# PASSENGER DOOR-TO-DOOR SOLUTIONS

*a strategic move for sustainable mobility*

SUSTAINABLE DEVELOPMENT FOUNDATION

Fondazione per lo Sviluppo Sostenibile

PREPARATORY STUDY

# Index

# Foreword

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**WHY THE UIC DOOR-TO-DOOR PROJECT**

Sustainable mobility is an increasingly important issue. It affects company reputation and decisions on financial support - but not only - provided by national governments. In many countries, there is a need to develop and improve transport and transit infrastructures with a complex network of connected high-speed rail, commuter trains, electric buses, monorail, street rail etc. In order to maintain the rail sector's leadership worldwide, this should be implemented beyond the environmental focus and supported by an effective communication. For example, UIC & CER set out a Sustainable mobility strategy with targets for the year 2030 and a vision for 2050.

Moreover, rail is not yet fully integrated into the broader network of mobility options – giving passengers the opportunity to easily travel door-to-door (e.g. from home to work). The first and last mile of journeys, together with interfaces between modes, represent a significant barrier for passengers' use of railways. The railway sector must respond to the challenges and opportunities of passengers' rising expectations, changing mobility patterns (vehicle sharing, automated driving, connected high-speed rail and commuter trains, etc.) and technology.

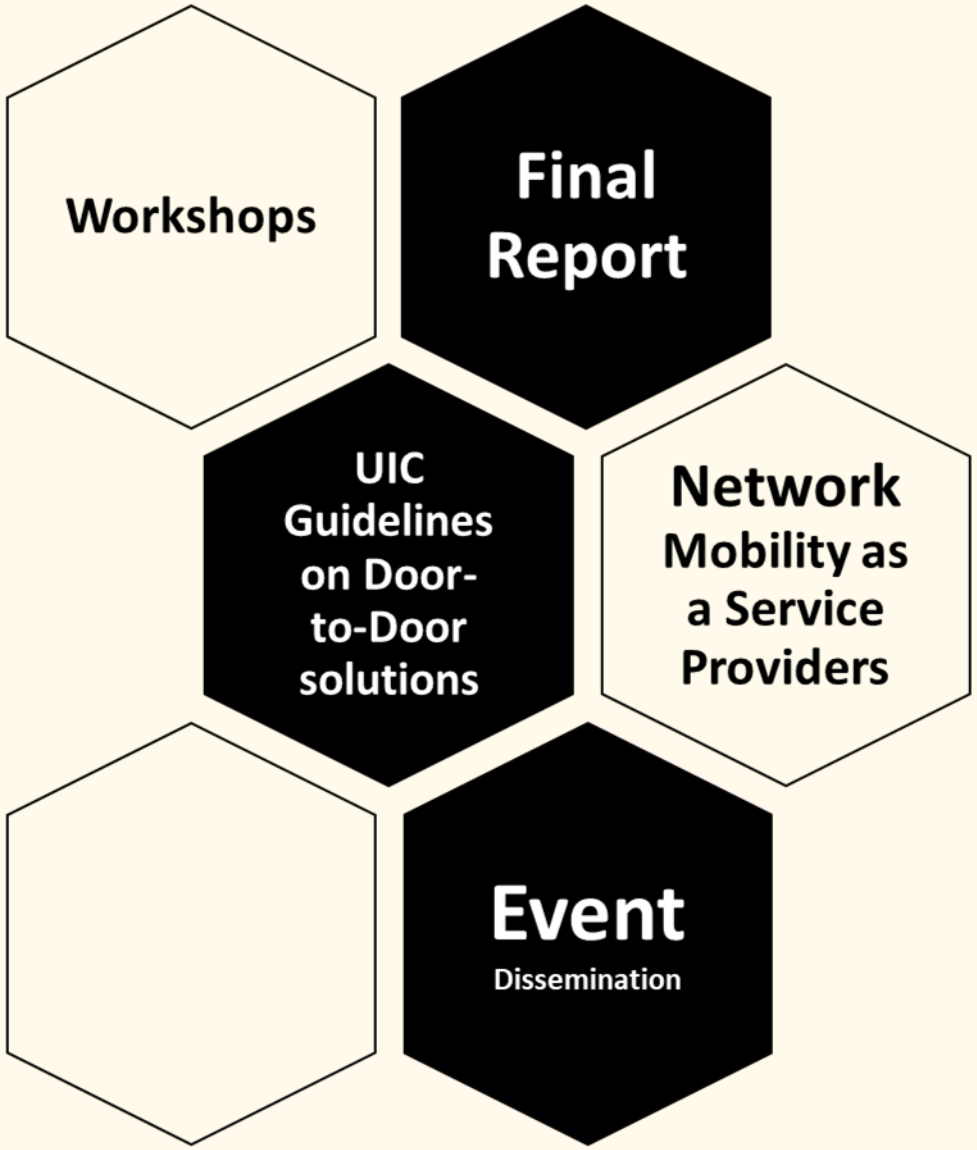
Optimizing interfaces between rail and other modes of transport not only will result in a faster and more flexible public transport system, but also in safer infrastructures and more user-friendly and attractive services. Increasing rail passenger numbers will result in a wide range of environmental, social and economic benefits, e.g., when it comes to congestion, land use and land take, air quality, $CO_2$ emissions, competitive services, reduced dependency on subsidies and equitable access. The door-to-door Project will support sustainable mobility strategies in many countries and regions, for example the EU Urban Mobility Package 2013, whose central element is the message: "Together towards competitive and resource efficient urban mobility".

At the European level, developing a UIC-CER Sustainable mobility strategy should be the first step along a path to wider sustainability issues. Otherwise, the rail sector risks losing its leadership in sustainability and failing to communicate effectively its strengths.

This project will develop a methodology and a policy framework, based on collective experience of members, to address passengers' satisfaction for a sustainable door-to-door mobility with a focus on accommodating new, innovative, disruptive and sustainable mobility and technologies. This will consider how to best maintain railway role as backbone of sustainable mobility and to assist the sector in developing partnerships, organizing and to offer sustainable multimodal services. It will also provide guidance and recommendations to align with policy regulations, institutions and strategies at national, regional and city levels.

# Introduction

# D2D Solutions Project: Outputs and Outcomes



# Foreword

**THE DOOR-TO-DOOR PROJECT: ACTIVITIES, GOALS AND DELIVERABLES**

The Door-to-Door Project will be led by the UIC SMEN Group, with the support of the Sustainable Development Foundation, and will comprise 3 phases along 3 years of activities:
Phase 1 – Concept; Phase 2 – Engagement; Phase 3 - Dissemination.

**Concept -** The goal of the conceptual stage is to set a theoretical framework, establishing a definition of what door-to-door solutions are as well as a shared vision of why and how best integrate these new customer-centric transportation services in a sustainable mobility approach.
**Engagement -** The Project should build upon experiences already implemented by railway companies around the world as much as possible, analyzing them and spreading their results among UIC members. The main purpose is to collect and analyze all types of cost effective modal and service integration, as well as all relevant examples of implementation of technologies, services and business models showing efficient or promising results in terms of growth of railway performance and modal shift. The Project will focus on innovative solutions involving new shared-use mobility services, current business models and public-private partnerships building upon and/or implementing new digital technologies as MaaS platforms and Internet of Mobility. Moreover, the role of public policies will be analyzed as well in the background of this analysis (regulation on digital market policy and measures oriented to shared mobility etc.). The main tools used at this stage of the Project are a series of Workshops, in cooperation with UIC SMEN Network, and the launch of a "Door to Door Solutions UIC Award". The Workshops, based on the presentation of case studies, initiatives and strategies by UIC members and relevant external stakeholders, will provide a comprehensive stocktaking and analysis, allowing the UIC community to learn from best practices. The UIC Passenger Transport Department will be involved to provide knowledge, expertise and to share its relevant network of railway company experts.
**Dissemination -** According to the results from the previous phases, a proposal for "UIC Guidelines on sustainable passenger door-to-door solutions" will be drafted. The guidelines should focus on the following main topics: technologies/services/business model of "door to door" solutions; international collection of "door to door" solutions best practices and experiences involving railways companies; KPIs in order to monitor the implementation of solutions by market share gains and positive environmental impacts; recommendations for a valuable "door to door" business strategy. The Final Report will provide a summary of the work done and the overall conclusions.

**Preparatory study**

# Concept of door-to-door services
# Limitations and barriers for the door-to-door services

**Dissemination Event**

**D2D Award**

**Workshops**

# 1 Warsaw
# 2 TBD - Asia Pacific Region
#3 Environment Agencies
# 4 UE
#5 TBD - Internal

**UIC door-to-door Guidelines**

**Selection of D2D Best Practices**

# Case study literature review
# Structured interview by request for information

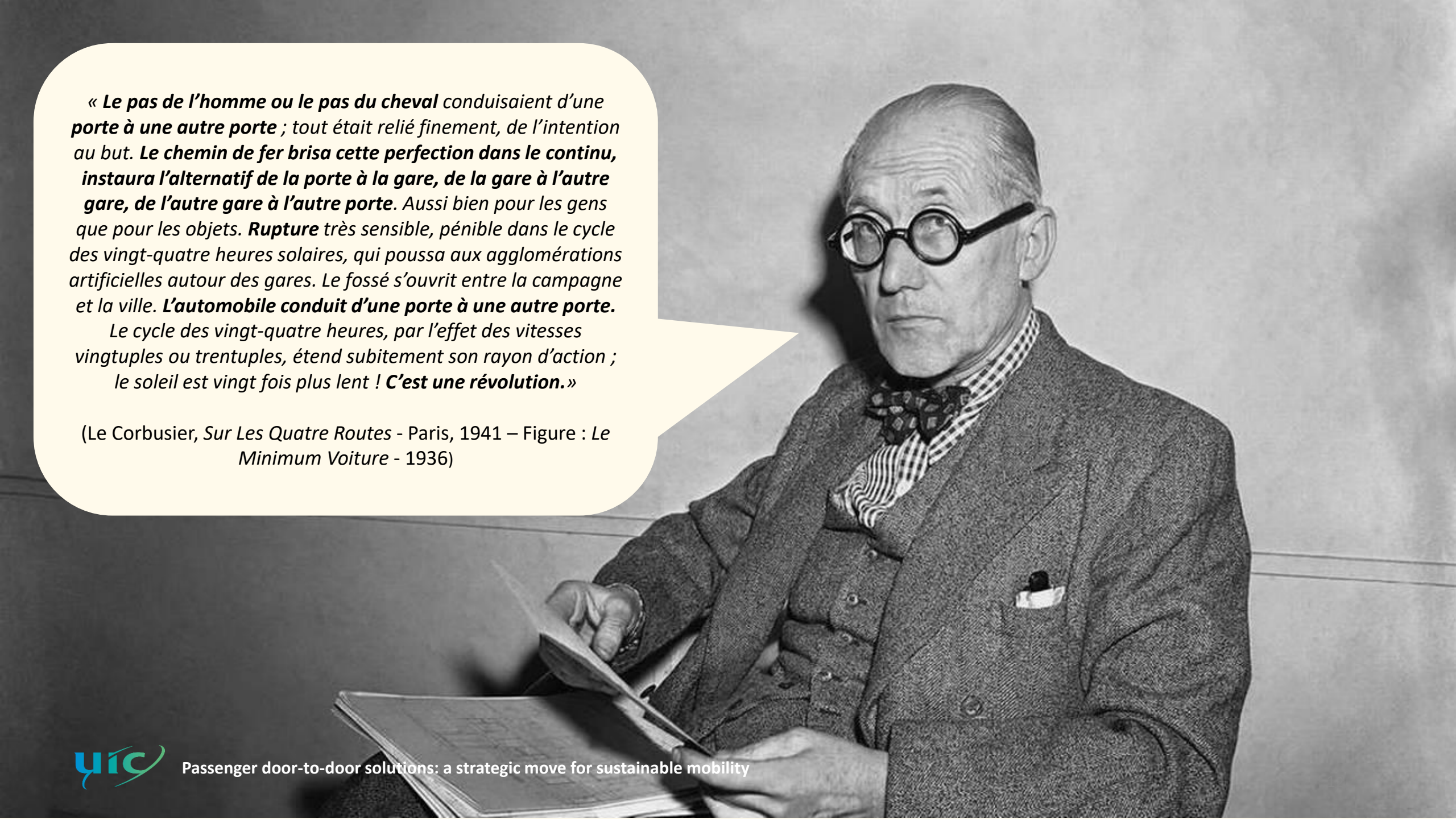
| 2018 | 2019 | 2020 |
|---|---|---|
| **Concept** | **Engagement** | **Dissemination** |


Number Train
To
JERSEY AVE
WASHINGTON
TRENTON
MONTCLAIR
SUMMIT
TRENTON
DOVER
SEC STOPS SECAUCUS
EWR STOPS AIRPO
PENNSYL
7-8
7123

# Introduction

The present Preparatory Study is the first deliverable of the Door-to-Door Project.
The first chapter has the function of explaining how the door-to-door theme is central in the shared or collective mobility system, contextualizing it from a technical and historical point of view. It starts from the rise of the personal car, product of the industrial revolution in the early 20th century, leading people back to the movement continuity that had been lost with the advent of railway after the era of "the passage of man and footsteps of the horse ". This analysis aims to clarify the boundaries between personal mobility and shared mobility, through the history of the leadership achieved by personal mobility in the transport sector thanks to some particular technical characteristics that made it a success. At the same time, the main environmental and social repercussions of this epochal transition are underlined.
The second chapter sets out the most important ongoing trends leading to changes in the transport sector, changes comparable to those that occurred during the advent of mass motorization. Among these, the digitalization stands out: the 21st century technological revolution is able to challenge the supremacy of personal cars in favor of shared transport once again.
To better understand this aspect, the third chapter of this report analyzes the innovative shared mobility services enabled by new digital technologies and new behavior. The report will also discuss the importance of accessibility, urban planning and urban development.
Defining which such services are, how they work and their characteristics will be the principle questions in order to shape the boundaries of the present shared mobility ecosystem, in which rail services are an essential component. The detailed analysis dedicated to the so-called innovative shared mobility services will lead not only to understand the potential of these services but also to bring out the enormous potential linked to their integration with traditional shared mobility services. In this chapter, we define what the door-to-door digital solutions mean for rail services and what the objectives related to their development are. In particular, we focus on the positive environmental consequences given by actually making the railway a choice of seamless mobility and filling the first and last mile between one train station and another.
The last chapter of the study outlines the framework of the main areas of intervention of door-to-door solutions, what are the strategic lines of intervention to enhance integration with other services and other actors of shared mobility considering also the importance of public policies and investments, trying to bring out risks and opportunities that the sector could face in the future. This chapter aims to bridge with next year's activity of the Door-to-Door Project, also including a brief summary of some good practices presented by railway operators during the first UIC-Workshop in Warsaw on this topic.

# 1. Travelling from door to door…



*« **Le pas de l'homme ou le pas du cheval** conduisaient d'une **porte à une autre porte** ; tout était relié finement, de l'intention au but. **Le chemin de fer brisa cette perfection dans le continu, instaura l'alternatif de la porte à la gare, de la gare à l'autre gare, de l'autre gare à l'autre porte**. Aussi bien pour les gens que pour les objets. **Rupture** très sensible, pénible dans le cycle des vingt-quatre heures solaires, qui poussa aux agglomérations artificielles autour des gares. Le fossé s'ouvrit entre la campagne et la ville. **L'automobile conduit d'une porte à une autre porte.** Le cycle des vingt-quatre heures, par l'effet des vitesses vingtuples ou trentuples, étend subitement son rayon d'action ; le soleil est vingt fois plus lent ! **C'est une révolution.**»*

(Le Corbusier, *Sur Les Quatre Routes* - Paris, 1941 – Figure : *Le Minimum Voiture* - 1936)

# 1.1 Travelling from door to door…


"L'automobile" - Umberto Boccioni (1904)

*"Man's and horse's steps led from door to door; everything was connected with accuracy, from intention to purpose. Railways broke this continuity, establishing the alternation from the door to the station, from the station to the other station, from the other station to the other door. For both people and objects. A significant rupture, tiring over the twenty-four hours, leading to the development of cities around railway stations. The gap between the city and the countryside was opened. Cars go from door to door. Thanks to speed, the range of action becomes twenty or thirty times bigger, the twenty-four hour cycle suddenly stretches out; the sun is twenty times slower! It is a revolution."*

(Le Corbusier, *Sur Les Quatre Routes* - Paris, 1941 – Figure : *Le Minimum Voiture* - 1936)

## 1.1 The car passed the train

As pointed out by Le Corbusier, the structural aspect of rail transport is enabling journeys from one station to another. This aspect implies that only very few journeys, for example those that start and end close to the nodes of the railway network, can take place without the support of another mode of transport. In other words, most rail journeys are intermodal journeys characterized by discontinuity, due to switching from one mean of transport to another.

At the same time, the railway service cannot provide a direct connection between all the nodes of the network, making interconnections necessary for the shift from one line to another. Thus, where an interconnection is necessary, a discontinuity occurs within the railway mode itself. Moreover, the other important aspect of railway transport is that the movement of people or goods takes place according to a timetable. This makes rail travel only possible when a train is available between two nodes of network in a given time frame.

Unlike train passengers, car drivers are free to determine their own path and travel, "from door to door", as mentioned by Le Corbusier. Not only those who own a personal vehicle can go from the origin to the destination of their journey, but they can also start the journey at their own convenience. The travel time is as short as the time needed to cover the distance from point A to point B, only making those stops required by the ones who undertake the journey. These aspects were very clear to the famous Swiss architect who published The Athens Charter in 1933. Le Corbusier foresaw the advent of a true revolution that, in the years to come, would radically transform society, the economy and the urban landscape: mass motorization.

Always Available

Ubiquity

**Self-production**

**Door-to-door journey**

Spatial Flexibility

Seamless

**On-Demand**

Scheduled

**Mobility as a service**

**Station-to-Station journey**

Fixed Route

Discontinuity

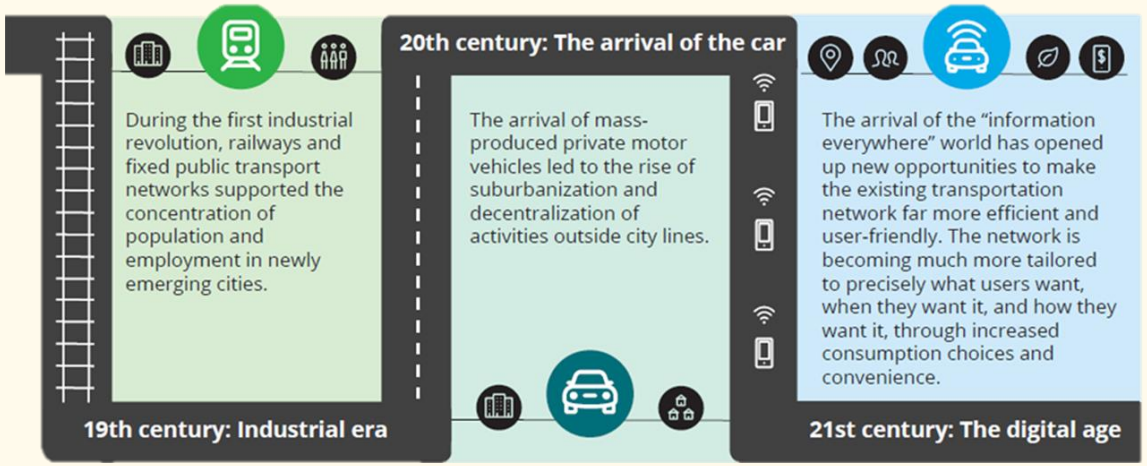
## 1.2 Personal mobility: back to the past

Mechanized transport systems were introduced in the 19th century with the invention of the train and the tram (after horse-drawn omnibus). Before that, land transport - whether walking or horseback riding - was self-produced, as was most of the food and many common use objects. With the advent of train, tram and bus, and ships before that, mobility began to be supplied as a service. One becomes a user/customer, who pays a fee for using a transport service. Today, most of the trips are carried out with a personal motorized vehicle (cars, motorcycles or scooters) and most people, billions every day, are again self-producing their transport, using their skills and often taking great risks.

Walking or horseback riding - like cars or motorbikes today - allow door-to-door journeys hardly offered by shared modes of transport and this is the main reason for many people to choose their personal car.

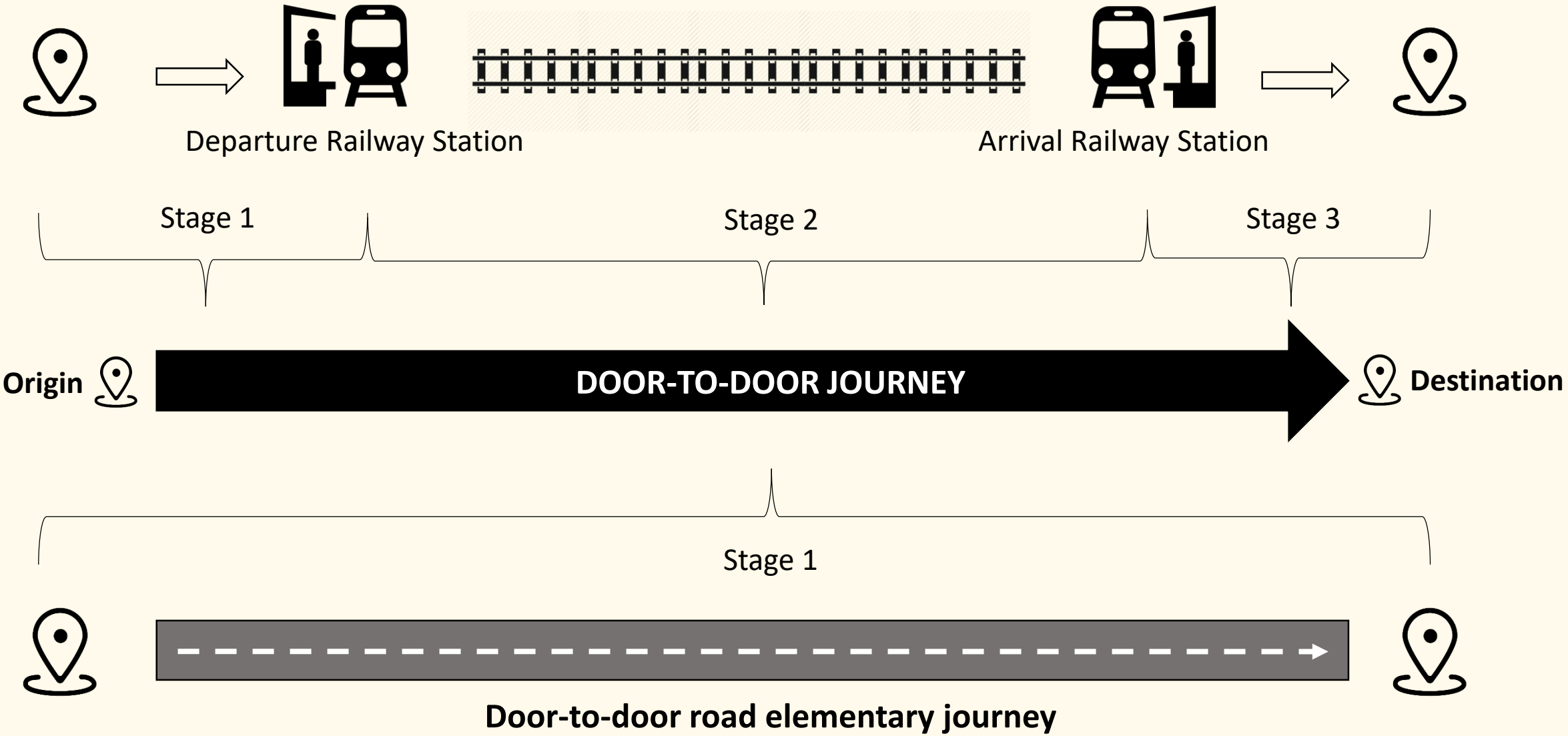
The high availability of cars with increasing performance and comfort, the ongoing development of road infrastructure, a widespread refueling network as well as an increasing income - just to mention some of the most important factors - have led to more and more people to own and use cars. The rising number of people living and working in the city, combined with the so-called urban sprawl, has further increased the need for car travel. In almost every country in the world, social and land-use planning are based on car ownership and car use (or other personal motor vehicles such as motorcycles and scooters, as well as trucks for freight transport).

**Mobility through the ages**




*Warwick Goodall, Tiffany Dovey Fishman, Justine Bornstein, and Brett Bonthron, The rise of mobility as a service: Reshaping how urbanites get around, Deloitte, 2015*

## Door-to-door railway elementary journey




## Door-to-door road elementary journey

## 1.2 Personal mobility: back to the past

The following technical performances have made the use of private cars ever more desirable and, at the same time, increasingly necessary.

**Accessibility**

Worldwide, cars allow easier access to remote places. The density of the road network is very high and allows direct connections between sites very far from each other. The widespread refueling network makes the range of a land trip almost infinite. Thus, all places with a road become accessible from another place with the same characteristics.

**Availability**

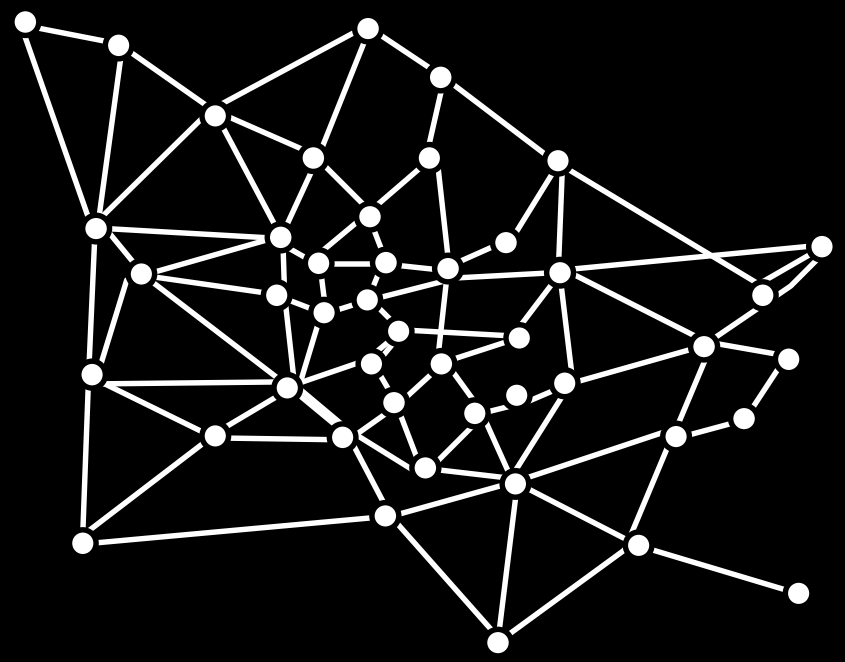
Unlike those who travel by train, the car driver is not constrained by a schedule. The owner of a personal vehicle can go from point A to point B with no need to change means of transport and the journey begins when needed, using the time needed to cover the distance, without making any stops except those considered necessary by those who decide to undertake the journey. The personal vehicle is always available over time.

**Continuity**

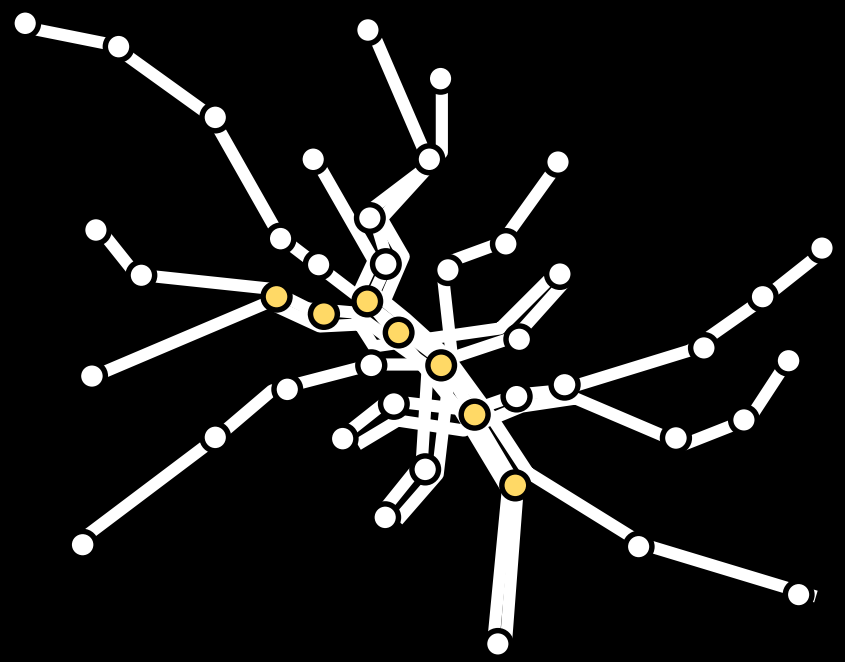
The seamless movement of a car is also an important feature of personal mobility. There is no need to plan a trip, buy a ticket, or wait for a connecting train: there is nothing between the decision to move and get started. However, there are further elements characterizing the continuity of a car journey. Just think about how a road is designed: an endless narrow strip that envelops the entire planet.

**Versatility**

As it is well known, there are intrinsic technical constraints in every modes of transport, allowing its best use only in some contexts and not in others. The peculiarity of the car is instead its versatility. The car is very flexible and adaptable to different travel needs: it can be useful for short or long trips, for work or leisure, and it can carry luggage or bulky items.



Sprawled spatial accessibility



Concentrated spatial accessibility

## 1.3 The shared mobility

The keystone of the preference of individual modalities, such as personal cars, compared to those used by buying (or exchanging) a service as railway services is the autonomy and self-sufficiency connected to the availability of a vehicle, therefore always available. Anyone who moves by car, bicycle or scooter, once buying the vehicle he or she intends to use, will autonomously produce the needed mobility service, not depending on anyone else. Vice versa, anyone who decides to access a mobility service will share it with others, because of its nature, whether it is a taxi service, a shared car service or a bus service. The availability of these services will always be conditioned, in whole or in part, by the organization of other subjects that are addressed, by definition, not to a single individual but to a multitude.

Consider a limited number of points (neighborhoods, cities, etc.) to be connected to each other within a limited area (a city, a nation, a region, etc.). In the case of a rail transport service, it is necessary to make choices to make best use of available resources (which are limited). For example, it will not be economically viable to expand beyond a certain limit neither the railway network nor the number of stops and stations, as it will not be efficient to offer trains that are not sufficiently used. A good economic balance between costs and revenues (but also between consumption, emissions and transport units), does not allow to connect all the points of an area or, for some pairs of these points, to activate a connection without passengers (or goods) moving from one line to another, from one train to another train. There will be a discontinuity within the railway system when, for example, transferring from one train to another one is necessary to continue to the desired direction and, or outside the system, when the origin and/or destination of the journey does not coincide with a node in the network railway and changing the mode of transport is necessary.

Even road transit services need to reduce the availability of their service (in terms of space and time) for efficiency reasons. This constraint also occurs if they are not necessarily bound to tracks, to a separate path and to stopping in specific stations. Although it is more flexible than rail transport systems, the road transit service cannot offer the same performance as a personal vehicle in terms of accessibility, availability, continuity and versatility.

In other words, the optimal synthesis between supply and demand influences, by its nature, any mode of transport involving the use of shared mobility services along a line and according to a timetable.

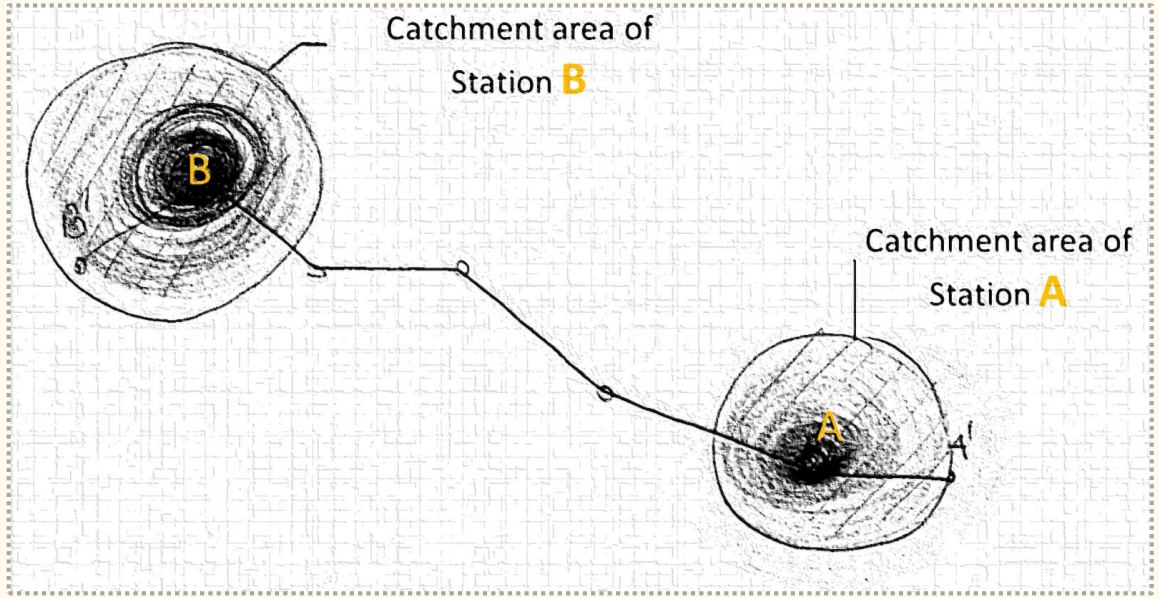
## 1.3 The shared mobility

Consequently, mass transit such as railways, subways, light railways, trams or road transit services (both urban and suburban) are, by their nature, available as shared mobility services and therefore provide:

- an organization (from very simple ones to extremely complex ones like a railway company) providing the mobility service;
- a multitude of subjects using the service, shared vehicles and journeys.

As a matter of fact, conventional shared modes are characterized by limited accessibility, availability and continuity, related to binding technical and economic reasons. For example, in the case of railway, the configuration and extension of the railway network, together with the scheduling of trains movement, represent the result of the optimization between the needs of passengers and the resources needed to provide the transport service.

**Door-to-door elementary railway journey**

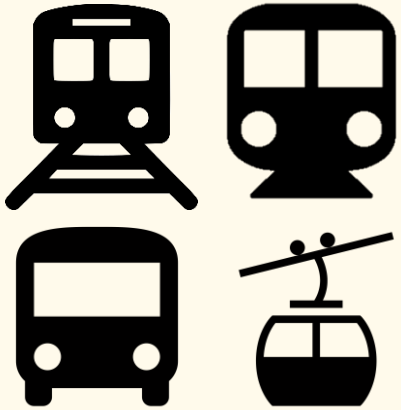


# PERSONAL

*vs*

# SHARED

*vs*



## 1.4 Personal/Shared vs Self-production/Mobility service

Passenger journeys can be made through different modes of transport such as rail, metro, tram, bus, ship, plane, car and motorbike. The standard unit of measurement to classify the mobility carried out in different ways is the pkm, which is the total number of all passenger journeys carried out in different ways.
In addition to classifying trips according to different transport systems, it is possible to classify them according to means of transport usage model. You can move in fact using a personal mean of transport, starting from your legs, your bike, motorbike or car, or you can move by sharing a vehicle or a trip (or both). In the first case, we will talk about personal mobility, in the second shared mobility.
Keeping in mind what has been said above, it is clear that cars high share in passenger mobility, above all in medium and short distance and especially in urban areas, not only is the primacy of a transport system, but also the dominance of a production and consumption model based on the ownership of a personal vehicle and on the self-production of a mobility service under exclusive use.
From this point of view, the current transport system is dominated not only by cars and roads, if compared, for example, to train and rail, but also by the primacy of personal mobility compared to shared mobility, self-produced mobility with respect to mobility as a service.

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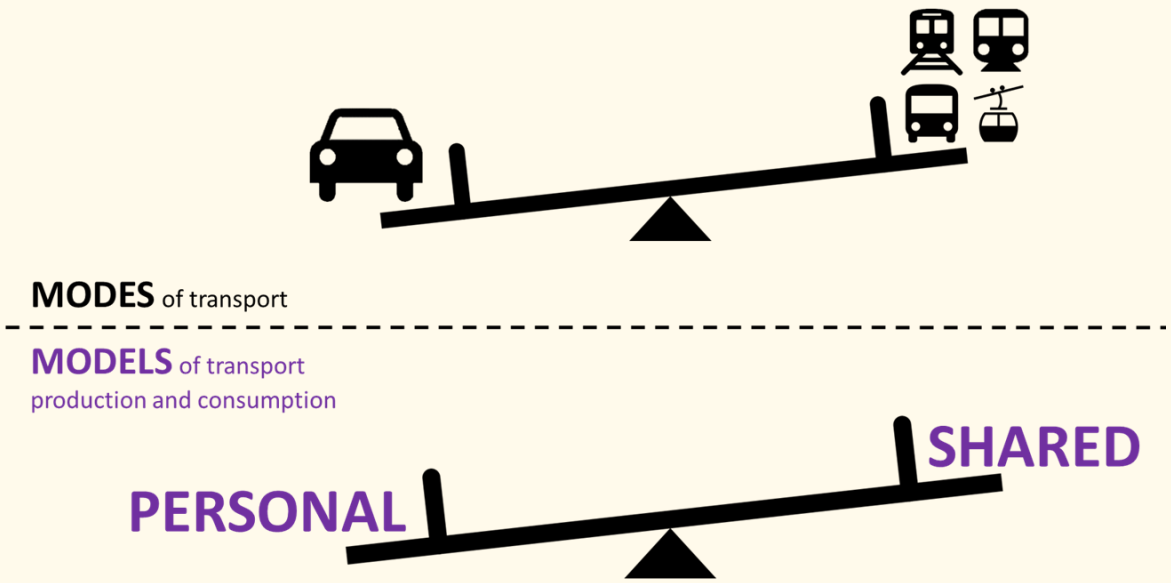


## 1.5 The car revolution

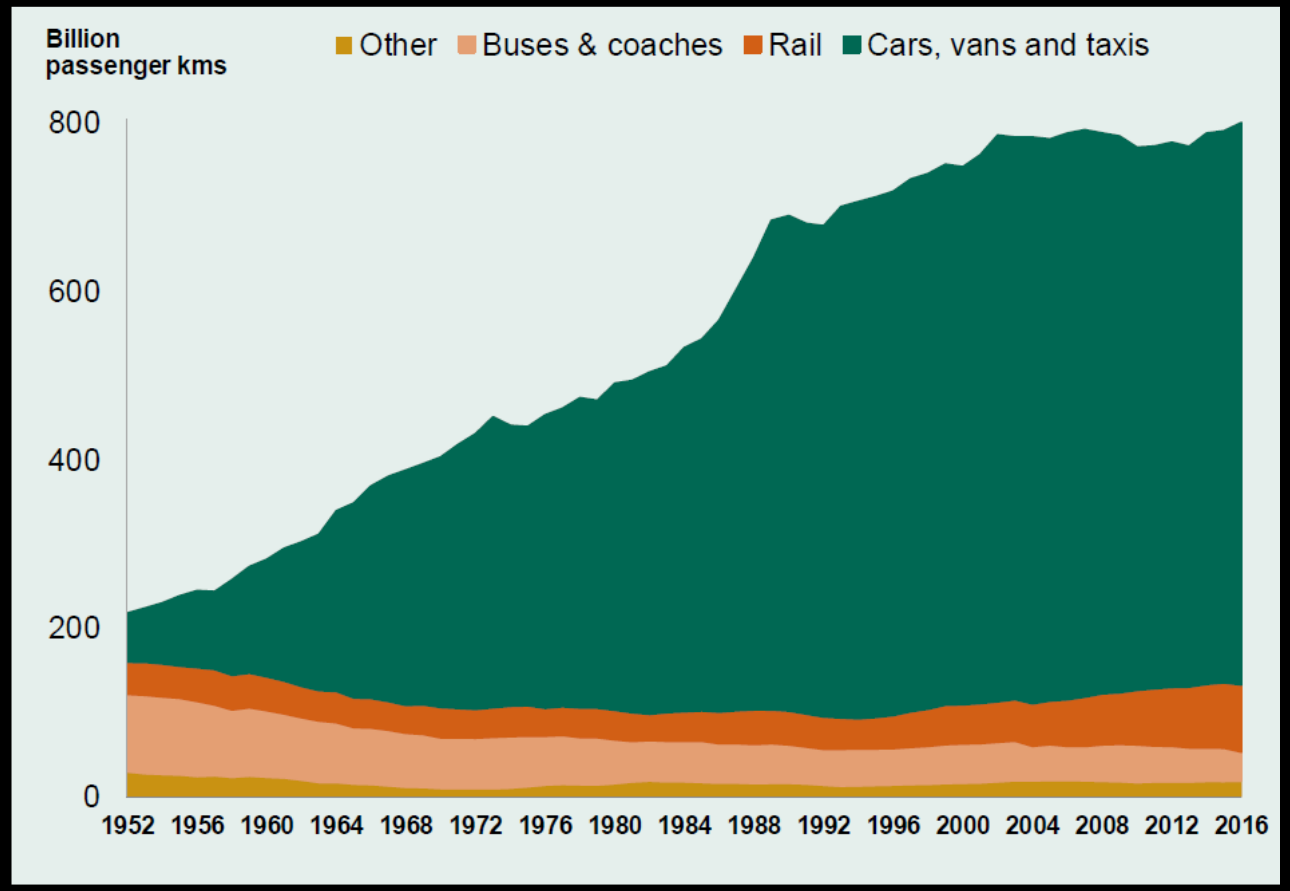
Le Corbusier is considered one of the pioneers of modern architecture and urban planning. He has been severely criticized for many of his positions, in particular the need to destroy historic cities (built around the "man's step and the horse's footsteps") to adapt them to the new needs of modernity. Among these, those who wrote the Athens Charter included the new mobility based on personal cars that required a lot of space, large urban highways and parking lots, and an expansion of the city to the outskirts, eventually removing the distinction between cities and countryside. Certainly, the revolution that Le Corbusier expected to come was accomplished (although, fortunately, the center of Paris was not razed to the ground to build a new Ville Radieuse).

In every advanced economy, this revolution has meant that the number of total passenger trips (for freight there is no difference) has first grown out of all proportion and that the predominant part of these journeys is currently done by personal cars. This process is currently affecting the so-called emerging countries, where motorization rates are rising rapidly to approach very quickly those of the OECD countries, where mass motorization occurred during the 20th century.

Current vehicle ownership levels are 487 passenger vehicles per 1000 population in OECD countries and 69 and non-OECD. In countries that have more recently reached middle-income levels (such China, India, Indonesia, etc.), the average annual ownership growth rates were typically in the range of 6–17% from 2005 to 2015. Anyway, personal vehicle ownership levels do not stagnate in high-income countries. In 2017, the sales of personal vehicles increased by 3% in the European Union. The same year, 15.1 million vehicles were registered in the European Union; the highest number of registered vehicles since 2007.

The great success of the car is not only linked to a technological evolution (from the carriage to the car), but also to a multitude of coordinating industrial sectors. It is not just a question of the success of a product, of a mode of transport, but of a production and consumption model and of an ecosystem in which many actors collaborate and coordinate their action (the automotive industry, the fuel industry, the insurance sector, and financial, governments and state institutions, local authorities etc.).


## Passenger kilometers by mode, Great Britain: 1952 to 2016




*Source: UK Government Department for Transport - Transport Statistics Great Britain 2017*

## 1.6 The side effects

The car revolution and, more generally, personal mobility, have been achieved thanks to the preference that individuals all over the world have accorded to this way of moving; on the other hand, they also brought with them decisively negative effects on the environment and society, the so-called external costs.

The effects induced by individual transport activities, just like its benefits, also cause damage and costs: to the natural environment and to ecosystems (greenhouse effect, climate change, soil acidification, etc.), to the urban environment (air quality, noise, land use change, buildings and monuments degradation, etc.) to health and life quality (illness, accidents, injuries, etc.), and also in terms of time efficiency (congestion, etc.). Negative externalities also concern the construction and maintenance of transport infrastructures such as the upstream and downstream impacts, i.e. the upstream and downstream impacts that are indirectly generated by the transport activity.

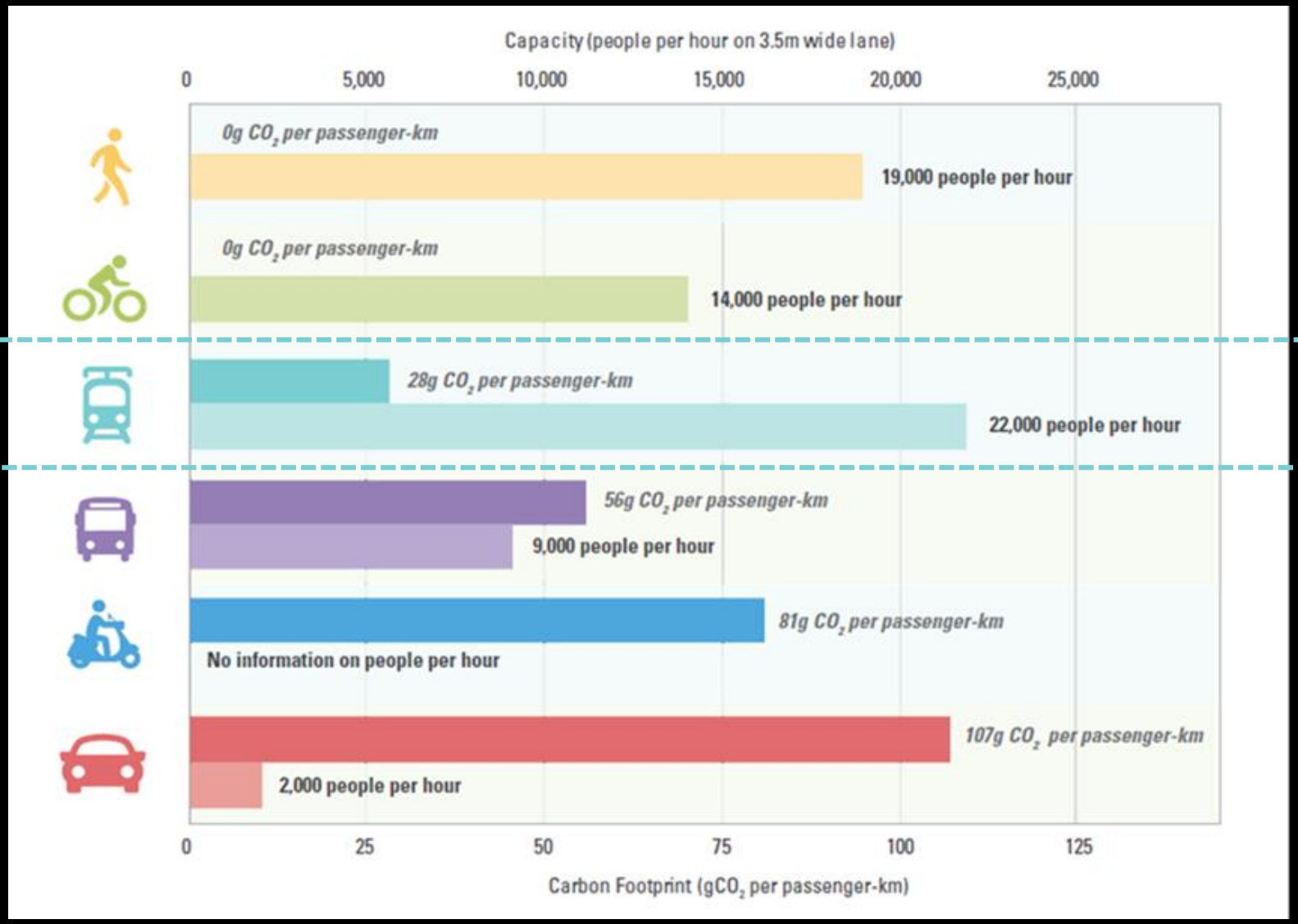
When considering the charts below, it becomes clear that average external costs for road transport are more than four times higher than rail for freight and more than six times higher for passenger services (excluding congestion).

If we move from specific impacts to total one, considering the volumes of trips involved, the panorama is even more problematic. Comparing the impact of different energy sectors in terms of energy consumed and climate-changing emissions globally, the road transport sector plays a decisive role. According to IEA source data, 21.1% of the final energy consumed in the world in 2015 and 20.9% of all CO2 emitted globally is attributed to the road transport sector.

In addition to GHG emissions and energy consumption, the road transport sector is also a critical sector in terms of emissions of local air pollutants with direct impacts on human health and ecosystems. According to the EEA data, road transport is largely responsible for the most significant air quality problems in cities. In addition to direct NO2 emissions, NOX also contributes to the formation of tropospheric O3. Road transport in cities is also a significant source of airborne particles. Local traffic air pollution is responsible for over 400 000 premature deaths in Europe each year.

Although vehicle specific emissions are in decline, NO2 and PM10 concentrations of in urban areas did not decrease in line with emissions trends since the late 1990s.

# Carbon Footprint of different modes of transport




RAILWAY

+ Capacity
- Emissions

*Source: SLOCAT*

## 1.6 The side effects

There are still many urban areas where the limit values for NO2 and PM10 are exceeded across Europe, mainly due to road traffic. For example, the EU annual limit value for NO2, one of the main air quality pollutants of interest and typically associated with vehicle emissions, was widely exceeded throughout Europe in 2014, with 94% of all overruns occurring on the side of the road monitoring sites. Furthermore, in 2014, around 16% of the EU-28 urban population was exposed to PM10 above the EU daily limit value.

The major source of noise pollution in Europe (measured in terms of affected people), both inside and outside urban areas, is road traffic. Data reported by EEA show that noise remains a major environmental health problem in Europe. In 2012, one in four Europeans was exposed to daily road traffic noise levels above the Directive's night noise threshold, with road traffic as the dominant source.

Greenhouse gases, air pollution and noise represent an important part of the external costs deriving from the transport sector, to which costs related to congestion, accidents and the deterioration of the urban and landscape environment must be added. UIC studies on this topic estimated the amount corresponding to the external costs is between 500 and 600 billion euros per year, increasing to 700 billion euros, with the addiction of congestion costs (approximately equal to 4% of the European GDP).

The average external cost for road transport is more than four times higher than rail for freight and more than six times higher for passenger services (excluding congestion).

A side effect of the massive use of the car is undoubtedly related to the road infrastructure. The extension of road pavement increased by 40% worldwide over the last twenty years, representing 97% of the global infrastructural surface dedicated to transport. This is in contrast with the stagnation and reduction of railway lines, except for the increase in high-speed lines over the last few years, in particular due to the strong development of the Chinese HSR. The minor efficiency of road in terms of capacity and the higher specific emissions determine the main negative impacts, amplified by the urban space degradation and the increase in street risk, in particular for those choosing personal active modes of transport (bike or walking).

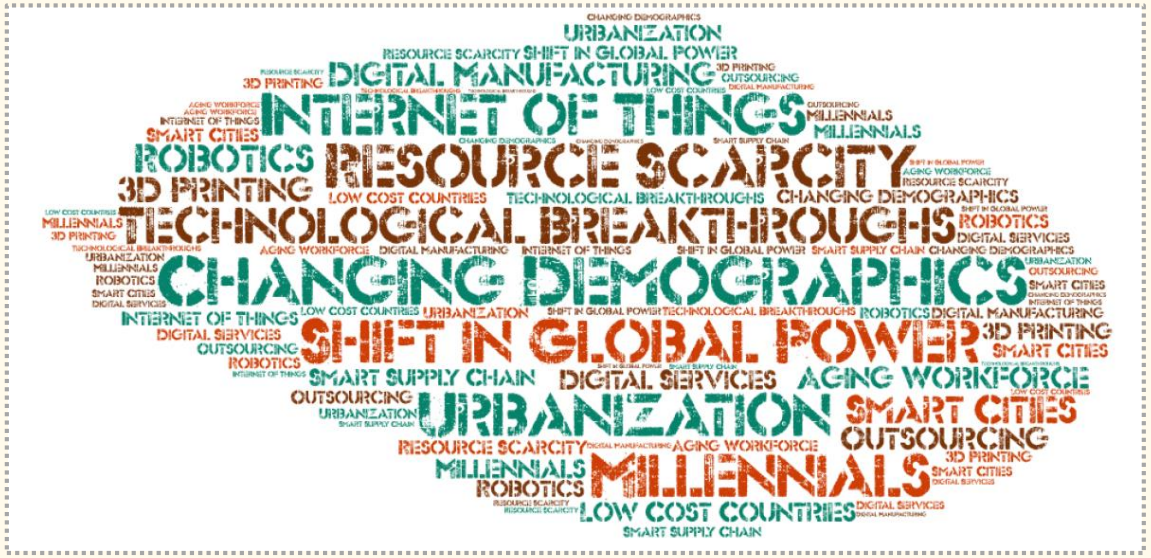
# 2. The times they are-a-changing

## 2.1 Megatrends

Because of its characteristics, the transport sector is deeply influenced by ongoing worldwide trends. Mobility can build innovation based digitalization, can propose climate change mitigation and resilience solutions while, at the same time, it can deepen the problem. Mobility can experience pressure on existing infrastructure from urbanization and can develop adequate countermeasures.
Among various ongoing worldwide trends, those considered for their strong impact on consumption and production patterns are:

- **Urban growth**
- **Climate change**
- **Demography**
- **Technological development**

The following paragraphs will briefly describe such trends, singling out the main trends relevant to the transport sector and their impact on mobility.
The so-called digital revolution also needs a special focus, as a consequence of the great IT sector developments started in the second half of the 20th Century and still ongoing. Digitalization is the enabling tool for innovative new shared mobility services, and it is also the foundation for door-to-door Solutions development, in order to increase and enhance the appeal of traditional shared mobility modes, including trains.



## 2.1.1 Urbanization and urban development

In 2000, at the start of the century, 371 cities over 1 Mln population existed worldwide. At the end of 2018, such figure had grown to at least 548, with an estimate of 706 cities in 2030.

There are, on the other hand, 33 so-called megacities, with over 10 Mln inhabitants, and this number is expected to grow to 43 in 2030. Cities with a population of 5 to 10 inhabitants will increase by 28 and will be 66 in 2030 80% in Asia and Africa. Most cities in the world has less than 5 Mln inhabitants. In 2018, 467 cities had a population between 1 and 5 Mln and 598 cities between 0.5 and 1 Mln. By 2030, the number of cities with a population between 1 and 5 Mln population will grow to 597, while 710 cities will grow over 0.5 Mln population.

In 2018, 1.7 Billion people, 23% of world population, was living in cities over 1 Mln inhabitants. In 2030, 28% of the world population in expected to be living in cities over 1 Mln inhabitants. Urban population in expected to grow in all size classes between 2018 and 2030, while rural population is expected to slightly decrease. In 2018, 45% of the world population was living in rural areas; such share is expected to reduce to 40% by 2030.

In 2018, 529 Mln people were living in megacities, 6.9% of the world's population. However, an increasing share of the world population will be living in such cities, as they are growing in number and size. In 2030, 752 Mln people are expected to be living in cities with over 10 Mln inhabitants, 8.8% of the world's population.

At the world level, the share of the population living in cities is growing in all regions. In North America in 2018, most of the population was living in cities over 0.5 Mln inhabitants and 1 person out of 5 was living in cities over 5 Mln inhabitants. Latin America and the Caribbean is the region with the highest share of megacities population: in 2018, 14.2% of the population was living in the 6 cities over 10 Mln inhabitants. In both Asia and Africa, most of the population was living in rural areas in 2018, with a decreasing trend in both regions. Between 2018 and 2030, the number of cities with over 0.5 Mln inhabitants is expected to grow by 57% in Africa and by 23% in Asia. Trends deriving from the increasing urbanization are very clear: higher congestion derived from the growing pressure on existing infrastructure networks; deriving in an increasing demand for new road infrastructures as well as investments demand; air quality worsening trends, resulting in regulations and limits for the various transport modes.

Increasing urbanization will put pressure on systems and infrastructures in cities already experiencing difficulties, pushing for an increase in their efficiency. On the other hand, an increased density in urban areas could also offer opportunities for those modes of transport whose efficiency is based on density, such as railroads. Such megacities growth will also generate an unprecedented urban sprawl.

## 2.1.2 The climate breakdown

All agree that climate change is the first priority for the economy and the environment. The 2015 Paris Agreement built the necessary commitment, in the horizon of the entire twenty-first century, with the consensus of 195 United Nations Member States.

The effects of climate change are complex and wide reaching, but there is increasing evidence suggesting that there will be a growth in the frequency and intensity of extreme weather events. With higher population density in urban areas, climate change could severely affect more and more people. Effects of temperature changes, intense storm activities and sea level rising will not spare the transport system and infrastructure, with increasingly important implications for their design, operation and maintenance.

As reported by the Global Carbon Project (GCP) and confirmed by the most recent data, there was an unexpected increase in carbon emissions from the combustion of fossils for energy purposes at global level in 2017. The CO2 emissions estimates for 2017 by the GCP are an alarming signal, defining a 1.5% increase, after three years of stable or slightly decreasing carbon emissions.

The transport sector provides a very important contribution in terms of energy consumption and greenhouse gas emissions. Currently, about one third of the world's energy is used to move people and goods, showing a highly growing trend due to the strong increase of personal mobility in Asian countries and few improvements in European and North American countries, which historically represent the largest share of consumers. Since the transport model based on personal vehicles powered by fossil fuels is still dominant, CO2 emissions from the transport sector follow the same trend, representing about 25% of global emissions today.

The situation is reaching the point of no return and the situation, pushing for rapid and strong implementation of innovations and new mobility solutions, especially in urban areas. Besides climate change resilient transport infrastructures, the mobility sector must promote innovations towards a more efficient use of energy resources, focus on electricity produced from renewable sources, use digital technologies to unlock hidden capacities of the current system, promote behavioral changes towards greater sustainability.


SELF STORAGE
Advance Au

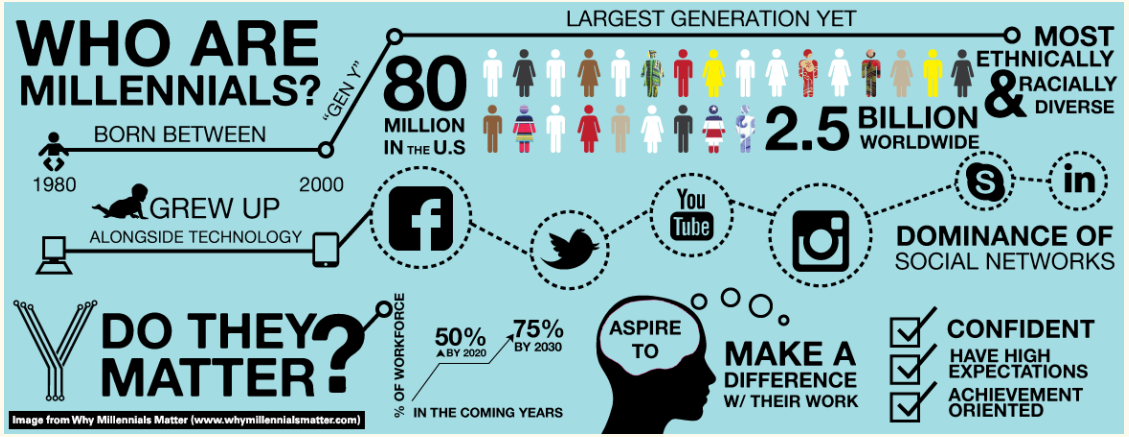
## 2.1.3 From ownership to access

The sharing economy is a social and economic phenomenon consisting in a progressive behavioral shift from owning instrumental goods to a temporary access to services, including in the transport sector. This phenomenon is especially related to the Millenials generation, those born between 1980 and 2000, following the X Generation (1965-1980) and Baby-Boomers (1946-1964).

As far as cars are concerned, there is a perception change from cars as one of the most tangible symbol of well-being in advanced industrial societies: Millennials favor access to a car rather than owning a car and using one's own car is just one mobility option out of many, and not necessarily the main or most efficient one.

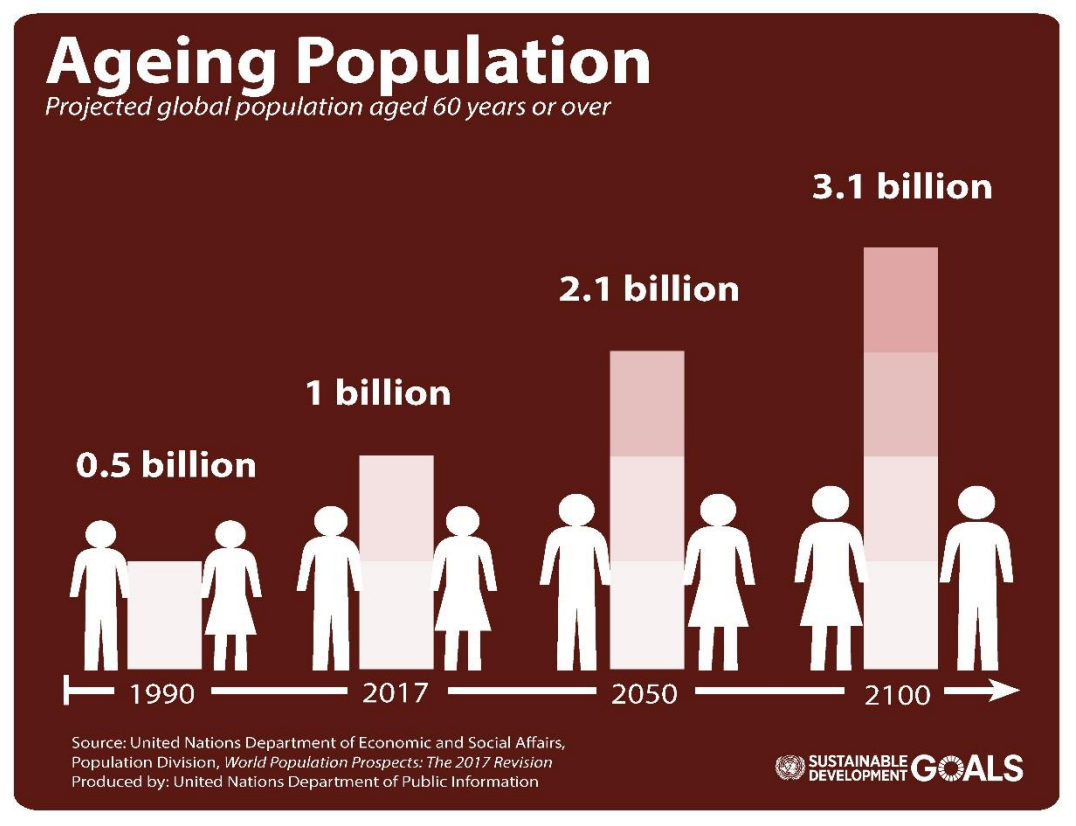
This is particularly true in large urban centers, especially in high-income central areas with a high concentration of infrastructures and shared mobility services (especially the traditional ones). However, this trend is less pronounced in suburban and rural areas with lower per capita income, even in advanced economies.

Changes involving this age group will likely increase the demand for new mobility services, especially shared services. Millennials are more urban than previous generations, with a growing incidence in the centers of most cities worldwide. In addition, they are less interested in cars, and are more likely to use public transport or active mobility (cycling and walking). Millennials are the first users of most new mobility services, such as carsharing, ridesharing and bikesharing and they are more open to connected, automated and less polluting vehicles. Millennials' preference for cities will boost such services, which are especially suitable for dense population urban areas. The new generation is reverting the balance between owners and users, shifting from owning goods towards shared services. In the United States, in 2014, an average Millennial was 30% less likely to buy a car as compared to previous generations. According to economic data, while in 2003 25% of citizens between 30 and 40 had obtained a loan to buy a car, this share dropped to 17% in 2015.



## 2.1.4 Demographics: population aging

United Nations estimates expect a global population aging, mostly due to higher life expectancy and lower mortality rate, except in some regions and countries in Africa, Asia and Latin America.
The UN expects over 2 Billion people, 21% of world population, reaching 60 years old by 2050, approximately doubling the current 12% share. In the following 50 years, the population over 60 years old will increase again by 50%, exceeding 3 Billion in 2100.
Aging population will be one of the strongest transformations in the 21st Century with consequences in all sectors, including transport.
Baby boomers mainly live in the suburbs. As they get older, driving is a greater challenge for them because of age-related health problems. The mobility challenges that a generation of aging baby boomers will face in a suburban environment mean that this cohort will increasingly need alternative mobility services, whether it be ride-ride, semi-flexible shuttles, multimodal solutions (especially last mile innovative solutions), or shared autonomous vehicles.



## 2.1.5 Technological innovation

Technological development is considered one of the most important global megatrends that changed profoundly people's lives over the last few decades, considering the digital technology and Internet.
First because of the exponential increase of data produced through the daily actions taken by an individual. Nowadays, any activity, even the most common one, leaves behind a myriad of information in the form of data on who carries out that activity and on everything related to it. In the world, the quantity of digital information produced is impressive: on average, in one minute in the world, 900,000 users login to Facebook, 450,000 Tweets are posted, 1506 million emails are sent and 15 million messages are sent.
The greatest contribution to this outbreak in data production is primarily due to the so-called Internet of Things, a main trend of our era that involves the connection and communication between intelligent devices through the exchange and reception of thousands of personal data, primarily carried out through smartphones. Forecasts on the development of the IoT predict that, by 2020, 75 billion devices will be connected worldwide.
Obviously, neither this level of data production nor the Internet of Things would have been possible without the enormous advances in computing power achieved in the last decades. Between 1975 and 2015, the computing power doubled every two years while in the 2018 every two and a half years. Calculation power enclosed in even smaller spaces and transportable in a pocket, inside a telephone or inside a watch.
The importance of technological and digital progress for the mobility system is very high and the scenarios seem very promising to date. Computing power, Big Data and IoT will allow transport modes to communicate with each other and with the environment around them, paving the way for truly integrated and intermodal transport solutions.
The IT will be one of the main infrastructural pillars of future cities, helping to improve the quality of life and resource efficiency. The technology will provide travelers with useful information and services, as well as a sense of control and participation. Interoperable tickets, valid for trains, buses, carsharing schemes and bicycles, could encourage intermodal travel by providing seamless connections through other modes.
At this regard, important issues about the digital revolution and the technological innovation still remain open: first of all, the possibility to ensure universal access, closing the digital divide represented by different digital knowledge, the age of users, the access to digital forms of payment without physical money, owning enabling technological support and related amount of data traffic. It is clear that all problems linked to a system increasingly dependent on digital technologies, if not addressed, could become the cause of a reduction in accessibility of transport systems.

## 2.1.6 Reconfiguration of the economic landscape

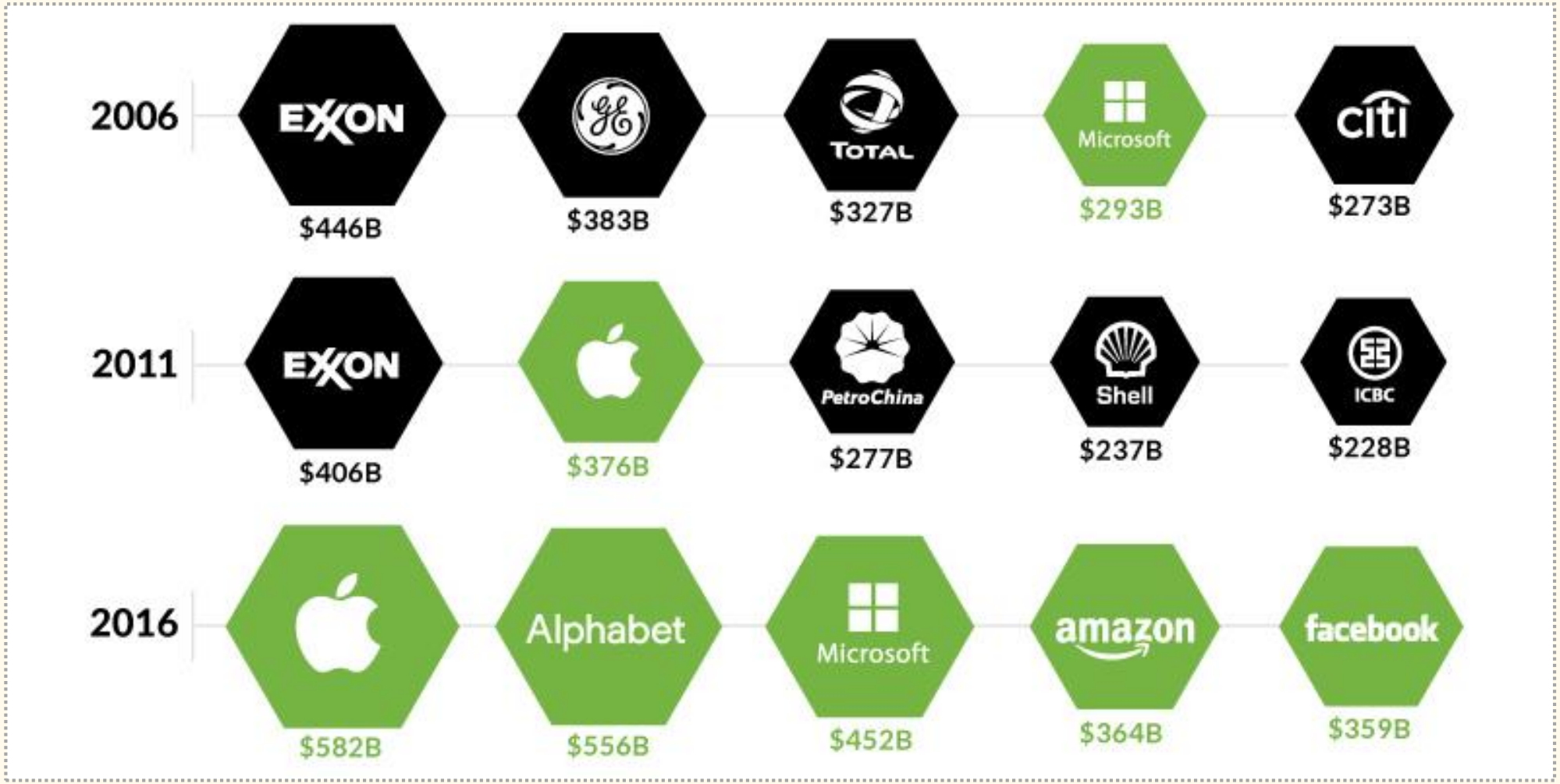
The acronym GAFAM (FAANG in the US, when also Netflix is considered or GAFA when Microsoft is excluded) refers to the hegemony of the American giants of the web and digital, namely Google, Apple, Facebook, Amazon and Microsoft. Their success is the very symbol of the rise of digital technology. In the US in 2001, only one in the world's top five largest market capitalizations was a technology company (Microsoft). Today, the top five places are entirely monopolized by technology players.

GAFAM has managed to dominate their respective sectors. More than 90% of online searches are from Google. Apple concentrates 45% of internet traffic on mobiles. Facebook and Google alone capture the lion's share of all global online advertising, including in the fast-growing mobile format, while Amazon dominates e-commerce and cloud services with its Amazon Web Services business. A key feature of the GAFA strategy is investing in the seven key digital transformation industries (telecoms, health, distribution, energy and utilities, media and entertainment, finance, travel and recreation). Companies are developing forward-looking projects (Google Car - autonomous car, Apple's solar farms), wanting to introduce digital in all aspects of our lives (dematerialized payments, specialized applications in health).

The proportion of the technology sector is greater than that of finance (3,582 billion in total market cap compared with 3,532 billion with finance, according to PwC). The top five technology valuations in the US have a higher value than the DAX-30. The average age of a NASDAQ company is 15 years; the average age of a CAC40 or DAX company 105 years. In 2018, the accumulated revenues of the 10 biggest American technology market caps is $1,000 billion.

In parallel, powerful digital industries have emerged from public investment in new infrastructure: the Internet and GPS. Apart from the transport sector, GAFA platforms have gradually created monopolies. In addition to large financial resources, large research teams, these actors have created a unique relationship with the large-scale citizen called "Multitude".

Market concentration and dominance assumed by few global players are two critical aspects in the current sector configuration, in particular because they represent a risk factor for the technological innovation itself and because they provide control (direct and indirect) on software and hardware infrastructure necessary for the delivery of content and services to internet users.



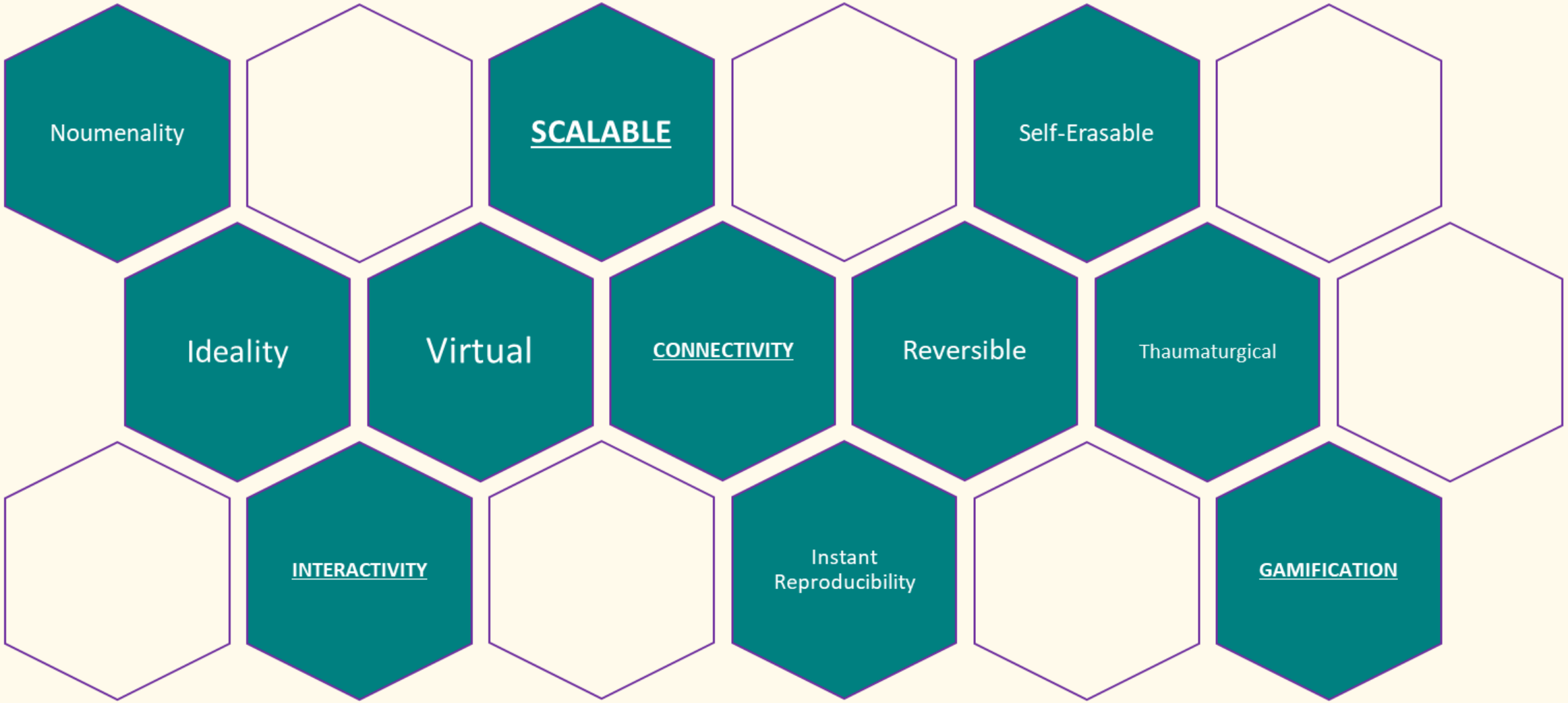

*Source: Pierre Trami – Fabrique des Mobilités*

## 2.2 Characteristics of the digital revolution

The digital revolution is bringing new and winning solutions for shared mobility. This study focuses on digital solutions to improve rail accessibility and other shared modes through mutual integration.
Digital mobility, which can be defined as the third revolution of transport after the train and personal car revolution, is the result of an even more important and larger scale revolution: the digital revolution or digitalization. The great changes in the transport sector have so far coincided with important technical and technological revolutions in which the matter treated has changed in terms of shape, type and scale. The revolution of new shared mobility has changed the use but not the modes of transport and it coincides with the digital revolution in which digital matters, information translated into numbers, is dealt faster and more massively thanks to the technical progress achieved by the digital machines: the smartphones. The digital information, not perceptible because of its nature, through the physical interface of digital technical instruments determines a new reality that becomes reality in turn. The use of a vehicle changes in the case of the new shared mobility, giving form and substance to a category that appears in reality: the sharing of means of transport.
Considering the thought of the contemporary philosopher Stephane Vial, the digital revolution has a rightful place in the evolutionary history of human technologies because it represents not simply an evolution of technical tools but a historical event within the succession of technical systems leading to the advent of a new "digital technical system".
The digital revolution, like all technical revolutions, involves a profound change in the perception and the idea of reality that can be shaped through specific technological tools:

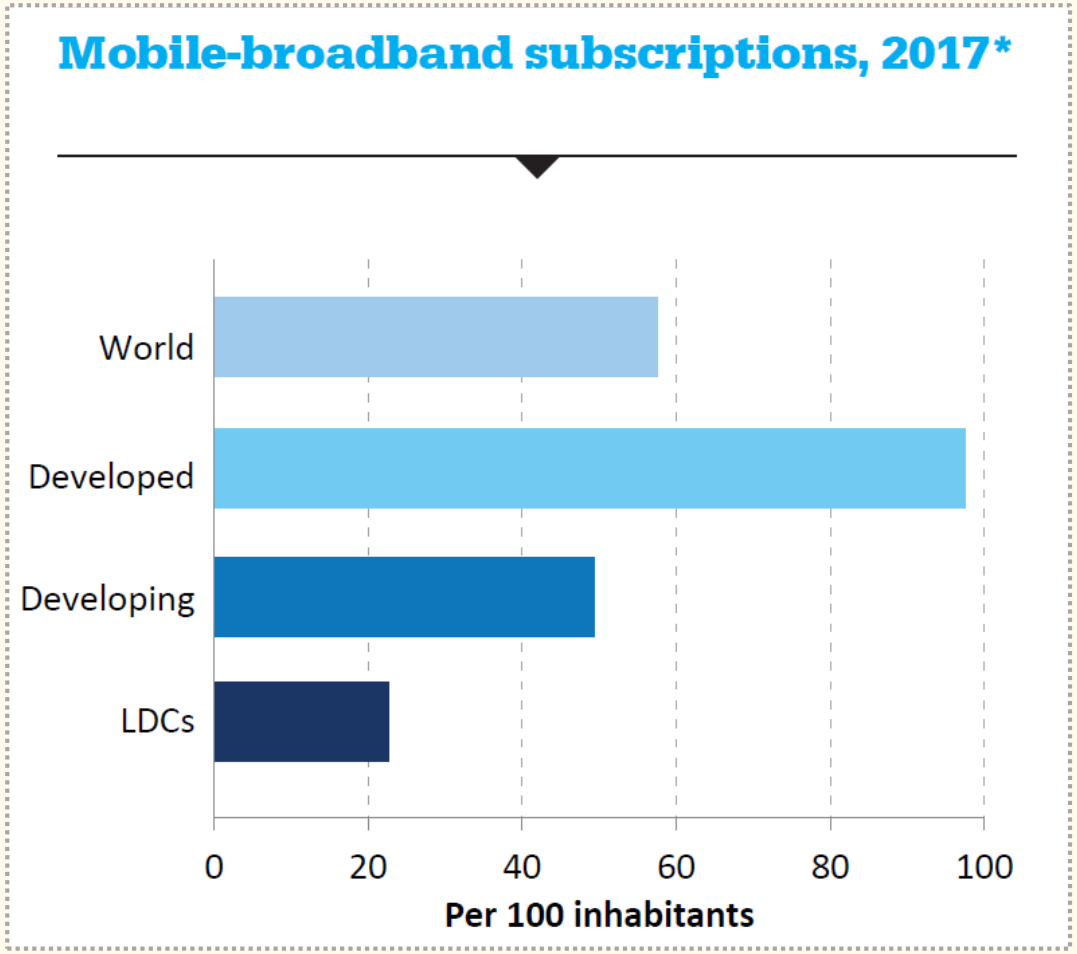
*“C'est une révolution de notre capacité à faire le monde, c'est-à-dire à créer de l'être”*

The same French philosopher lists eleven characteristics to comprehend globally the phenomenon of the digital revolution and how it reveals itself, characteristics that can be applied in parallel to the concept of the new door-to-door mobility: noumenality, ideality, interactivity, virtual, scalable, connectivity, instant reproducibility, reversible, self-erasable, thaumaturgical, gamification.


Noumenality
SCALABLE
Self-Erasable
Ideality
Virtual
CONNECTIVITY
Reversible
Thaumaturgical
INTERACTIVITY
Instant Reproducibility
GAMIFICATION

## 2.2 Characteristics of the digital revolution

The use of platforms, the dematerialization of transactions, the phenomenon of "continuous connection" and "navigation", or even the transition from the primacy of binary relations to that of interactions, processes and networks are an integral part of our daily life. This perception pushes individuals to desire a way to move in the physical reality more and more similar to what is happening in the virtual world. This means that individuals are increasingly oriented towards the use of mobility services, even because they consider them more suitable to the contemporary lifestyle: it is better to travel by train, read a book, watch a movie or "chat" with a friend, rather than keep your hands fixed on the steering and the eyes on the road.




*Source: ICT Facts and Figures 2017*

# 3. The shared mobility today

## 3.1 What we mean by shared mobility service

Regarding mobility services, the characteristic of sharing is the feature common to all forms of transport that do not involve the use of a vehicle owned for exclusive use. This is an essential aspect that concerns all transport services, even the traditional ones also called collective, in common or public.

The definition "shared mobility services" includes all transport services whose use is shared among users. This definition includes traditional mass transportation services such as train, underground, tram, bus and taxi, as well as the so-called new shared mobility services such as bikesharing, carpooling, carpooling and other innovative on-demand services.

The sharing of mobility services, both innovative and traditional, can take place in two different ways: sequentially and simultaneously. In the case of sequential use of transport services, consider for example the use of a bikesharing service or a taxi ride; while for the simultaneous sharing of a transport service it is possible referring to a train or subway journey, as well as to the crew of a carpooling.

Therefore, it is possible to say that the sequentially shared services are generally the vehiclesharing services, those in which users temporarily access the use of a vehicle available to realize their personal travel needs (in particular in terms of space and time). The simultaneously shared services, instead, refer to the services where to be shared is both a vehicle and a journey (or a section of it).

| ON-DEMAND SHARED SYSTEMS | |
|---|---|
| Bikesharing | Low-Tech |
| | IT Dock-based |
| | Free-floating |
| Scootersharing | Free-floating |
| Mopedsharing | Free-floating |
| Carsharing/Vansharing | Station-based |
| | Free-floating |
| | Peer-to-Peer |
| | Microcarsharing |
| E-Hail | |
| Ridehailing/TNC | |
| Ridesplitting | |
| Car&Vanpooling | |
| Shuttles | |
| Microtransit/Bus Responsive Network | |
| Taxi | |
| CONTINUOUS SHARED SYSTEMS | |
| Funicular/Public Elevator | |
| Public Escalator | |
| Automated People Mover | |
| Cablecar | |
| SCHEDULED SHARED SYSTEMS | |
| Bus | |
| Bus Rapid Transit | |
| Tramway | |
| Light Railway | |
| Rail | |
| Urban Rail | |
| Metro | |

**On-demand shared system**

Photo: BikeMI – Bikesharing – City of Milano (Italy)


**Continuous shared system**

Photo: Minimetro – City of Perugia (Italy)


**Scheduled shared system**

Photo: Tube Map – City of London (UK)

## 3.2 Innovative shared mobility services: what they are and how they work

**VEHICLESHARING**

**Bikesharing:**
*Dock-based systems* allow users to pick up and return bikes from IT-enabled docks or stations located throughout a service area. This is the most widely recognized form of public bikesharing.
*Dockless or GPS-based systems* put GPS technology directly into the bikes themselves as opposed to docks. The bikes often also have their own locks, allowing users to secure them to any public bike rack within a predetermined service area.
*Low-cost, tech-light systems* do not place technology in the bike or the dock. Instead, users often sign up online and then receive a text or email with a code to open the bike's lock or access a lock box with a key.
*Peer-to-peer bikesharing,* which allows users to rent or borrow bikes hourly or daily from individuals or bike rental shops.
**Carsharing:**
*Traditional or round-trip carsharing*, which requires customers to borrow and return vehicles at the same location
*One-way or point-to-point carsharing*, which allows customers to pick up a vehicle at one location and drop it off at another.
*Peer-to-peer (P2P) carsharing*, which allows car owners to monetize the excess capacity of their vehicles by enrolling them in carsharing programs.
*Niche carsharing services*, closed-network carsharing systems that serve specific communities, such as apartment complexes or universities.
**Scootersharing:**
A service that allows users to rent for a short time scooters distributed to the network within a predetermined area. Usually, the scootersharing is a *one-way* system.
**Micromobility:**
A new trend for vehicle-sharing systems. It allows users to rent an electric kick scooter that weigh less than 500 kg. The systems can be *free-floating.*
**Vansharing:**
It works similar to a carsharing system but users can rent a light-duty vehicle instead of a passenger car.

## 3.2 Innovative shared mobility services: what they are and how they work

**RIDESHARING**

**Carpooling:**
Carpools typically involve travelers riding together to save on fuel and vehicle operating costs. Often used for commuting, carpools can be arranged between known or unknown parties (none as service provider) using personal vehicles.

**Ridesplitting:**
Taxi services or ridehailing services that allow creating a crew among several users who coordinate to share the journey also dynamically during the journey.

**Ridehailing:**
Similar to taxi and limos services with the particularity that drivers use personal vehicles. On-line platforms connect passengers with drivers.

**E-hail:**
Taxi and limos services through digital platforms and not just through physical or telephone channels.

**Microtransit:**
Most recently, IT-enabled private shuttle services have emerged that serve passengers using dynamically generated routes. Because they provide transit-like service but on a smaller, more flexible scale, these new services have been referred to as *Microtransit*. In general, they draw customers who are willing to pay somewhat more for greater comfort and service. The dynamic route-generating technology used by many of these services also has tremendous potential for transit and paratransit services.

**VEHICLESHARING**


**RIDESHARING**

## 3.3 Specific characteristics of the innovative shared mobility services

**Digital Platforms**

Technology is a necessary support especially for the innovative shared mobility services: websites and mobile apps are needed to enable the collaborative service model and make it useful, scalable and original. The digital platforms allow creating relationships and exchanges beyond the physical boundaries, in a faster and more effective way. All the new services of shared mobility pre-exist at the advent of Internet, the development of ITS and ICT and the most recent mass diffusion of the use of mobile devices such as Tablets and Smartphones. However, it is due to these innovations that some niche practices have started to impose themselves as forms of mass consumption. On the other hand, some consolidated business models have been distorted and have gained new market shares.

**Adaptive**

The new sharing mobility services offer transport options adaptive to the user needs. They are tailored to the needs of each customer and characterized by a strong flexibility in the use: for example, there are no timetables or pre-established routes.

**Interactive and collaborative**

Through the digital platform and the different channels used in the communication between shared mobility operators and users, the latter have the opportunity to use but also to create/modify service offered. The real-time interaction enabled by the platform also allows a continuous adaptability of the product to the customer needs. Moreover, in particular for the new shared mobility services, operators pay a special attention to include an element of "sociability" in the user's experience. It is a collaboration between peers in order to create a real social connection or simply an additional experiential and relational element in order to enrich the normal economic transactions between people.

On-Demand

Continuous

Scheduled

| Shared Modes | System | Sharing a Mobility Service | Enabled by Digital Platform | On-demand Service | Interaction and Cooperation | Unlocking Idle Capacity |
|---|---|---|---|---|---|---|
| Bikesharing | Low-Tech | ooo | o | ooo | o | oo |
| | IT Dock-based | ooo | oo | ooo | ooo | oo |
| | Free-floating | ooo | ooo | ooo | ooo | oo |
| Scootersharing | Free-floating | ooo | ooo | ooo | ooo | oo |
| Mopedsharing | Free-floating | ooo | ooo | ooo | ooo | oo |
| Carsharing/Vansharing | Station-based | ooo | oo | ooo | ooo | oo |
| | Free-floating | ooo | ooo | ooo | ooo | oo |
| | Peer-to-Peer | ooo | ooo | ooo | ooo | ooo |
| | Microcarsharing | ooo | ooo | ooo | ooo | ooo |
| E-Hail | | ooo | ooo | ooo | ooo | o |
| Ridehailing/TNC | | ooo | ooo | ooo | ooo | o |
| Ridesplitting | | ooo | ooo | ooo | ooo | ooo |
| Car&Vanpooling | | ooo | ooo | ooo | ooo | ooo |
| Shuttles | | ooo | o | ooo | o | o |
| Microtransit/Bus Responsive Network | | ooo | ooo | ooo | ooo | oo |
| Taxi | | ooo | o | ooo | o | o |
| Funicular/Public Elevator | | ooo | o | o | o | o |
| Public Escalator | | | | | | |
| Automated People Mover | | ooo | o | o | o | o |
| Cablecar | | ooo | o | o | o | o |
| Bus | | ooo | o | o | o | o |
| Bus Rapid Transit | | ooo | o | o | o | o |
| Tramway | | ooo | o | o | o | o |
| Light Railway | | ooo | o | o | o | o |
| Rail | | ooo | o | o | o | o |
| Urban Rail | | ooo | o | o | o | o |
| Metro | | ooo | o | o | o | o |

## 3.3 What are the key factors of shared mobility services?

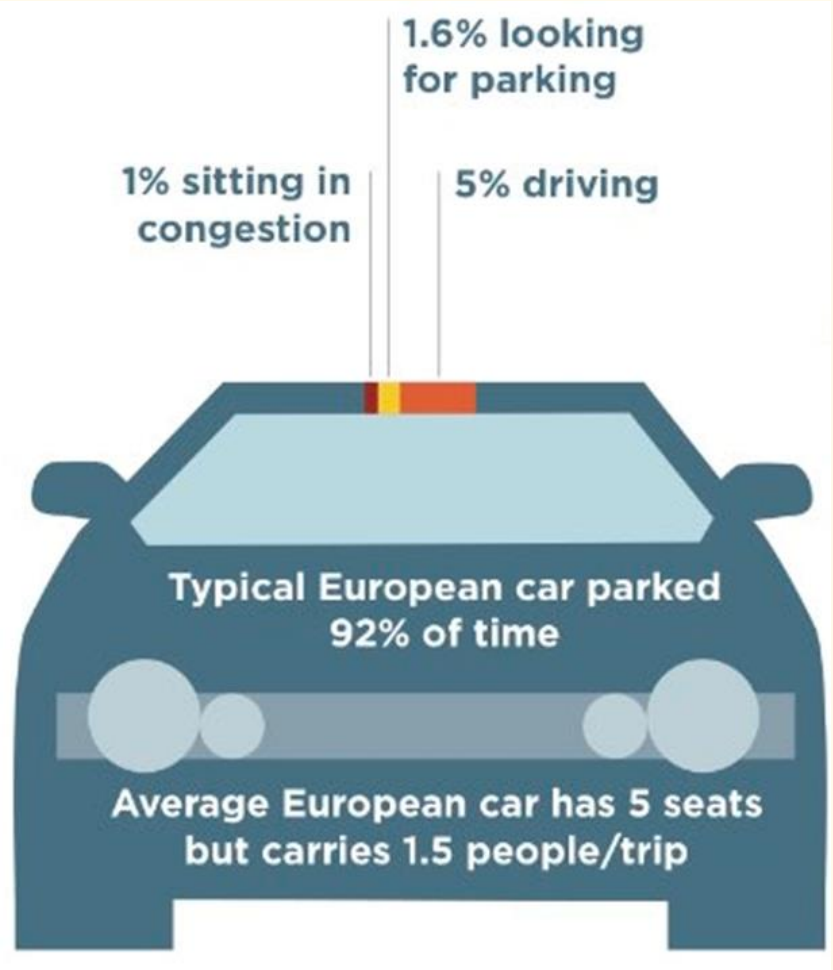
**Use of idle capacity**

In the current transport sector, whose center of gravity is still the use of personal vehicles, a large amount of idle capacity is locked. Among the shared mobility services characterized by the exploitation of residual capacity using digital platforms are:

- Ridesharing services such as carpooling;
- Vehiclesharing services (regardless of the means of transport used).

For the ridesharing services, the remaining capacity used is equal to the number of seats left free when only the driver uses the vehicle. In the case of Vehiclesharing services, the residual capacity used is equal to the transport capacity compared to the average of a vehicle not shared and used only by the owner in a given amount of time.

Other mobility services that do not include the possibility of personal use and ownership can nevertheless increase their level of use thanks to new organizational models and new digital technologies. Demand-based transport services, for example, can constantly optimize the route in order to collect more passengers along the route initially set.



# 4. Solutions for door-to-door journeys: a challenge for sustainability

## 4.1 The field of shared mobility becomes wider and stronger

The shared mobility services enabled by digital platforms emerged in recent years, making the field of mobility, intended as a shared service, richer in terms of both quantity and quality.

New shared mobility services, inconceivable until now, are launched and become established every year. In some cases, these are new business models applied to successful initiatives implemented in the last few years all around the globe, as for free-floating bikesharing. In other cases, these are services first established in specific urban areas then successfully spreading all around, as for the case of the so-called shared micro-mobility, supported by the availability of electric scooters. Then there are services foreseeing a great potential but not having yet an equally disruptive affirmation, such as the microtransit (also called DRT) or the peer-to-peer carsharing.

Alongside these innovations, recently introduced services such as ridehailing, carpooling and all vehicle sharing services that allow the sharing of cars, scooters and bicycles are consolidating and continue to grow.

The analysis of the performance of both traditional and innovative shared mobility services, shows that, while traditional services ensuring capacity, speed and range of action, continue to hold an irreplaceable position in the panorama of contemporary transport, shared mobility services based on Apps have those characteristics of accessibility, availability, flexibility and versatility typical of the model of use of the personal vehicles.

Thanks to the use of digital platforms, in fact, these services enable the sharing of vehicles designed for personal use, from which they inherit some key features. In the light of the potential transformations connected to the digital revolution, this aspect is crucial because it lends weight to the hypothesis that we are facing a new and imminent change of paradigm, as important as the one predicted by Le Corbusier.

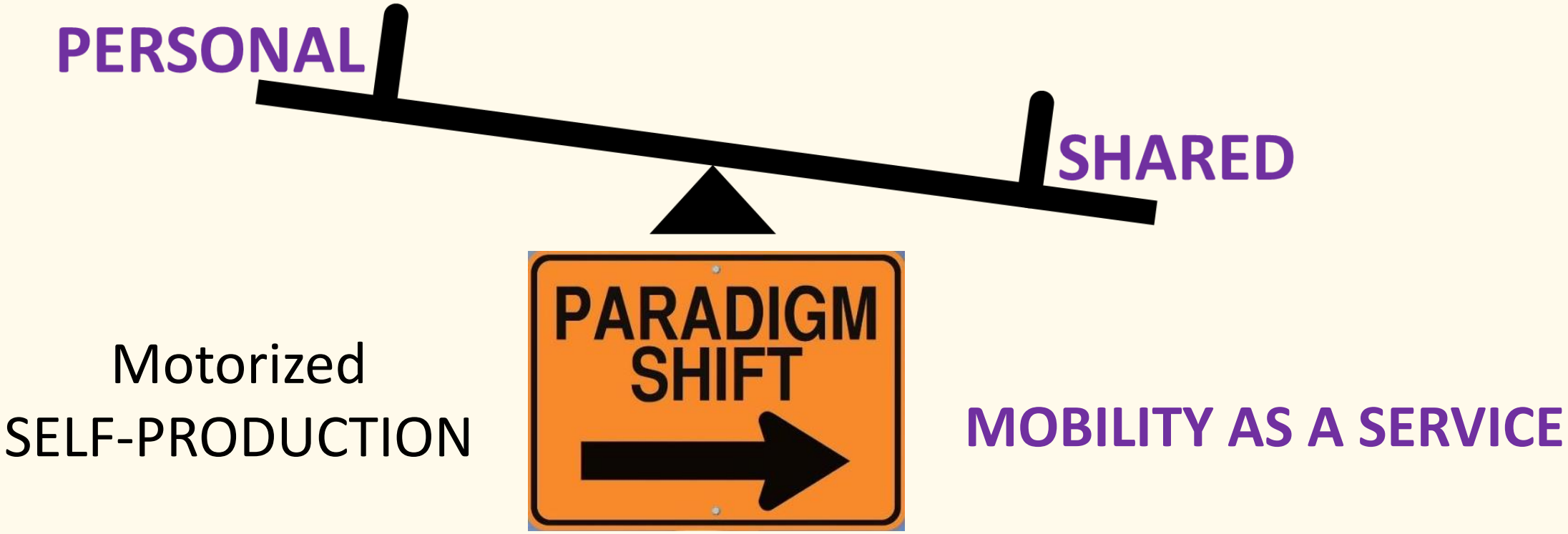
This is a new reversal that can challenge the primacy of individual mobility compared to the shared one, of self-produced mobility with respect to mobility as a service. A revolutionary innovation that could radically change the transport sector, and much more.

On-Demand

Continuous

Scheduled

| Shared Modes | System | Accessibility | | Transport Capacity | Operating range | Spatial characteristics | Action Area |
|---|---|---|---|---|---|---|---|
| | | Spatial | Temporal | | | | |
| Bikesharing | Low-Tech | oo | ooo | o | o | High-density | Urban |
| | IT Dock-based | oo | ooo | o | o | Hi-d | U |
| | Free-floating | ooo | ooo | o | o | Hi-d | U |
| Scootersharing | Free-floating | ooo | ooo | o | o | Hi-d | U |
| Mopedsharing | Free-floating | ooo | ooo | o | o | Hi-d | U |
| Carsharing/Vansharing | Station-based | oo | ooo | o | oo | Hi-d | U/Functional Area/Rural |
| | Free-floating | ooo | ooo | o | o | Hi-d | U |
| | Peer-to-Peer | ooo | ooo | o | ooo | Hi-d | U |
| | Microcarsharing | o | ooo | o | oo | Hi-d | U/Functional Area/Rural |
| E-Hail | | ooo | ooo | o | oo | Hi/Med-d | U |
| Ridehailing/TNC | | ooo | ooo | o | oo | Hi/Med-d | U/Functional Area |
| Ridesplitting | | ooo | ooo | o | oo | Hi/Med-d | U/Functional Area |
| Car&Vanpooling | | ooo | ooo | o | oo | Low-d | Functional area/Rural |
| Shuttles | | o | ooo | oo | oo | Low-d | Functional area/Rural |
| Microtransit/Bus Responsive Network | | ooo | ooo | oo | oo | Low-d | Functional area/Rural |
| Taxi | | ooo | ooo | o | oo | Hi-d | U |
| Funicular/Public Elevator | | o | o | oo | oo | Hi/Med-d | U |
| Public Escalator | | o | | oo | oo | Hi/Med-d | U |
| Automated People Mover | | o | o | oo | oo | Hi/Med-d | U |
| Cablecar | | o | o | oo | oo | Hi/Med-d | U |
| Bus | | o | o | oo | oo | Med/Low-d | U |
| Bus Rapid Transit | | o | o | ooo | oo | Hi-d | U |
| Tramway | | o | o | ooo | ooo | Hi-d | U |
| Light Railway | | o | o | ooo | ooo | Hi-d | U |
| Rail | | o | o | ooo | oooo | Hi/Med/Low-d | U/Functional Area/Rural |
| Urban Rail | | o | o | oooo | ooo | Hi/Med/Low-d | U/Functional Area |
| Metro | | o | o | oooo | oo | Hi-d | U |




**GOAL and TREND at the same time**

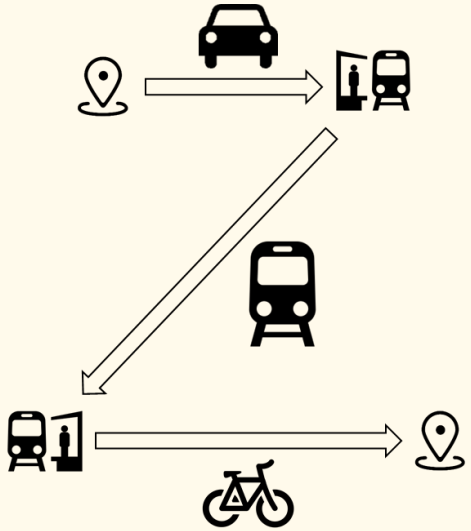
## 4.2 Intermodality and Multimodality

The number of innovative shared mobility services is growing and the performance of new services is complementary to those of traditional services. This creates new opportunities for integration, particularly in the context of the digital revolution which is still ongoing and whose effects are still all to be deciphered.
These new opportunities can be implemented according to two evolutionary lines, both related to the overall picture of the travel options, that grow in number, quality and possibility of integration thanks to the new technologies:

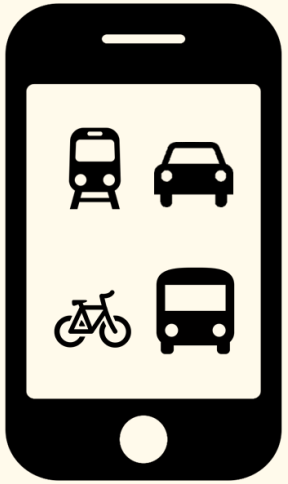
- to improve the overall quality of trips that combine multiple transport modes to move from door to door (Intermodality);
- to consolidate the habit of individuals to access, mainly, to mobility services by choosing the most suitable mode of transport for each specific journey (Multimodality).

In particular, Multimodality will be further encouraged by the market penetration of the so-called "bundles", or all-inclusive rate time/distance mobility services, like those proposed by the Whim platform, in Helsinki and London. These mobility packages offer many types of different mobility services (taxi, bus, metro, carpooling ...) to be consumed by users according to their needs, as it is the case of all-inclusive plans (data, text messages and voice) in the mobile phone sector.
Both these two evolutionary courses mutually support each other, leading to the same outcome: reducing the number of journeys made with personal vehicles and the overall rate of motorization of the population.
Of course, in this evolutionary process of transport, the railway sector is among key players and main beneficiaries. However, this report and this project focus on investigating the first level of development (intermodality), which is the one linked to the development of door-to door solutions analyzing opportunities for a shift to rail.

# Intermodality *and* Multimodality



**Focus Door-to-Door Project**



## Door-to-door solution

Increasing the attractiveness of Railway by improving all the stage of the travel chain that involves a railway journey -> **IMPROVING ACCESSIBILITY BY INTEGRATED SOLUTIONS**

New behaviors, Progressive reduction of car use / ownership, New mobility model based on shared services -> **BUILDING ACCESSIBILITY by MOBILITY AS A SERVICE**

## 4.3 Develop new opportunities

The development and widespread of digital technology represent a decisive innovation to increase the degree of intermodality and multimodality of transport systems, multiplying and creating new door-to-door solutions able to close the gap of preference between personal motorized mobility and shared mobility, in which the train plays a key role.

The question is whether there are the right conditions to build a multimodal and integrated mobility demand and supply, able to overcome - meaning both going beyond and being stronger - the individual mobility model, based on the use of personal motorized vehicle.

Today, old and new shared mobility services are able to intercept a demand for mobility that intends to progressively avoid using personal vehicles. This trend, observable in all advanced industrial societies, is destined to consolidate further. New technologies and new shared mobility models offer the concrete opportunity to "beat the opponent", the personal motorized car, on his elective field: comfort, pleasure, fun, economy, status.

Our daily experience has radically changed over the last ten years thanks to the use of digital platforms, the dematerialization of transactions, the phenomenon of "continuous connection" and "navigation", the transition from the primacy of binary relations to that of interactions, processes and networks.

This perception drives people to desire a way of moving in the physical reality that is increasingly closer to what happens in the virtual world. This means that individuals are increasingly more oriented towards using mobility services rather than producing one's own mobility, considering such approach closer to a contemporary lifestyle: it is better to travel by train, being able to read a book or texting to a friend in the meanwhile, rather than keeping hands fixed on the steering wheel looking the asphalt.

In order for a new behavioral approach to service accessing to prevail, it is necessary to consolidate a service supply meeting new needs and new desires.

Even if integration multiplies opportunities by raising the overall performance of shared mobility, a sufficiently large base of shared mobility services must still exist. This means choosing public policies pushing to expand and improve the supply of shared services and then to connect and integrate them. To this end, it is necessary to bet on change and to focus on policies able to pursue this goal.

First, in order to increase the demand for shared mobility as a whole, public transport services, the backbone of the mobility system, must grow and improve.

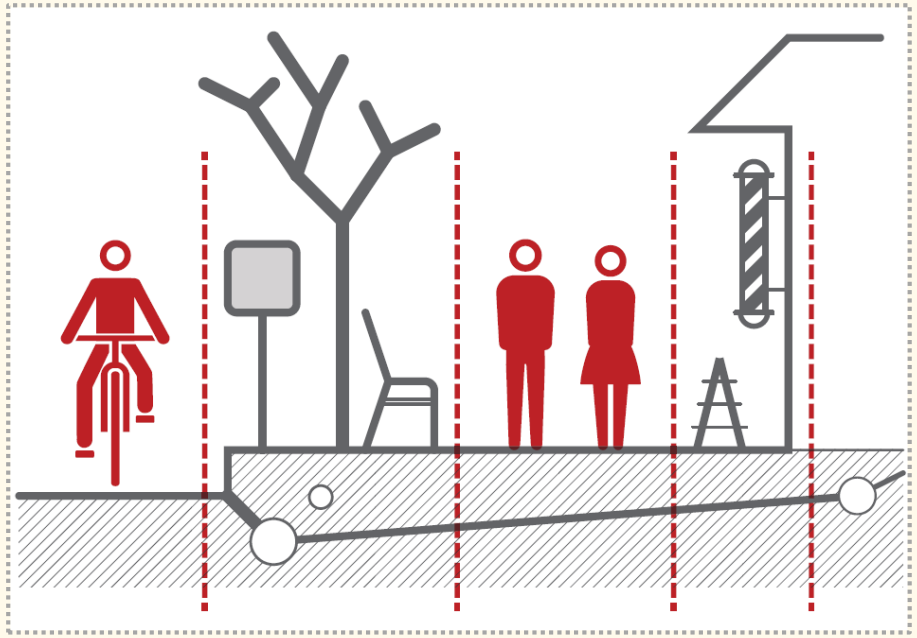
## 4.3 Develop new opportunities

The other fundamental elements of an expansion strategy in the use of shared mobility services are policies discouraging private mobility in urban areas, reducing, in general, the "public space" granted to private vehicles and the "regulatory space" that has been reserved to it until today.

Another essential aspect is the creation of an urban environment conducive to walking and biking and, more generally, planning the city, its development, the arrangement of functions in the territory and the design of space public sector favoring more sustainable modes of transport and access to shared mobility services.

Finally yet importantly, it is important to guarantee accessibility to people regardless of their status and their economic and social conditions. For this reason, it is important to reduce inequalities in the access to mobility services between the center and the suburban areas, between cities and non-urban areas, between people with higher and lower technological skills and between the youth and the elders.

In order to overturn the current paradigm of passenger transport, we need to believe in an intervention strategy that can effectively challenge the model of individual motorized mobility and push for an overall growth of the so-called ecosystem of shared mobility, in which the door-to-door railway solutions represent a very important cornerstone.



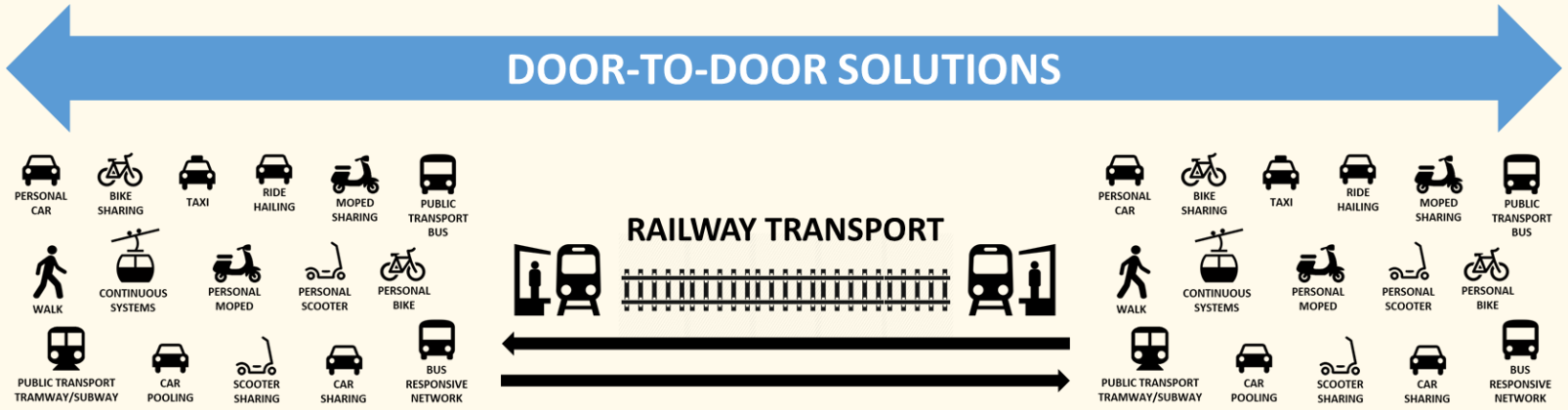
*To ensure the comfort and efficiency of non-motorized mobility as a means for transportation, the spaces needed for bicycle and pedestrian traffic must be designed.*

## 4.4 Definition of door-to-door solutions

By searching *door-to-door solutions* in the web, it emerges that the term is widely used for the logistic of goods, not necessarily transported by rail. In the railway sector, the term door-to-door solutions is often associated with customized travel solutions for people with disabilities, for which the physical limitation in starting and ending a journey by train autonomously, require a door-to-door transfer.
In this project, the term has the following meaning:

*"All the actions currently available for a railway company to offer its customers an INTEGRATED MOBILITY SERVICE that may start form the initial origin of the customer's movement and end at its final destination and INCLUDES THE RAILWAY TRANSPORT service among the travel solutions used during the entire journey."*

In more general terms, door-to-door solutions refer to all those transport modalities allowing a mobility provider to offer an integrated mobility service covering multiple modes and use models (the personal bicycle used to reach the departure station and the shared bicycle used to reach the final destination from the arrival station is an example of integration of the same mode, the bicycle, with two models of use).
These are mostly digital solutions considering how the theme of intermodality, as widely explained above, is as old as the railway itself. The interest of the study is therefore to focus on how digital platforms enable the adoption of new solutions in the physical-analogical dimension of intermodality.



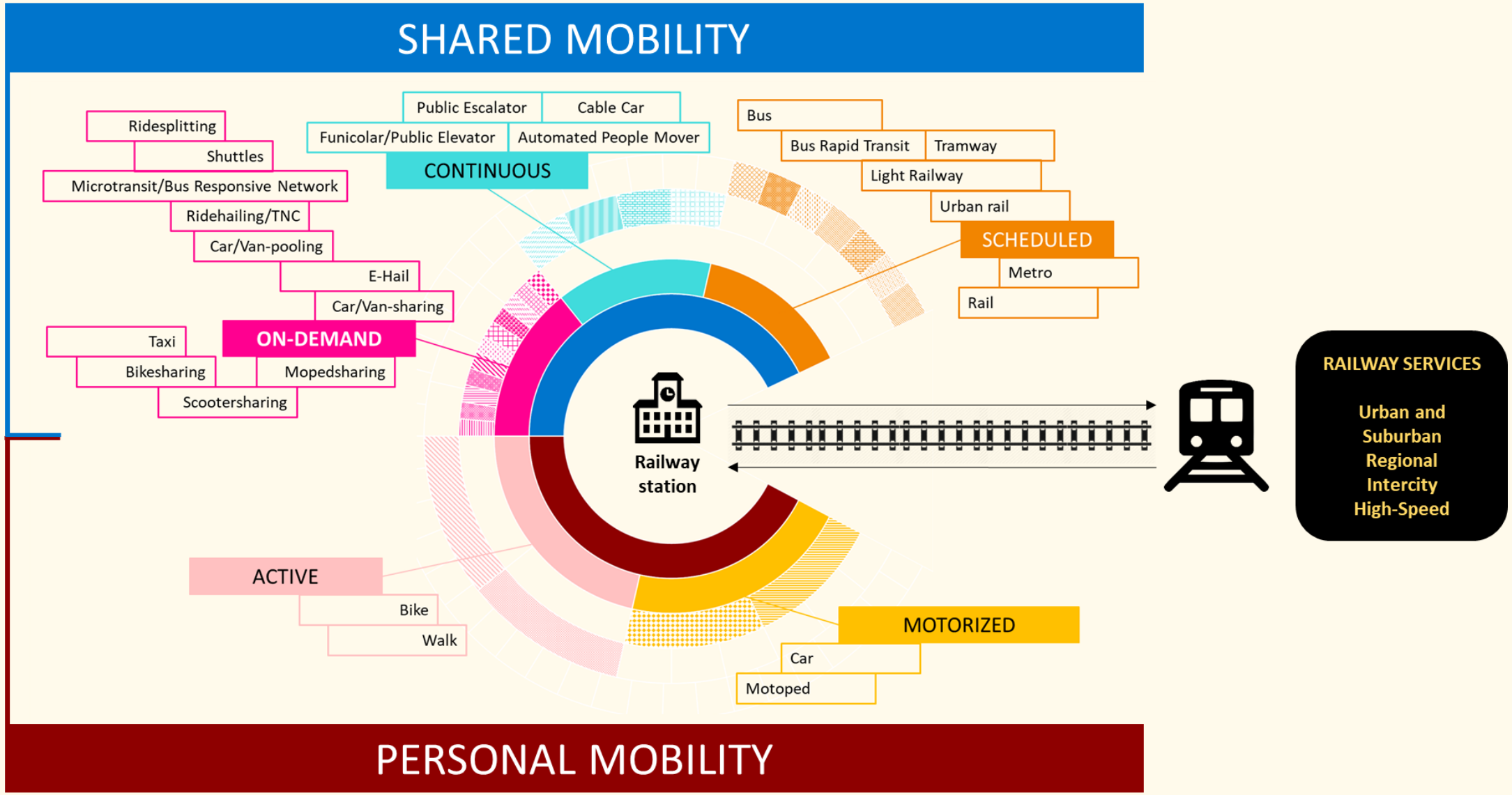
## 4.5 Goals to be achieved by door-to-door solutions

For railway companies, the goal of developing new innovative door-to-door solutions is a key driver to become competitive with respect to door-to-door travelling by a personal car. This means, for instance, providing users the opportunity to choose a single travel solution, although consisting of multiple elementary transfers, through a single easy-to-use interface for the purchase, payment, information flow and feedback collection.
However, being this field new and subject to continuous changes, it is difficult to restrict, a priori, the scope of this type of solutions.
Nevertheless, the goals to be achieved are unchanging and clear:

- promoting modal shift to railways;
- increasing railway accessibility;
- making stations the hubs of shared mobility;
- improving the interchange between railway and other modes of transport (in particular shared and non-motorized ones), whilst minimizing inefficiencies and, at the same time, increasing the perception of transfer continuity;

The figure in the following slide shows the whole ecosystem of shared mobility (services that are part of it) and personal mobility, both active and motorized, with the railway station as center of gravity and main point for any modal integration.

**Promote the shift to rail**
As part of the ASI strategy, the modal shift aims to reduce the impact of people and goods mobility by promoting the use of transport modalities with reduced specific impacts. The objective is to decrease the impact of that part of the transport demand that cannot be effectively reduced or avoided in other ways and must be satisfied through more sustainable modes that offer travel / displacement performances similar or comparable to those to be avoided. It is known that cars, trucks and airplanes are travel modes with higher specific impacts than rail, bus and subway, which, in turn, impact more than non-motorized modes, such as walking or cycling. The current percentage of use of the different travel modalities, the modal share, is the result of the choices that the demand makes compared to a diversified offer between various transfer and travel arrangements. Reshaping the balance between different modalities, therefore, means both offering alternative transport options and also changing the individual behavior.


SHARED MOBILITY
Ridesplitting
Shuttles
Microtransit/Bus Responsive Network
Ridehailing/TNC
Car/Van-pooling
E-Hail
Car/Van-sharing
ON-DEMAND
Taxi
Bikesharing
Mopedsharing
Scootersharing
Public Escalator
Cable Car
Funicolar/Public Elevator
Automated People Mover
CONTINUOUS
Bus
Bus Rapid Transit
Tramway
Light Railway
Urban rail
SCHEDULED
Metro
Rail
Railway station
RAILWAY SERVICES
Urban and
Suburban
Regional
Intercity
High-Speed
ACTIVE
Bike
Walk
MOTORIZED
Car
Motoped
PERSONAL MOBILITY

## 4.5 Goals to be achieved by the door-to-door solutions

**Stations as a mobility hub**

In the framework of the shared mobility services offer, the train will continue to play a major role as an alternative to the personal car based travel model, and in particular when considering medium-long distances or capillary and integrated rail services in the urban network. The results could be even greater, creating or strengthening interactions between the different railway services, in which intermodality always has an essential and strategic value, and the different components making up the total mobility offer. To do this the railway system should count on the diffusion of railway stations in the urban physical space, regaining, from this point of view, the centrality and the importance lost in the transition to personal cars based mobility.

Railway stations that become hubs of urban mobility, especially the shared one, offering easy access and seamlessly exchange of different modes of transport, are the key to increase passenger volume and mobility demand. Smart and low-impact railway stations, catalyze the offer of transport services and become the backbone of urban mobility, as well as safe and regenerated places to meet, work and stay. Many interventions can be adopted to make a better travel experience for passenger: good station design and wayfinding can significantly improve customers' perception of a transit system, as can amenities such as Wi-Fi, phone reception, platform screens, communication, shops and public art. Parking infrastructures for shared vehicles, drop-off areas for carpooling, special tariffs for intermodal passengers, these are only few examples of combination between different modes of transport to increase the railway accessibility and its weight in the multimodality offer.

**Increase the accessibility**

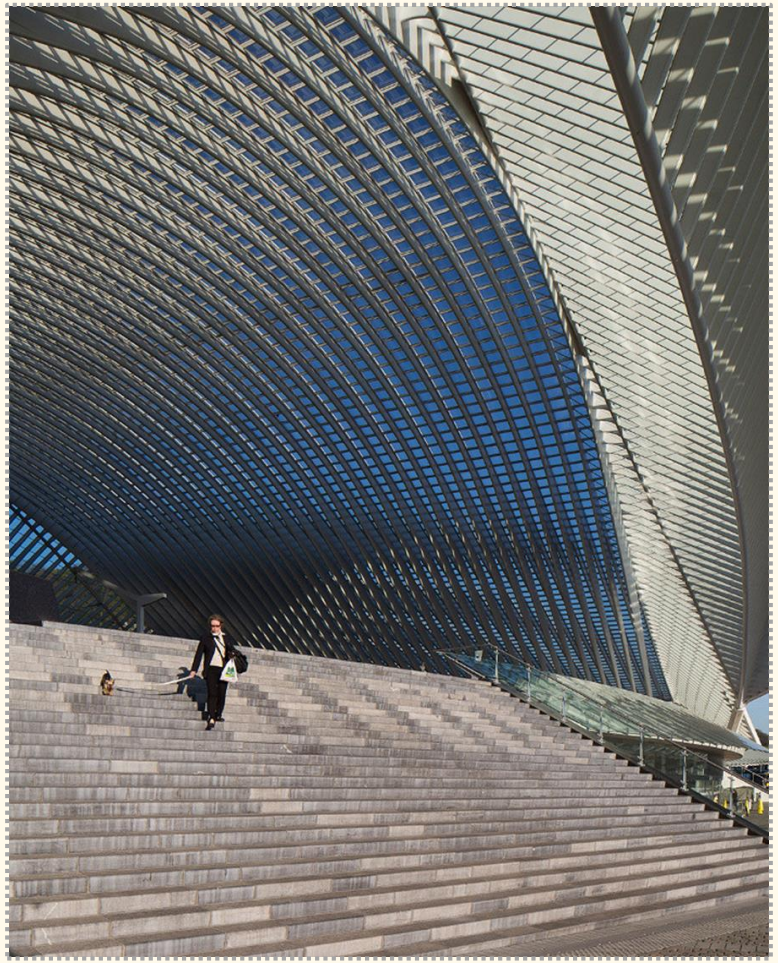
The accessibility of the railway service, as discussed at the beginning of this Report, is extremely limited. To give an order of magnitude of the importance of this topic in the railway sector, it is worth reminding that 29% of the Italian population is located within a radius of 1 km from a railway station and that this share rises to 73% if the distance grows only to 5 km. Of course, the Italian case is extreme, given the geographic conformation of the country, its high urbanization and the concentration of the population along main railway lines.

Nevertheless, increasing the attraction area of the stations, and consequently of the railway service, is extremely important for inducing the modal shift towards the railway. The accessibility of the railway through modal integration can concern the railway system itself (the harmonization between different types of railway service such as AV, Intercity, metropolitan trains, etc.) as well as the individual modes of transport that can be distinguished in motorized and active, through collaboration with other mobility services.

## 4.5 Goals to be achieved by the door-to-door solutions

**Seamless connection**

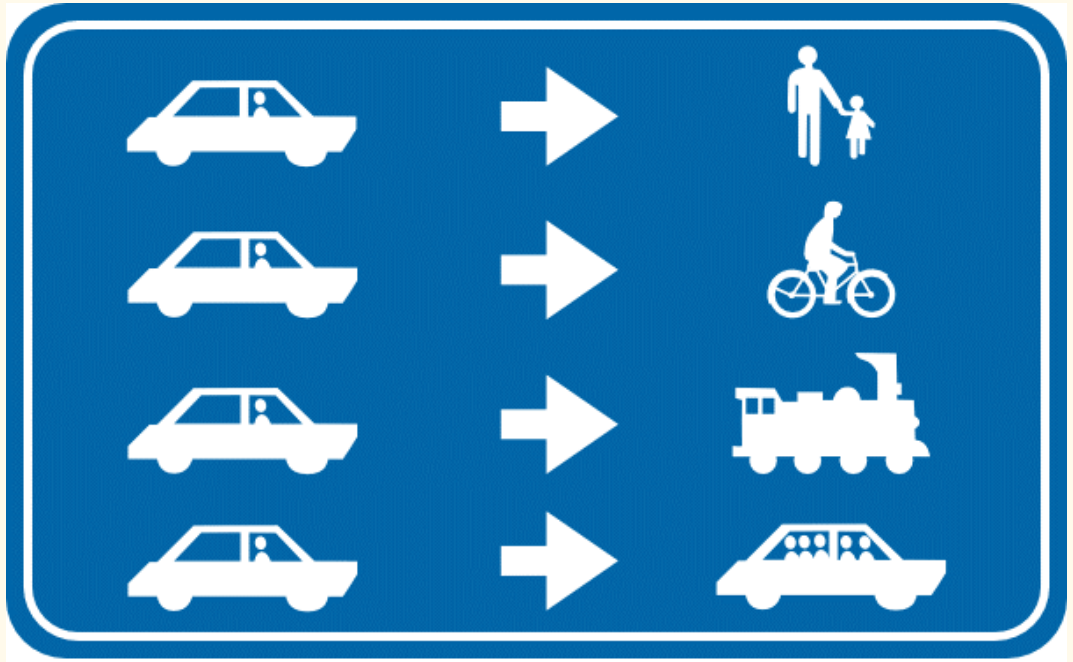
As discussed in the first part of this Report, in shared transport systems, such as railway, the journey begins and ends with a transfer on foot and always involves the progressive change of one or more modes of transport. This specificity is crucial. Physical and digital spaces accompanying this movements and the sequence of passages from one mode to another take place today mostly with strong discontinuities: of time (waiting for a mean or means of transport), of means (we go from one mean of transport to another), of space (we go from a physical environment with some characteristics to another), of rules (we go from one transport contract to another). What instead distinguishes personal motorized mobility is the perceived continuity of the movement. This specific perceptual feature, generally underestimated, is the key to the improve effectiveness of a transport system based on intermodality. The seamless movement perception must be related to the whole travel.



*Liège-Guillemins Station, Belgium - Architect: Santiago Calatrava*

# MODAL SHIFT

## FROM private car TO SHARED and/or NON-MOTORIZED Modes

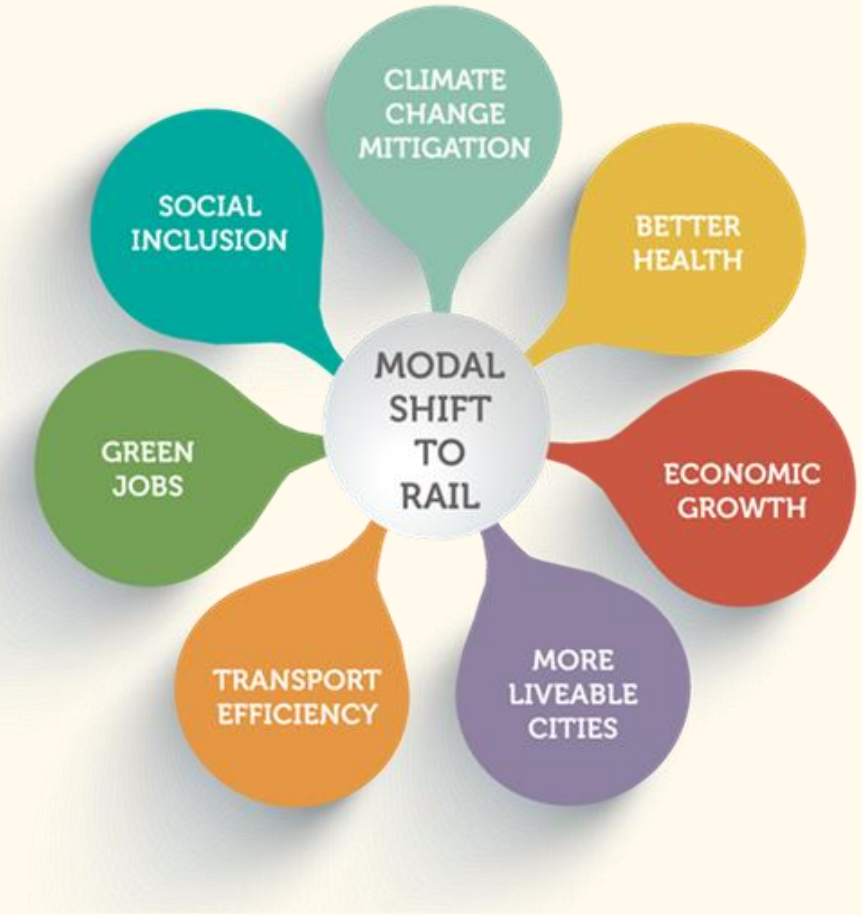


## 4.6 Environmental aspects of shift to rail

**Door-to-door solutions and modal shift**
The current transport system, based mainly on the use of vehicles powered with fossil fuels, generates unsustainable social, environmental and economic impacts. In order to overcome the structure of the current system, it is necessary to reach a real paradigm shift in the direction of making mobility of people and goods low carbon, socially inclusive and efficient in the use of resources. This overall vision must be combined with a holistic strategy based on three lines of intervention in the framework of the so-called Avoid / Shift / Improve (ASI) approach:

**Avoid** - Avoiding or reducing the need for travel, managing the total travel demand;
**Shift** - Shifting travels to more sustainable transport modes;
**Improve** - improving the sustainability of vehicles, fuels and infrastructures concerning all modes.

Modal shift to rail has multiple positive impacts, from an environmental, economic and social point of view. The challenge of green transport for railways is to reduce the specific impact on energy consumption or carbon emissions and to expand their market share to scale up this competitive advantage. Currently, the energy consumption and CO2 emissions of railways are substantially lower than other transport modes: therefore rail is the transport mode mobility has to be shifted towards.

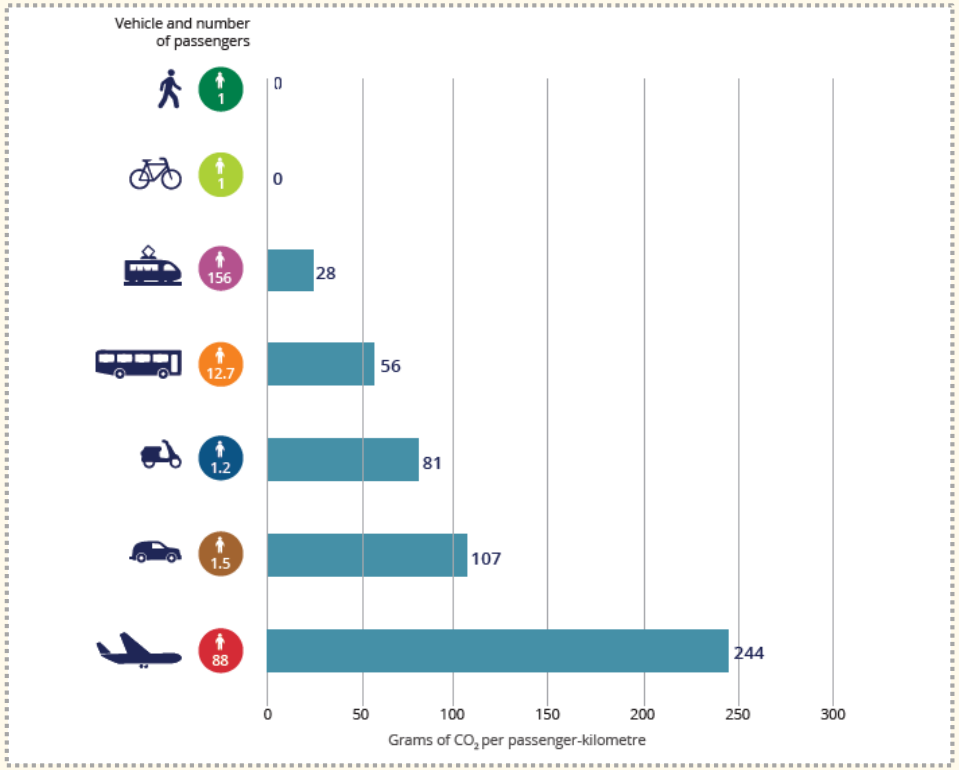


## 4.6 Environmental aspects of shift to rail: door-to-door and shift to rail

However, for this to happen, railway modes should become the backbone of every journey. It must be as convenient and straightforward as possible to make a door-to-door journey by combining railway, public transport, app-based shared mobility solutions, bicycle and pedestrian mobility. Making a door-to-door journey by railway means necessarily using the railway along with other modes of transport.

Traditionally, the different modes of transport are considered as separate industries, but this does not reflect what people really perceive when they plan a trip. When planning a commuting or long-distance journey, people consider the cost, convenience, and complexity of the entire door-to-door journey - not each single element of it. While more and more customers need to deal with integrated travel solutions, technology is definitely transforming the transport sector, enabling new mobility models. The ability to request, track and pay for travel on mobile devices is changing the way people move and interact with mobility services. Digitalization is the core of this revolution and we currently have new instruments to improve the entire door-to-door journey in order to encourage and enable more people to choose sustainable transport for the whole journey.

**Specific CO2 emissions at average occupancy for various transport modes, 2014**




*Source: Transitions towards a more sustainable mobility system, TERM 2016: Transport indicators tracking progress towards environmental targets in Europe, EEA, 2017*

## 4.6 Environmental aspects of shift to rail: door-to-door and shift to rail

The App-based shared mobility services, for example, as bikesharing, carpooling or carsharing allow using a personal vehicle, not owned and ideally shared with other people, and offer new travel solutions. These new modes increase the use of traditional shared modes as railways or public transit as the backbone of an integrated, multimodal transportation system.

For those who offer mobility services, such as railway companies, this new transport demand and this technical improvement is a great opportunity to expand their market share and play a key role in organizing and offering new multimodal services, while also, at the same time, pursuing sustainability goals.

Moreover, the real green challenge for railways is not only to reduce their specific impact on energy consumption or carbon emissions but also, in order to reduce the use of less sustainable modes, to expand their usage and, this way, promote a resource efficient, socially inclusive and low emissions transport system.

The digital revolution allows enlarging the offer of new shared mobility services and new opportunities for integration between different modes of transport, making the ecosystem of shared mobility scalable. The progressive increase in transport services offered to people living in this ecosystem leads to an increase in the use of shared mobility, whilst reducing the individual mobility. There are two possibilities for achieving this integration: intermodality and multimodality. Door-to-door solutions make the use of rail transport more attractive not just for a part of the trip, but for the entire door-to-door journey. They act along the strategic action line to improve intermodality. The goal is to make an intermodal door-to-door journey more attractive than a trip with a personal car.

Each time, thanks to an integrated travel solution, a door-to-door transfer otherwise carried out by a personal motorized vehicle is replaced in whole or in part by train, a certain social and environmental advantage is achieved. That’s because a passenger travel by rail is on average more sustainable than one by personal car. The advantage will be the product of the routes shifted by the car multiplied by the specific impacts of the railways compared to those of the personal car.

The most important challenge in evaluating the impact of modal shift is to understand if and how people would otherwise have traveled. This basic methodological problem is common to any evaluations of the modal shift. Digital solutions allow tracking movements made and the huge amount of information deriving from this, thus resulting in more solid evaluations than ever before.

## 4.6 Environmental aspects of shift to rail: door-to-door and shift to rail

The other challenge related to the evaluation of the effects of the modal shift is the correct identification of the specific impact factors related to the different modalities. Due to their recent introduction in the market and the lack of public data, there is no complete agreement about the impact reduction of some new shared mobility services. To date, for instance, there are no sufficient studies that can demonstrate incontrovertibly that car rentals or ridehailing reduce the use of personal cars altogether or does not replace that of other means of transport such as buses, train or the bicycle.

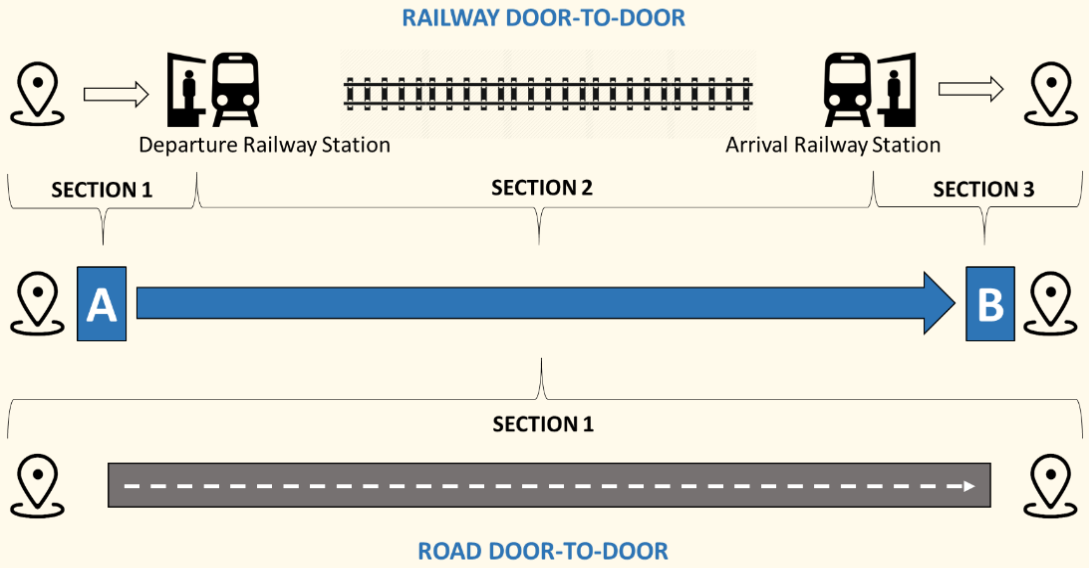
This theme, very complex and certainly more and more central in the years to come for the sustainability of transport, concerns only a small part of the door-to-door solutions analyzed in this project. Focusing the study on digital solutions that necessarily include greater use of the train compared to that of the car, makes the reference methodological framework easier.

**How door-to-door solutions reduce environmental impacts**

The lower impacts deriving from the adoption of door-to-door railway solutions, considering the use of train within a journey from the point of origin to the point of destination, as compared to door-to-door solutions with exclusive use of private car, are demonstrable from the specific emissions of the methods used.

Considering, for example, a journey from A to B, we assume that:

- in the case of the Railway door-to-door solution, among all the theoretical combinations, the origin/destination movement is divided in only 3 sections, and the middle one (section 2) is traveled using a train service;
- in the case of the Road door-to-door solution, the distance from the origin to the destination is traveled seamless and only using a personal motorized vehicle (only one section).



## 4.6 Environmental aspects of shift to rail: door-to-door and shift to rail

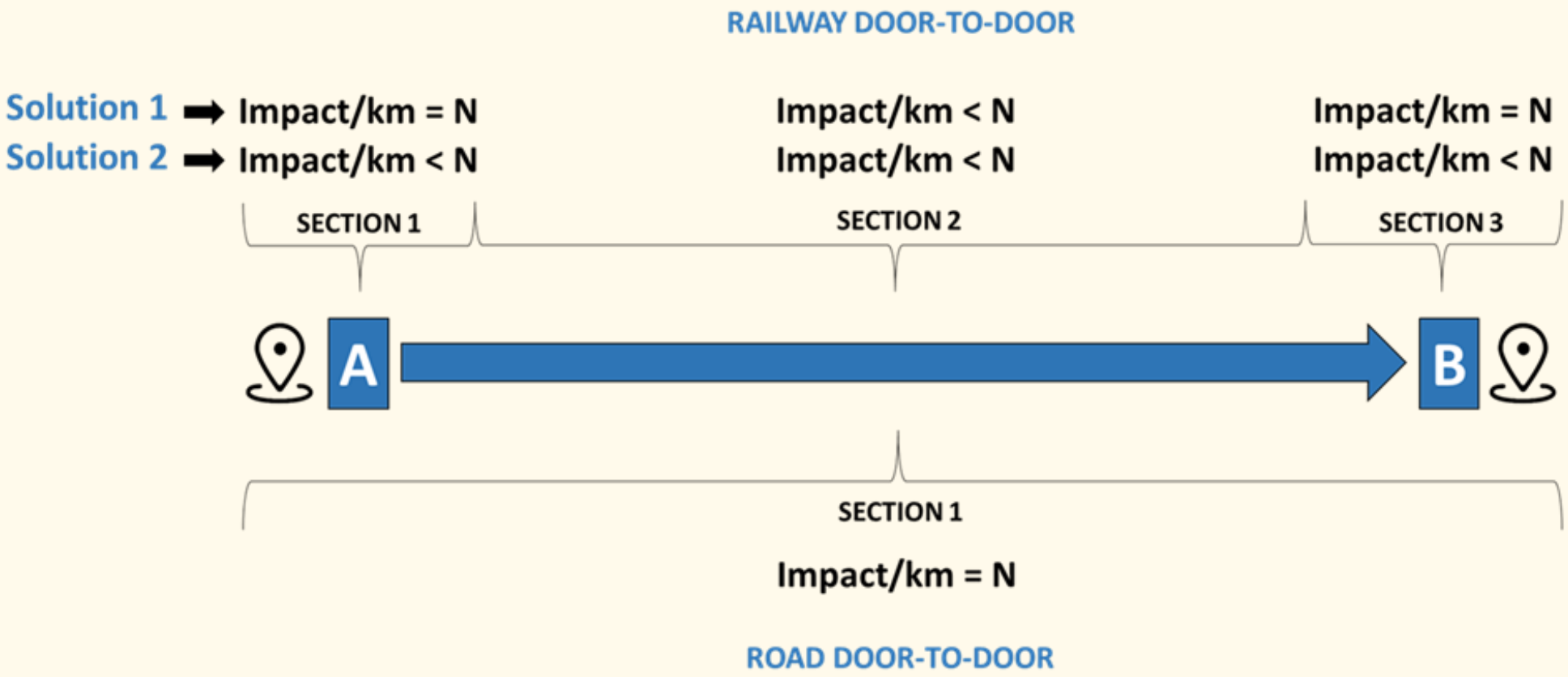
In the case of an intermodal journey including the train, starting from the diagram in the previous slide, there are several possible mobility solutions available for both section 1 and 3, either shared or personal mobility solutions (see slide 63 for a detailed list):

- Shared on-demand
- Shared continuous
- Shared scheduled
- Personal motorized
- Personal active (bike and walking)

Each solution has a different impact coefficient, including different aspects related to environmental sustainability such as air pollution, GHG emissions, congestion, land use, noise, and accidents. Considering this, the impact coefficients of the various solutions will be included from the minimum value of the pedestrian and cycle mode to the maximum value of the fossil-fueled personal car. For the purposes of this study, the Ecopassenger methodology is taken as a reference, considering the impacts of passenger transport (emissions of $CO_2$, NOx, PM, NMVOC and energy consumption) according to a well-to-wheel approach that does not consider the impacts related to construction and decommissioning phases of vehicles and infrastructures. It is therefore necessary to specify that this methodological approach does not take into account the impact on the construction, use and disposal of technological equipment functional to the use of digital door-to-door solutions.

From the point of view of the adopted methodological approach, referring to the figure in the next slide, even the worst possible combination of a Railway door-to-door solution to carry out the A-B movement in terms of specific impact in the three sections (motorized personal vehicle -> Railway -> motorized personal vehicle) has a smaller impact than just using a personal motorized vehicle, thanks to the lower train coefficient in the central section (solution 1).

The impact could be even lower adopting shared mobility or cycling / pedestrian solutions in sections 1 and 3 within a railway door-to-door solution, thanks to the lower specific impacts in all three sections in which it breaks down the journey from A to B (solution 2).


RAILWAY DOOR-TO-DOOR
Solution 1 ➡ Impact/km = N
Impact/km < N
Impact/km = N
Solution 2 ➡ Impact/km < N
Impact/km < N
Impact/km < N
SECTION 1
SECTION 2
SECTION 3
A
B
SECTION 1
Impact/km = N
ROAD DOOR-TO-DOOR

## 4.6 Environmental aspects of shift to rail: door-to-door and shift to rail

**Impacts of digital technology**

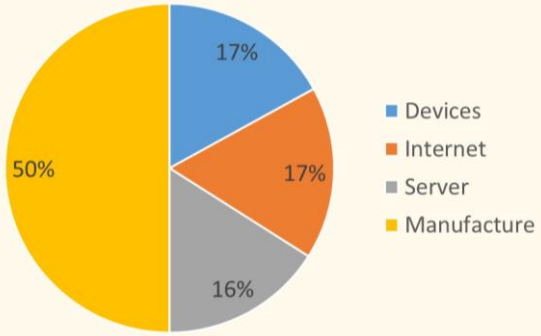
The ever increasing of computing power and data processed, as what happened during the Industrial Revolution in the 19th century, extends the productive forces of human societies which pay a cost in terms of natural resources depletion and overall deterioration of their habitat.

Handling digital material, not perceptible because of its nature, needs server and hardware systems production, and therefore raw materials, energy and processes of manufacturing and dismantling. Although nowadays the digital is present in every aspect of human life, attempts to determine its environmental impacts are still limited, also due to its speed of change and its widespread at global scale.

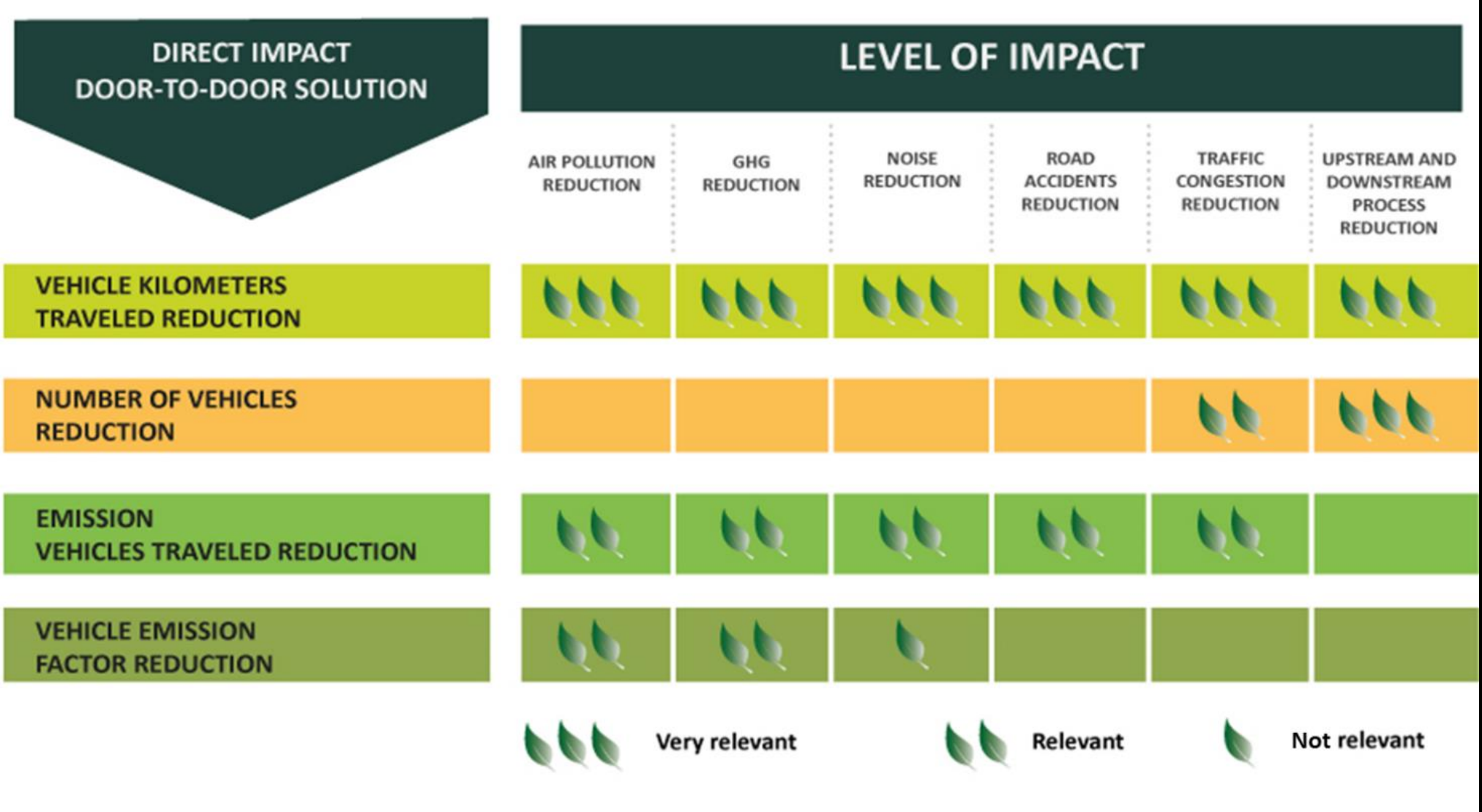
According to the report "Lean ICT - pour une sobriété numérique" by The Shift Project, for example, the growth in energy consumption for digital use is equal to an average annual rate of 8.5% in the last 5 years. Also the share of total energy consumption at the global level should continue to increase, with an exponential curve identified in the worst case scenario, from the current 20% to 50% in 2030. The digital energy consumption, and therefore the negative impacts in terms of greenhouse gas emissions, is concentrated for about 50% in the production phase of technological supports. At this regard, it is important to bring the attention to the critical issues concerning the raw materials production: metals and rare earths in nature, whose scarcity could condition the development and resilience of a strongly digitized society. It is also important to consider that raw elements have a strong environmental impact in their extraction and disposal phase, in terms of emissions of greenhouse gases and soil pollution.

It is necessary to underline that, looking at the sustainability, the great potential offered by innovative digital door-to-door solutions to increase the rail modal share is not for free. On the contrary, important issues still remain open, in particular observing the entire life cycle of products and services. Anyway, issues that are not less challenging than those that remain open looking at the current model of transport based on private cars fueled by fossil fuels.

**Global energy consumption for digital technology, 2017**




*Source: The Shift Project*


DIRECT IMPACT
DOOR-TO-DOOR SOLUTION
LEVEL OF IMPACT
AIR POLLUTION REDUCTION
GHG REDUCTION
NOISE REDUCTION
ROAD ACCIDENTS REDUCTION
TRAFFIC CONGESTION REDUCTION
UPSTREAM AND DOWNSTREAM PROCESS REDUCTION
VEHICLE KILOMETERS TRAVELED REDUCTION
NUMBER OF VEHICLES REDUCTION
EMISSION VEHICLES TRAVELED REDUCTION
VEHICLE EMISSION FACTOR REDUCTION
Very relevant
Relevant
Not relevant

## 4.6 Environmental aspects of shift to rail: door-to-door and shift to rail

The increase of railway modal share has direct and indirect positive environmental effects on the transport sector. Therefore, it is possible to say that door-to-door solutions represent a real eco-innovation for railways.

In recent years, the eco-innovation concept has evolved towards a more inclusive view, encompassing "*any form of innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment, enhancing resilience to environmental pressures, or achieving a more efficient and responsible use of natural resource*", as reported in the Eco-innovation Action Plan (Eco-AP) by the EU Commission.

This ground-breaking definition, in addition to referring to sustainable development as the goal of eco-innovations, focusses on both the environmental aims and the environmental performances of the eco-innovation, the environmental benefits of its use being the core interest. In this sense, eco-innovation may embrace both "environmentally motivated innovations", which are intentionally designed to reduce the environmental impact of production and consumption activities, and "unintended environmental innovations", intended as innovations which may produce environmental gains as a cost-free side-effect of other goals, such as reducing production costs or reducing energy consumption during use.

Accordingly, eco-innovation can be understood and analyzed along three main dimensions. First, the target, which is the basic focus area to which eco-innovations applies (products, processes, marketing methods, organizations, and institutions); second, the mechanism, which is how changes in the target areas are made (modification, re-design, alternatives, creation); third, the impact, which is how the eco-innovation affects environmental conditions across its lifecycle.

Of course, the three dimensions are interrelated and the potential environmental benefits maximization depends on how eco-innovation targets and mechanisms interact, and it is widely acknowledged that radical and systemic changes generally have higher potential benefits than incremental modifications.

# 5. Areas of intervention, strategies and business models more promising for the future

## 5.1 Areas of intervention

The basic objective of developing new door-to-door solutions is to improve the interface between railways and other modes of transport (particularly those that are shared and not motorized), to achieve seamless mobility, to make stations the vibrant hubs of shared mobility, to increase railway accessibility and, ultimately, to facilitate modal shift to the railway.

According to the preliminary analysis carried out on the development of current best practices in the transport sector, some of the main areas of intervention on which railways can concentrate their efforts in the field of door-to-door solutions have been identified:

**Connection** - Regular and straightforward mobility services connections at all stages of the journey and between different modes of transport;

**Facilities** - Safe, comfortable and green transport facilities (e.g. EV charging points, Bike and Scooter Parking etc.);

**Information** - accurate, accessible and reliable information about the different transport options for integrated journeys (and related IT tools: journey planners, aggregators etc.), even during the journey to overcome unexpected troubles

**Ticketing** - Convenient and affordable tickets (or payment methods), for an entire journey;

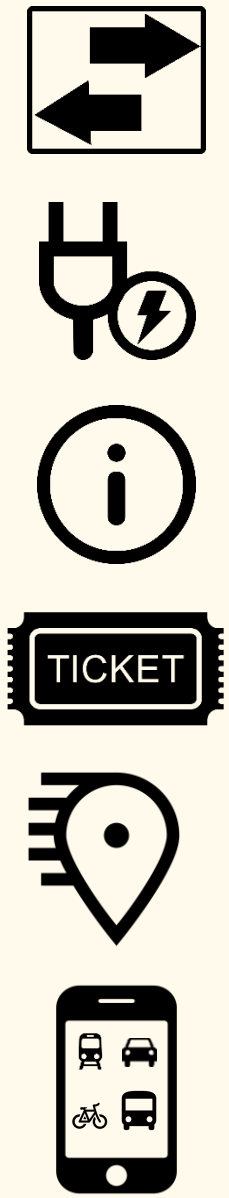
**Tracking** - Acquisition, selection and tracking of integrated movements and customers feedback to feed predictive algorithms, profile users and continuously adapt mobility services to customer needs

**MaaS** - building Apps combining each transport modes supporting multi-modal, leveling the playing field by integrating other mobility players, facilitating trips through deeper integrations.

**Connections**

The increase in accessibility of the railway is achieved through modal integration with both the individual transport modes - which can be distinguished in motorized and active - and with other shared mobility services. The integration also concerns the railway system itself, when different types of railway service such as AV, Intercity, metropolitan trains etc. are planned to fit together efficiently. The crucial aspect of the increase of railway accessibility through a better and increased offer of railway services and its coordination with other services supplied by other mobility providers will not be analyzed in the Door-to-Door Project. However, this aspect represents the main condition for every digital integration solution, which cannot be separated from existing physical reality.

# Connection
# Facilities
# Information
# Ticketing
# Tracking
# MaaS (Mobility as a Service)



## 5.1 Areas of intervention

**Enhancing transport facilities**

Safe, comfortable and easily accessible transport facilities to meet the passengers' needs means to deliver high-quality stations and interchange facilities. For railways, the goal is to make the stations evolve from a closed to an open model characterized by an increased interaction between city and station, enhanced permeability and functional mixity. Railway stations will be more and more a mobility hub linked to a global network but at the same time an urban square and a commercial and business hub.

EV charging infrastructures in railway stations are a way to develop synergies between shared mobility and electric mobility EVs charged, further rising railway accessibility.

The mobility model based on vehiclesharing - both on the demand side and on the supply side - allows, already today, to overcome the main obstacles electrification is currently facing.

Those who use a shared electric vehicle - be it a scooter, a car (either a shared car or a taxi) or a bus - are not interested in the problems of autonomy of the EVs or the recharging times. Taking care of these aspects is the task of the mobility provider. Moreover, those who offer shared mobility services on the market, in turn, have a competitive advantage over those who self-produce their own journey. The economic advantage of using an electric vehicle increases proportionally with the increase in annual vehicle mileage and the shared vehicles are used more intensively than vehicles used by single households.

Moreover, carsharing operators could gain additional income from the provision of vehicle-to-grid services: a grid with a high proportion of renewable energy sources and fluctuating energy production, the load can be stabilized by the storage, feeding and charging of electricity from EVs.

**Travel Information**

As demand for mobility grows, so does the market offering mobility services which, in addition to traditional public-transit, train, bus, taxi, car rental and plane, already account for a wide variety of service alternatives including vehiclesharing and pooling (cars and van, scooters, bikes) promoted / offered by several market players. In this context, a step ahead to make the offer of mobility more coherent with consumer's needs, consists in gathering digital data about different typologies of modal transits to be integrated into a database and organize them into a smart source of information useful to plan multimodal door-to-door journeys.

## 5.1 Areas of intervention

This is done by Journey Planners (JPs), a technology that enables users to plan multimodal journeys according to their habits and preferences, which may concern modal affordability, price, duration, environmental impact, etc..

The offer of JPs in the market is already quite large, however products are not homogeneous in terms of transport multimodality, equipped features and service coverage.

Most of the available JPs, refer to urban areas and the surroundings. They can be divided in two categories:

- JP solutions offered by local transport companies to guide their customers in the public-transit multimodal solutions offer;
- JP solutions offered by private operators which, to different extents, integrate public-transit information with information/data related to other mobility modal services such as sharing and pooling vehicles.

In most cases, JPs features are limited to only show multimodal alternatives for a well specified route - from street A to street B - with additional information about public-transit timetable, waiting time for the next arrival at a specified stop, availability of shared cars or bikes in the neighborhood of the user's position. Among these JPs proposals, the most advanced versions include environmental impact information about multimodal travel-solution choices, while just a few have implemented a gamification proposal.

Mobile trip planning apps may play a crucial role in the provision of the information that is needed to plan trips, especially multimodal trips or trips involving shared mobility. Such apps can trigger the use of shared mobility, but also improve the competitive position of public transport by providing real time information and allowing for electronic ticketing.

**Smart and integrated ticketing**

Regardless of the technology used, payment systems for mobility aim to offer the following three opportunities:

- users can travel without buying multiple tickets in advance;
- users can prove his regularity during the trip, even before any charge;
- users can later be charged the most convenient fee based on trip type and user profile. In addition, discounts, automatic subscriptions and promotions, or highly specialized service packages from a business point of view can be applied, and marketing opportunities that are still missing in the mobility market can therefore be realized.

In addition to a user-friendly way to buy tickets, payments can measure the amount of service actually used during the trip, reducing people who are not paying.

## 5.1 Areas of intervention

**Tracking**

The essential information today is the analysis of displacements. Knowing the day-to-day practices of citizen mobility is essential to enable mobility providers to act and decide better. Today, the Household Travel Survey is the reference tool at the local level for measuring and quantifying mobility practices. Due to the cost of implementation, these surveys take place on average every 5-10 years. In addition, the information lacks continuity and precision in the most important scales.

Digital technology makes possible to produce this knowledge in many different ways, especially software, to improve the production of useful and shared resources mobility data. These new tools allow to dynamically report on mobility behaviors in a territory. The acquisition, selection and tracking of integrated movements and customers feedback are essentials to feed predictive algorithms, profile users and continuously adapt mobility services to customer needs.

**MaaS**

The full commercial integration between different mobility services, with full interoperability of their payment systems, is realized today through the MaaS platforms (Mobility as a Service). With such systems, consumers can buy mobility services provided by the same or different operators. The platform provides an intermodal journey planner (...), a booking system, a single payment method, and real time information.

There are already many positive examples of integrated transportation network platforms, which offer on demand ride services including public transport, taxi, carsharing and bikesharing. The biggest advocates for private MaaS platforms, like Whim for example, are often national and local governments who envision a simplified commuter experience that nudges constituents away from using a personal vehicle.

| AREAS OF INTERVENTION | Railway Undertaking | Infrastructure Manager - Station Manager |
|---|---|---|
| Connection | OO | OOO |
| Facilities | O | OOO |
| Information | OOO | OO |
| Ticketing | OOO | O |
| Tracking | OOO | OO |
| MaaS | OOO | O |

## 5.2 Strategies and business models

Door-to-door solutions and seamless mobility represent a great opportunity for railways, called to deploy strategies to deal with a mobility service market with new actors and probably new power relations between them. A system that becomes more complex requires innovative approaches to cooperate with other companies and sectors.
We propose a first collection of the main strategies railway companies might implement in the future:

**Wait & See**
Focusing on Railway core business, maximizing the accessibility of rail transport in itself.
**Vertical Integration**
Taking over other Mobility Service Providers and integrating them within company boundaries.
**New Deal**
Leading Horizontal Integration through agreements between different mobility service providers.
**Public benefits via open data**
Promoting open digital infrastructure to enhance a competitive and vibrant mobility market. Work together instead of against each other.

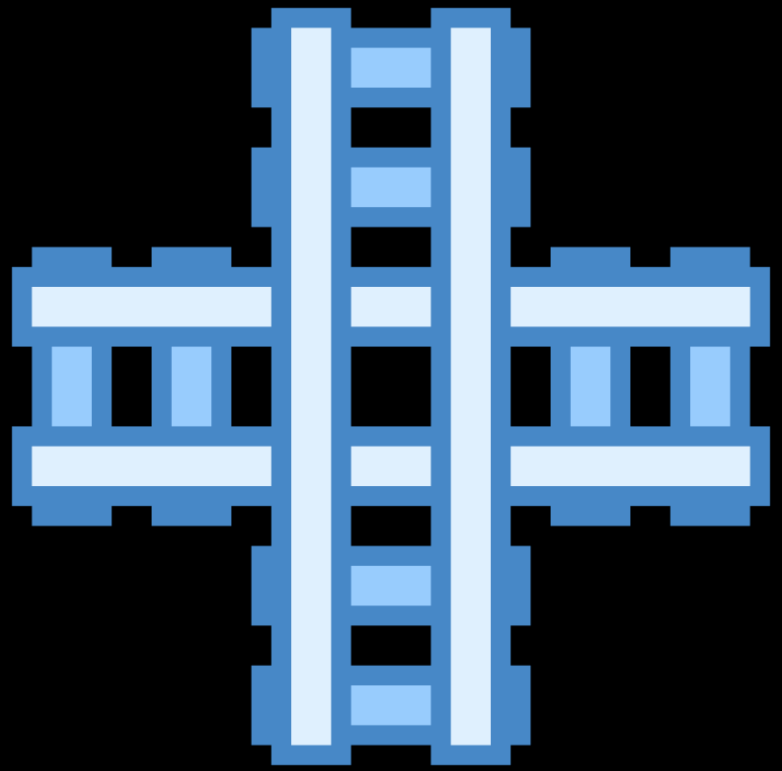
In order to develop a strategy fitting for railway companies business while scaling up the ecosystem of shared mobility, it is essential to consider all shared mobility services as a whole. The integration of shared services of all types, from both a spatial and temporal point of view, is a key aspect for both producing efficient services and having less cars on the road. Only the overall growth of the shared mobility ecosystem is able to pursue the goal of a mobility efficient in resource consumption, low emissions and social inclusivity.
Even today, it is commonly agreed that App based shared mobility services such as carsharing and bikesharing or carpooling, are a kind of hybrid mobility, between public transport system and personal mobility. Many public transport companies and governmental bodies perceive these new forms of mobility services as a competitor of traditional shared services, able to erode their market shares, rather than personal cars. On the other hand, the new digital actors, often private start-ups, fear any kind of service integration as the first step to losing autonomy, dynamism, and to lose the direct relationship with their customers.
Both perceptions can be true but, in a sustainability perspective, both of them miss the crucial point. Shared mobility services based on small vehicles (bikes, scooters, cars and vans) are not able to replace unnecessary or outdated trains, subways, trams or bus services.

## 5.2 Strategies and business models

On the other hand, the new digital actors, often private start-ups, fear any kind of service integration as the first step to losing autonomy, dynamism, and to lose the direct relationship with their customers.
Both perceptions can be true but, in a sustainability perspective, both of them miss the crucial point. Shared mobility services based on small vehicles (bikes, scooters, cars and vans) are not able to replace unnecessary or outdated trains, subways, trams or bus services. On the other hand, as deeply explained in the first chapter of this preparatory study, traditional shared mobility service needs to cope with other means of transport that harness the strengths of new shared mobility solutions to solve the 'first/last' mile problem.
In order to better understand this point, the simulations carried out in the last three years by the International Transport Forum are extremely useful. ITF carried out a series of simulations on three cities in the world - Lisbon, Helsinki and Auckland - with the aim of verifying what would happen if the entire motorized road traffic in these cities were replaced by a large-scale deployment of shared vehicle fleets providing on-demand transport combined with rail and metro services still operating. The results of these studies, presented at the first Door-to-Door Project workshop in Warsaw on November 15, 2018, show that the most efficient combination of services is the one where every mean of transport (or mobility service) does its best. Therefore, railways (and other rapid mass transit means of transport as metro, light rail, or bus rapid transit systems) will probably increasingly concentrate on the task where they have the biggest competitive advantage: moving significant quantities of people from one transport hub to the other.
Railway companies, often under state control, can actively support innovation and new businesses linked with sustainable pathways in transport, but also through creating ways for effective collaboration between traditional public transport services and new mobility services, opening-up information on schedules and other characteristics, and leading to rise new synergies throughout the whole mobility system.

# Public Benefits via Open Data

Vertical Integration



Wait and See

New Deal

## 5.3 The role of public policies

In conclusion, it should be noted that the success of rail door-to-door solutions based on a new shared transport ecosystem partly depends on the role that national and local institutions will decide to play in this game.
Designing seamless mobility challenging the primacy of personal cars requires a strong commitment from policy makers and mobility operators, both traditional and innovative. It could not be otherwise considering the inseparable link existing between space and movement of people, and therefore between those managing public space and those organizing, in any form, the movement of people within such space.
Development of cities, urban space planning, regulations and service standards, are just some of the tools available for policy makers in order to shape the physical space and determine a change in the mobility needs of people. From this point of view, the regulatory framework is crucial, both on a national and local scale, to outline the field and the possibilities for each player to influence the results.
The following are just some of the main actions on which public policies should focus on in order to foster a positive revolution in today's transport sector:

- Devoting public spaces to enhance integration between traditional and innovative shared mobility systems;
- Implementing new interpretations of the Traffic Laws in order to limit the undisputed dominance of personal cars;
- Creating sustainable mobility hubs to facilitate intermodality between different shared transport modes;
- Increasing the accessibility of places, ensuring personal safety and mobility of the vulnerable population.

Regulatory schemes are an important aspect of the issue, similarly to the definition of incentives intended to change the paradigm described in the previous paragraphs.
Employing part of public finances in direct incentives for shared mobility, intermodality and multimodality, means investing money to change cities in depth, towards a great social, economic and environmental improve.
The transition towards shared and more sustainable forms of mobility cannot be implemented without adequate investments in infrastructures, both physical and digital.
An example of this concept is that the creation of an urban bike lane network, functional to the door-to-door railway movement, and the enhancement of the internet network to exchange information through MaaS platforms are necessary but sufficient conditions to increase the use of trains as an alternative to personal cars.

## 5.3 The role of public policies

An urban planning completely designed around the use of personal cars over the 20th century explains the request to local and national institutions to modify and improve the physical and digital space today, especially because, in many cases, neither the rail operator nor any mobility operators can take positive actions in this field.
As already explained, the success of the railway door-to-door solutions requires a change of paradigm in the transport system. This change will depend not only on the ability of the different shared mobility operators to create synergies and solutions to face the demand of transport, but also on the affirmation of a new way of designing the urban space with mobility of people at the center and not that of vehicles.

*Hauptbahnhof, Berlin - Architect: Gerkan, Marg and Partners Architects*

# 6. Next Steps

## 6.1 Next steps

The collection and analysis of good practices and best experiences on seamless railway mobility is a critical part of the UIC Door-to-Door Solutions Project. The second stage of the project, the engagement phase, aims to identify the most important door-to-door railway solutions taking into account their technological innovation and synergy with innovative and traditional shared mobility services, focusing especially on operational models, economic sustainability and results in terms of modal shift and increased railway production.

Four tools will be used in order to achieve the goals envisaged in the engagement phase: UIC workshops, desk analysis, structured interviews and questionnaires.

The workshops will be the most important tool in this stage, creating relations between stakeholders, both inside and outside the railway sector.

They will be organized throughout 2019, with the objective of disseminating best practices on door-to-door railway solutions among UIC members, also creating exchange opportunities between railways, shared mobility providers and institutions.

In particular, the collection of good practices and case studies will focus on the areas of intervention and strategies previously identified as crucial for railways about door-to-door solutions, as well as on the environmental benefits associated with the actions implemented. This phase will provide the main contents for drafting the "UIC Guideline on Door-to-Door Solutions" document, envisaged in the following stage: the dissemination phase.

1. Concept

**2. Engagement Phase**

3. Dissemination

## AREAS OF INTERVENTION

**Connection** | **Facilities** | **Information** | **Ticketing** | **Tracking** | **MaaS**

UIC Workshop

Litterature review

# CASE STUDIES & BEST PRACTICES COLLECTION

Structured Interviews

Questionnaires

**Vertical Integration** | **New Deal** | **Wait and See** | **Public Benefits via Open Data**

## STRATEGIES AND BUSINESS MODELS

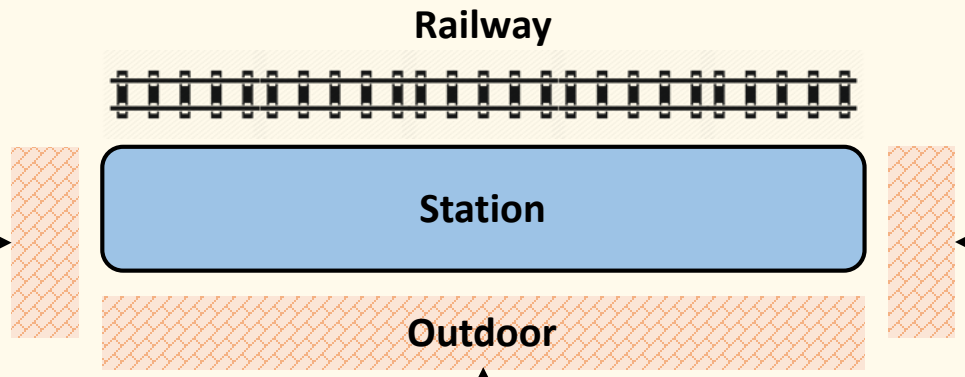
# Door-to-Door Solutions GUIDELINES

**Target:**
- Operation Manager
- Infrastructure Manager / Station Manager

## 6.1 Next steps

A specific focus in the following phase will be devoted to spatial design of external areas of railway station, as the core issue of this phase.
While designing door-to-door railway solutions requires collaboration between different mobility operators, both traditional and innovative, finding solutions to problems related to spatial organization of railway stations is also important, as they will constitute the physical infrastructure and connection nodes between the different transport modes.
As described in the previous paragraphs, digital technology is the great innovation able to widen the transport ecosystem and to expand the potential of railway services. Starting from this assumption, the growth of physical and digital infrastructures have to be connected. For example, thanks to the presence of an interchange parking close to the railway station, an innovative shared mobility service such as a bikesharing scheme would be more functional for a railway passenger and even more if the railway station is also connected to a wide urban cycle lines network.
The focus on the areas of intervention for railway door-to-door solutions already identified will be the starting point in the engagement phase, highlighting the most important open issues regarding the different shared mobility services, also taking into account their relation with the physical space of railway station. In conclusion, the level of engagement (RU, Station Manager, Town Council) for each question it will identified, providing possible answers and solutions.
The images below show the open questions that will be clarified during the engagement phase for "Facilities", as an example for other Areas of Intervention in this Preparatory Study. Considering the spatial design of railway stations, “Facilities” is one of the most important Area of Intervention in order to increase accessibility and connection with other transport services.

# FOCUS: Spatial design of external areas
# Area of Intervention: FACILITIES




**Level of engagement**
RU = Railway undertaking
IM = Infrastructure manager/Station manager
TC = Town Council

**Personal Motorized CAR / PTW**

| Personal motorized modes – Car and powered two wheelers (PTWs) | RU | IM | TC |
|---|---|---|---|
| ***Car parking supply*** | | | |
| How to manage parking supply as an effective ways of influencing modal choices? | | X | X |
| How to reduce conflicts between cars and other modes (or even between different types of car use)? | | X | X |
| How to define parking provision (including the car park, private car park, on-street parking)? | X | X | |
| How to balance short and long stay spaces? | | X | |
| How to manage demand for charging arrangements (for example to encourage off-peak travel) with charging regimes and enforcement mechanisms? | | X | |
| How many charging points for EVs are needed and where to provide them? | | X | |
| How to manage on parking restrictions (roads affected by nuisance parking close to the railway station)? | | | X |
| ***PTWs parking supply*** | | | |
| How to define parking provision (including the PTWs park and on-street parking)? | | X | X |
| How to overcome vulnerability to theft? | | X | X |
| How to reduce conflicts between PTWs and other modes (or even between different types of PTWs use) assuring access routes from the station entrance to PTW parking spaces? | | X | |
| ***Car drop-off*** | | | |
| How to ensure set sufficiently large down area (sufficient capacity), conveniently located and well sign-posted? | | X | X |

**Personal Active BIKE**

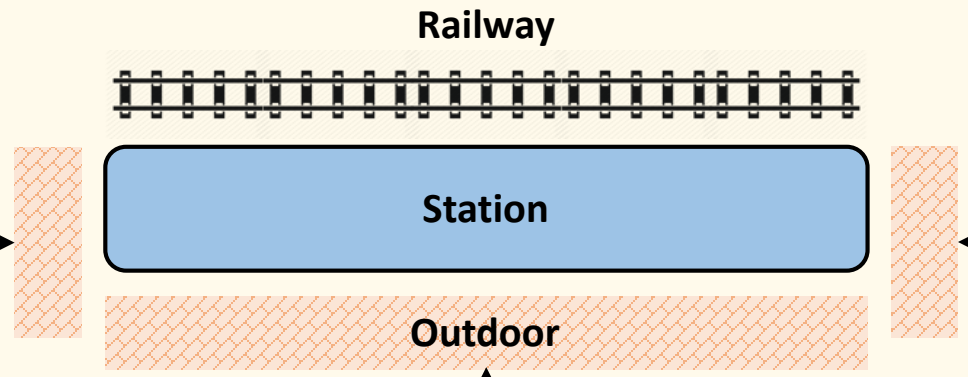
| Personal active modes – Bike | RU | IM | TC |
|---|---|---|---|
| ***Cycle parking supply*** | | | |
| How and where provide new or additional cycle parking? | | X | X |
| How to reduce conflicts between bikes and other modes? | | X | X |
| How to define parking provision (including bike station, on street bike parking and e-bike etc.)? | X | X | |
| How to improve the quality of cycle parking (cycle racks, shelters, secure cycle lockers, secure cycle storage, CCTV surveillance etc.) and visibility to cyclists? | | X | X |
| How to manage demand for charging arrangements and providing charging points for e-bikes for EVs? | | X | |
| ***Improving accessibility*** | | | |
| How to improve quality of routes to cycle parking area from local network (rise dedicated cycle paths, on road cycle lanes, cycle-friendly road junctions and crossings, traffic calming or other road safety measures to help cyclists)? | | X | X |
| ***Improved information about bikes routes*** | | | |
| How to improve cycle route maps (printed and online) and signposting of local routes? | X | X | X |

**Personal Active WALKING**

| Personal active modes – Walking | RU | IM | TC |
|---|---|---|---|
| ***Quality of environment*** | | | |
| How to improve walkability and pedestrian seamless perception (e.g. removing obstructions and clutter, improving pavement surfaces, space designetc.)? | | X | |
| How to build a fluid spatial exchange between external and internal spaces of the station? | | X | X |
| How to meet requirements for people with impaired mobility and vision? | | X | X |
| How to improve safety improving crossing provisions on roads accessing the station/pedestrian areas, traffic calming or other road safety measures to help pedestrians? | | | X |
| How and where provide new or additional shops, shelters, commercial corners etc. ? | | X | |
| ***Improved information about walking routes*** | | | |
| How to improve pedestrian route maps (printed and online) and signposting for a clear and rapid interchange with other modes and to find local destinations/main attractions? | X | X | X |
| How to improve personal safety? | | X | X |

**Interchange inside the station between different railway services are not taken into account*

# FOCUS: Spatial design of external areas
# Area of Intervention: FACILITIES




**Level of engagement**
RU = Railway undertaking
IM = Infrastructure manager/Station manager
TC = Town Council

**Scheduled PUBLIC TRANSPORT**

| Scheduled and continuous shared modes - Public Transport (PT) | RU | IM | TC |
|---|---|---|---|
| ***Improving routes and services*** | | | |
| How to increase the number of routes serving the stations, by rerouting or extending services, by creating new routes between the station and some key destinations? | X | X | X |
| How to increase service frequency, changing services timetable to provide better connections with train station and railway services? | X | X | X |
| How improve journey times through PT priority measures along the routes? | | | X |
| ***Traveller information*** | | | |
| How to provide or improve route maps and timetable information displays at station? | X | X | X |
| How to provide or improve service information by digital solution (Journey planner, MasS etc.)? | X | X | X |
| How to improve signposting to direct rail users to and from nearby PT stops? | X | X | X |
| Which system to choose to provide real time information at PT stops and/or within station? | X | X | X |
| ***Quality of interchange spaces*** | | | |
| How to improve PT stops and waiting areas (eg new shelters, seating, CCTV)? | | X | X |
| How to improve pedestrian route between station and PT stops/stations? | | X | X |

**Vehicle sharing BIKESHARING**

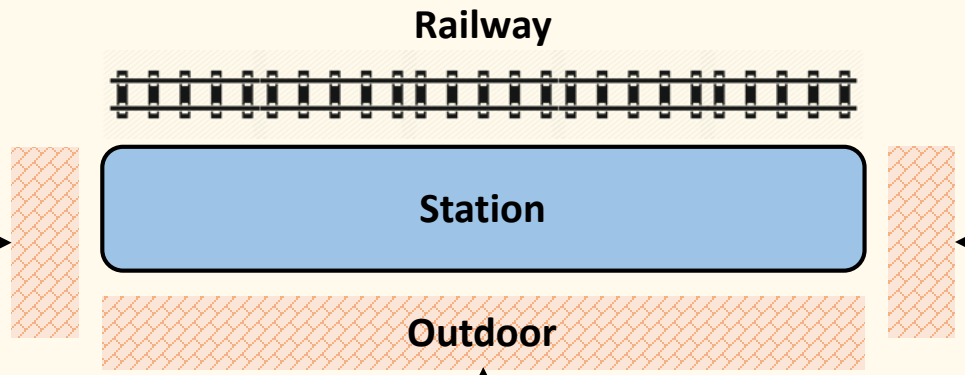
| On demand shared modes – Vehicle sharing/Bikesharing | RU | IM | TC |
|---|---|---|---|
| ***Improving services*** | | | |
| How to increase the availability of shared bikes around the station? | X | X | X |
| ***Bikesharing parking supply*** | | | |
| How to reduce conflicts between bikes and other modes (or even between different types of car use)? | | X | |
| How to define parking provision (including bike station, on street bike parking and e-bike etc.)? | | X | |
| How to balance Free floating/station-based bikesharing services spaces? | | X | |
| How to manage demand for charging arrangements and providing charging points for shared e-bikes? | | X | |
| How to reach appropriate arrangements with bikesharing companies? | X | X | |
| ***Traveller information*** | | | |
| How to provide or improve route maps and availability information displays at station? | X | X | X |
| How to provide or improve service information by digital solution (Journey planner, MasS etc.)? | X | X | X |
| How to improve signposting to direct rail users to and from nearby dedicated bikesharing parking spaces? | | X | X |
| Which system to choose to provide real time information at bikesharing areas and/or within station? | | X | X |

**Vehicle sharing CARSHARING**

| On demand shared modes – Vehicle sharing/Carsharing | RU | IM | TC |
|---|---|---|---|
| ***Improving services*** | | | |
| How to increase the availability of shared cars around the station? | X | | X |
| ***Carsharing parking supply*** | | | |
| How to reduce conflicts between cars and other modes (or even between different types of car use)? | | X | |
| How to define parking provision (including the car park, private car park, on-street parking)? | | X | |
| How to balance Free floating/station-based carsharing services spaces and car hire service? | | X | |
| How to manage demand for charging arrangements (for example to encourage off-peak travel) with charging regimes and enforcement mechanisms? | | X | |
| How many charging points for EVs are needed and where to provide them? | | X | |
| How to reach appropriate arrangements with carsharing companies? | X | X | |
| ***Traveller information*** | | | |
| How to provide or improve route maps and availability information displays at station? | X | X | X |
| How to provide or improve service information by digital solution (Journey planner, MasS etc.)? | X | X | X |
| How to improve signposting to direct rail users to and from nearby carsharing areas? | | X | X |
| Which system to choose to provide real time information at carsharing areas and/or within station? | | X | X |

**Interchange inside the station between different railway services are not taken into account*

# FOCUS: Spatial design of external areas
# Area of Intervention: FACILITIES




**Level of engagement**
RU = Railway undertaking
IM = Infrastructure manager/Station manager
TC = Town Council

**Vehicle sharing**
**SCOOTERSHARING**

| On demand shared modes – Vehicle sharing/Scootersharing | RU | IM | TC |
|---|---|---|---|
| ***Improving services*** | | | |
| How to increase the availability of shared PTWs around the station? | X | X | X |
| ***Scootersharing parking supply*** | | | |
| How to reduce conflicts between PTWs and other modes (or even between different types of car use)? | | X | |
| How to define parking provision (including the car park, private car park, on-street parking)? | | X | |
| How to balance Free floating/station-based carsharing services spaces and car hire service? | | X | |
| How to manage demand for charging arrangements (for example to encourage off-peak travel) with charging regimes and enforcement mechanisms? | | X | |
| How many charging points for EVs are needed and where to provide them? | | X | |
| How to reach appropriate arrangements with carsharing companies? | X | X | |
| ***Traveller information*** | | | |
| How to provide or improve route maps and availability information displays at station? | X | X | X |
| How to provide or improve service information by digital solution (Journey planner, MasS etc.)? | X | X | X |
| How to improve signposting to direct rail users to and from nearby dedicated scootersharing parking spaces? | | X | X |
| Which system to choose to provide real time information at scottersharing areas and/or within station? | | X | X |

**Ride sharing**
**TAXI**

| On demand shared modes – Ridesharing/Taxi | RU | IM | TC |
|---|---|---|---|
| ***Improving services*** | | | |
| How to increase the availability of taxi serving the stations? | X | X | X |
| ***Taxi drop-off*** | | | |
| How to manage pick-up provision as an effective ways of influencing modal choices? | | X | |
| How to Improve ensure suitable pick-up provision and attractive location for station access/egress? | | X | |
| How to ensure set sufficiently large down area (sufficient capacity), conveniently located and well sign-posted? | | X | |
| How to reduce conflicts between taxi and other modes? | | X | |
| How to provide greater capacity, to enable more taxis to serve the station? | X | X | X |
| ***Traveller information*** | | | |
| How to provide or improve service information by digital solution (Journey planner, MasS etc.)? | X | X | X |
| How to improve signposting to direct rail users to and from nearby dedicated taxi drop-off? | X | X | X |

**Ride sharing**
**CARPOOLING**

| On demand shared modes – Ridesharing/Ridehailing, ridesplitting, carpooling | RU | IM | TC |
|---|---|---|---|
| ***Improving services*** | | | |
| How to increase the availability of ridesharing services serving the stations? | X | X | X |
| How to manage prearranged regular commuter travel (in partnership with local employers) or, for more rural locations, on-demand travel solutions by ridehailing/ridesplitting/carpooling services? | X | | |
| ***Ridehailing, ridesplitting, carpooling drop-off*** | | | |
| How to manage pick-up provision as an effective ways of influencing modal choices? | | X | |
| How to Improve ensure suitable pick-up provision and attractive location for station access/egress? | | X | |
| How to ensure set sufficiently large down area (sufficient capacity), conveniently located and well sign-posted? | | X | |
| How to reduce conflicts between ridesharing vehicle and other modes? | | X | |
| How to provide greater capacity, to enable more ridesharing services to serve the station? | X | X | |
| ***Traveller information*** | | | |
| How to provide or improve service information by digital solution (Journey planner, MasS etc.)? | X | X | X |
| How to improve signposting to direct rail users to and from nearby dedicated taxi drop-off? | X | X | X |

**Interchange inside the station between different railway services are not taken into account*