framework Programme)	Y					
HOST	Human Oriented Sustainable Transport means	01/05 - 12/09	European (6th RTD Framework Programme)				Y		
BICAR	The definitive 100% energy autonomous, CO2-free and recyclable last mile solution	05/18 - 09/18	European (H2020)				Y	Y	
GALILEO 4 Mobility	Fostering the adoption of GALILEO for mobility as a service	11/17 - 06/20	European (H2020)					Y	Y
MSH	The one-stop-shop for urban and regional mobility	12/17 - 03/18	European (H2020)			Y			
EMPOWER	EMPOWERING a reduction in use of conventionally fueled vehicles using Positive Policy Measures.	05/15 - 05/18	European (H2020)	Y		Y		Y	
MEISTER	Mobility Environmentally-friendly, Integrated and economically Sustainable Through innovative Electromobility Recharging infrastructure and new business models	09/18 - 08/21	European (H2020)			Y		Y	

ELVITEN	Electrified L-category Vehicles Integrated into Transport and Electricity Networks	11/17 - 10/20	European (H2020)	Y		Y			
CriticalMaaS	Concepts, theories and models for planning, operating and evaluating the dynamics of Mobility as a Service	01/19 - 12/23	European		Y				
C2ART	Towards a Connected, Coordinated and Automated Road Transport (C2ART) system	01/16 - 12/19	European (H2020)	Y					
DESTINATIONS	CIVITAS DESTINATIONS	09/16 - 05/21	European (H2020)					Y	
MOSAIC	Mobility Management Applications in the Community	01/96 - 12/98	European (4th RTD Framework Programme)	Y				Y	
MaaS4EU	End-to-End Approach for Mobility-as-a-Service tools, business models, enabling framework and evidence for European seamless mobility	06/17 - 05/20	European (H2020)					Y	Y
ISCOM	Information Systems for Combined Mobility Management in Urban and Regional Areas	01/00 - 12/02	European (5th RTD Framework Programme)			Y			
TRANSFORuM	Forum to help implement four key goals of the 2011 Transport White Paper	02/13 - 01/15	European	Y					Y

MOMENTUM	Mobility Management for the Urban Environment	02/96 - 01/99	European (4th RTD Framework Programme)	Y				Y	
TAPESTRY	Travel Awareness Publicity and Education Supporting a Sustainable Transport Strategy in Europe	01/00 - 10/03	European (5th RTD Framework Programme)					Y	
SUM PROJECT	Sustainable Urban Mobility	01/12 - 06/14	European	Y					Y
Cities-4-People	New approaches for community-driven sustainable mobility innovations at neighbourhood and urban district level	06/17 - 05/20	European (H2020)					Y	Y
MyCorridor	Mobility as a Service in a multimodal European cross-border corridor	06/17 - 05/20	European (H2020)			Y			
UTOPIA	Urban Transport: Options for Propulsion Systems and Instruments for Analysis	01/98 - 06/00	European (4th RTD Framework Programme)						Y
SEGMENT	SEGmented Marketing for ENergy efficient Transport	04/10 - 04/13	European					Y	Y
INVETE	Intelligent In-Vehicle Terminal For Multimodal Flexible Collective Transport Services	01/00 - 05/02	European (5th RTD Framework Programme)			Y			

INPHORMM	Information and Publicity Helping the Objective of Reducing Motorised Mobility	12/96 - 01/99	European (4th RTD Framework Programme)						Y
MOST	Mobility Management Strategies for the Next Decades	01/00 - 12/02	European (5th RTD Framework Programme)	Y	Y			Y	
MIRACLES	Multi Initiatives for Rationalised Accessibility and Clean, Liveable Environments	02/02 - 01/06	European (5th RTD Framework Programme)	Y				Y	
TRENDSETTER	Setting Trends for a Sustainable Urban Mobility	06/00 - 12/05	European (5th RTD Framework Programme)					Y	Y
ECOCITY	Urban Development towards Appropriate Structures for Sustainable Transport	02/02 - 01/05	European (5th RTD Framework Programme)						Y
TRANSPLUS	TRANSport Planning, Land Use and Sustainability	04/00 - 12/03	European (5th RTD Framework Programme)						Y
ASI	Assess implementations in the frame of the Cities-of-Tomorrow programme	02/03 - 05/05	European (5th RTD Framework Programme)	Y					Y

MAX	Successful Travel Awareness Campaigns and Mobility Management Strategies	10/06 - 09/09	European (6th RTD Framework Programme)	Y	Y				Y
DELTA	Concerted coordination for the promotion of efficient multimodal interfaces	01/09 - 12/10	European (7th RTD Framework Programme)	Y				Y	Y
5GMETA	Monetizing car & mobility data for new Entrants, Technologies and Actors	09/20 - 08/23	European (H2020)			Y			
MERLIN	Multimodal electrified infrastructure planning	02/18 - 01/22	European	Y					
InCoMMune	Incentivizing Collaborative Mobility by means of Multimodal Sharing Services	04/14 - 03/18	European	Y		Y			
SHOW	SHared automation Operating models for Worldwide adoption	01/20 - 12/23	European (H2020)					Y	
TRANSIT	Travel Information Management for Seamless Intermodal Transport	05/20 - 10/22	European (H2020)	Y					
INCIT-EV	Large demonstratIoN of user CentrIc urban and long-range charging solutions to boosT an engaging deployment of Electric Vehicles in Europe	01/20 - 12/23	European (H2020)		Y			Y	

SOLUTIONSplus	Integrated Urban Electric Mobility Solutions in the Context of the Paris Agreement, the Sustainable Development Goals and the New Urban Agenda	01/20 - 12/23	European (H2020)						Y
MS FUNDED PROJECTS									
UG293	Car share and car clubs – Potential and impacts	06/01 - 02/02	National (UK)	Y					
e-covoiturage.ch (car sharing) (09007)	e-covoiturage.ch (car sharing) (09007)	07/09 - 12/10	National (CH)			Y			
Enhanced Corporate & Public Vehicle Sharing Initiative	Enhanced Corporate & Public Vehicle Sharing Initiative	05/14 - 07/14	National (UK)						Y
Sharing Mobility for innovative and inclusive green cities	Sharing Mobility for innovative and inclusive green cities	01/16 - 12/19	National (Norway)	Y	Y				Y
TEMPEST	Transforming household mobility practices through shared consumption: Low-carbon transport and sustainable energy solutions in urban areas	01/16 - 12/19	National (NO)	Y	Y				Y

Shared Autonomy	Potential for the use of shared autonomous vehicles in rural areas	06/16 - 05/17	National (AT)				Y		
REBUTAS	Development of a reactive booking and tariff system for free-floating vehicle sharing services	04/18 - 12/20	National (AT)		Y			Y	
Active and sustainable management of mobility behaviour with the help of ride-sharing as approach for the organised transport of persons	Active and sustainable management of mobility behaviour with the help of ride-sharing as approach for the organised transport of persons	01/17 - 01/19	National (DE)		Y				Y
CoShA	Cooperation and Sharing Applications	03/17 - 02/18	National (AT)			Y			
MICHAEL	MIkro-ÖV and CarsHAring ELegant pinch	09/16 - 02/19	National (AT)		Y			Y	Y
A2 (NRP 41)	Car-free Households	01/97 - 01/01	National (CH)		Y				
SARRASIN	Rural car service for registered users	01/03 - 01/07	National (FR)		Y			Y	
E-CARUSO	E-CARUSO	06/12 - 08/14	National (AT)			Y	Y		

The Upscaling of Carsharing in The Netherlands (438-14-904)	The Upscaling of Carsharing in The Netherlands (438-14-904)	08/15 - 08/19	National (NL)		Y				Y
Pick&Mix	Pick&Mix: A mobility service for 16-25 year olds that outshine the car	06/16 - 05/18	National (UK)			Y		Y	
Intelligence in Transport and Wisdom in Mobility	Intelligence in Transport and Wisdom in Mobility	01/13 - 12/17	National (FI)		Y			Y	
eMaaS	eMaaS	01/18 - 06/20	National (AT)			Y			
BIE	Evaluation of integrated electric mobility	10/14 - 03/17	National (DE)			Y		Y	
The Smarter Travel Solution	The Smarter Travel Solution	03/16 - 02/18	National (UK)			Y			Y
UG207	Potential for mode transfer of short trips	04/98 - 06/01	National (UK)		Y				
Smarter Travel Areas Programme	Smarter Travel Areas Programme	2012 - 2016	National (IE)					Y	Y
SADA	Smart Adaptive Data Aggregation	02/15 - 01/18	National (DE)			Y	Y		

New concepts of use for individual mobility	New concepts of use for individual mobility	11/14 - 02/16	National (DE)	Y	Y				
Ci.Ro.	Ci.Ro. City Roaming	10/12 - 09/15	National (ITAL)			Y		Y	
eMoVe	Electromobility Moves Aachen	12/12 - 06/15	National (DE)	Y	Y				
eFahrung	eFahrung – use of electric vehicles across corporate vehicle fleets	07/13 - 12/15	National (DE)					Y	
IEMM	Intermodal e-mobility Management	06/12 - 09/15	National (DE)			Y		Y	Y
LivingLab diffusion -	LivingLab diffusion - strategies to expand the market for electromobility in Baden-Wuerttemberg - electromobility within the LivingLab BW mobil	11/12 - 09/15	National (DE)						Y
Mobility Trends in Cutting Edge Cities	Mobility Trends in Cutting Edge Cities	02/14 - 03/15	National (DE)	Y					
Creative Carbon Partnerships (CCP)	Creative Carbon Partnerships (CCP)	01/00 - 12/01	National (CH)	Y					

Vehicle-focussed analyses on the integration of electric vehicles into the electric grid in the context of the utilisation of renewable energy sources	Vehicle-focussed analyses on the integration of electric vehicles into the electric grid in the context of the utilisation of renewable energy sources	09/11 - 10/13	National (DE)						Y
A3 (NRP 41)	New, Integrated Mobility Services, NIM	01/97 - 01/01	National (CH)		Y				
Electric mobility for social welfare institutions	Electric mobility for social welfare institutions	05/13 - 04/16	National (DE)					Y	Y
SINGER	Sino-German Electromobility Research	01/14 - 12/20	National (DE)	Y					
Smart use of smart media and games for the promotion of pro-social mobility behavior (314-99-009)	Smart use of smart media and games for the promotion of pro-social mobility behavior (314-99-009)	06/15 - 05/16	National (NL)		Y				
DaBrEM	Dalian - Bremen Electric Mobility	07/13 - 06/15	National (DE)					Y	

MAMBA	Multimodal Mobility Assistance	02/14 - 01/17	National (Luxembourg)			Y			
Mobility-as-a-Service and changes in travel preferences and travel behaviour: a literature review	Mobility-as-a-Service and changes in travel preferences and travel behaviour: a literature review	12/17 - 09/18	National (NL)		Y				
Social science monitoring of the model regions	Social science monitoring of the model regions	03/10 - 09/11	National (DE)		Y				Y
TraffiCO2	Social network for communities' urban mobility	06/12 - 07/15	National (ITAL)	Y				Y	
Multimodality in cities and regions - supply and demand	Multimodality in cities and regions - supply and demand	01/18 - 12/20	National (DE)	Y					Y
Mobility pricing: synthesis report	Mobility pricing: synthesis report	07/05 - 10/07	National (CH)	Y					

Potential analysis and evaluation of factors for the fast and efficient implementation of electromobility in public transport	Potential analysis and evaluation of factors for the fast and efficient implementation of electromobility in public transport	08/17 - 11/18	National (DE)	Y					
Get-e-Ready	Get-e-Ready - Operator model for electric fleets in Stuttgart	01/13 - 06/16	National (DE)	Y					Y
Mobility Management in companies – motives and effectiveness (SVI 2004/045	Mobility Management in companies – motives and effectiveness (SVI 2004/045	09/06 - 12/08	National (CH)	Y					
Playmobi	Changing mobility behavior in a playful way	05/14 - 04/16	National (AT)		Y	Y			
AUTOPILOT	AUTOmated driving Progressed by Internet Of Things	01/17 - 02/20	European (H2020)			Y			
SynArea	Synergetic area coverage by public transport and low-threshold short trip-private transport	01/14 - 03/15	National (AT)	Y					

SynArea II	Synergetic land development with public transport and low-threshold short-haul private transport II	03/17 - 02/20	National (AT)				Y		
AALmobi_cargo	AALmobi _ cargo-the integrated crowdlogistics and Shareconomy service for AAL and communities	01/17 - 05/18	National (AT)			Y			
KONIM	Smart cities concept in the Czech Republic	07/14 - 12/14	National (CZ)	Y					
WOMO	Living & Mobility – integration of location-based mobility in the planning process	01/14 - 12/14	National (AT)		Y			Y	Y
MobilityIntegrator	Tools for overall system planning and management of integrated path chains and multimodal mobility nodes	03/18 - 02/20	National (AT)	Y					
Transport 2030	Transport 2030	03/07 - 12/30	National (FI)						Y
A1 (NRP 41)	Mobility Management	01/97 - 01/01	National (CH)	Y				Y	
Achieving sustainability in urban transport in developing and transitioning countries	Achieving sustainability in urban transport in developing and transitioning countries	11/10 - 07/11	National (DE)						Y

Support to Sustainable Transport in the City of Belgrade	Support to Sustainable Transport in the City of Belgrade	05/10 - 05/14	National (Serbia)					Y	
STREAMS	Supporting Tool foR Empowering Advanced Mobility Services	09/17 - 08/20	National (Luxembourg)	Y					
PLAYMOBeL	Planning and Activity-travel Analytics for Future Mobility Optimisation in BelvaL	03/15 - 02/19	National (Luxembourg)			Y			
STABLE	Sustainable Transport behaviour considering Activity chains of BelvaL commutErs	09/13 - 08/17	National (Luxembourg)		Y				

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