INNOVATION TREND REPORT

SMART MOBILITY

INTESA SANPAOLO
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Innovation trend report – Smart mobility

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Publisher
Intesa Sanpaolo Innovation Center

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A project by
MoSt — more-studio.it

Opening chapter infographics
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Printed by
Graficart

SMART MOBILITY

Our lexicon, like everything else, has been turned upside down by COVID-19. Everything used to be *smart*, sustainable and Green, but we were looking at a future form which we had taken away a variable: uncertainty.

Now we are back to fundamentals and this means studying, analyzing, pondering and deciding, it means making conscious and competent choices.

That is where the true importance, the real usefulness of this report resides. Based on solid assumptions, this book provides elements of true knowledge, precise scenarios and figures. This book offers us a map, a legend that helps us understand the deep changes we are going through in the mobility space. Mobility, a concept that goes far beyond the mere meaning of the word itself, the meaning we knew until artificial intelligence and, more broadly, new technologies took the center stage and became the main characters.

It is not by chance that artificial intelligence is the focus of a previous book in this same series, a series that should be looked at in its entirety. This series is a guide in a more and more interconnected, and therefore complex world.

Enjoy the reading.

Maurizio Montagnese
Chairman

An incredibly rich research, a document that does not spare stimuli. The reader can take her or his own perspective and point of view to form an opinion about the trend we are moving along. Talking about smart mobility could take us to very different and apparently irreconcilable and separate scopes. This is why this book is a powerful tool, a compass that does not deceive us.

The content is the result of an outstanding and thorough analysis that enables each reader to reach a synthesis, a summary point. However, contrary to what most of us believe, synthesis does not always mean brevity, levity or superficiality. Ours is a synthesis that enables us to make the most important and most relevant ideas emerge, building solid foundations for solid, individual thinking.

The research experience so far accumulated by Intesa Sanpaolo Innovation Center guarantees quality. Ours is a team that has been gaining a well-deserved credibility by being able to deep dive into phenomena and trends, reading them through original lenses, while always looking into the future.

Enjoy your reading.

Guido De Vecchi
Executive Managing Director

The mobility of the future

1

"Roman roads are a factor of incalculable importance in the very history of mankind. Rome became a mobile source of civilization and mistress of the world precisely because, through her roads, she had managed to systematically control a great part of the Earth's surface."

Thus Victor von Hagen describes, in his work "Le grandi strade di Roma nel mondo" (1978), the mobility infrastructure created by the Roman Empire that would extend for over 100,000 km across the continent of Europe.

Beyond the expertise and mastery underlying the planning and construction of these road projects, with thoroughfares that would be used regularly up to, and right through, the medieval period, and with bridges still in function today, emphasis is rightly placed on the strategic value of an infrastructure permitting the rapid movement of men and goods, for both military and commercial purposes.

Sliding the time axis along the timeline of the centuries preceding and then following the Roman Empire, we can always observe the role played by the mobility of men and means of transport, and by the development thereof in underpinning the role and geopolitical growth of those indi-

Thus Victor von Hagen describes, in his work "Le grandi strade di Roma nel mondo" (1978), the mobility infrastructure created by the Roman Empire that would extend for over 100,000 km across the continent of Europe.

vidual nations that had become, in time, hegemonic in their own historical spaces.

It is sufficient to think of the Silk Roads built in Imperial China, which connected the ancient capitals Xi'an and Luoyang to Central Asia and beyond to Europe, and of how these have entered the collective imagination more, even, as an archetypal intercultural journey than as a trade route.

Today, in this moment in history, we have at our disposal a technology that brings to maturity the futuristic designs of Leonardo and the visionary machines of Jules Verne.

Through this evolution in time and up until roughly the middle of the second millennium of Christian civilization, the development of mobility coincided with the development and enhancement of infrastructures that permitted swifter and safer transit of means of transport that, in contrast, did not follow a corresponding innovation curve.
A first strong sign of discontinuity, perhaps more conceptual than actual, would be observed in the 15th century thanks to the visionary and creative genius of Leonardo da Vinci.

An extremely innovative designer, albeit one not adequately supported by suitable technology, which, incidentally, would take another four hundred years to arrive, Leonardo laid the ideological foundations of the machine-innovation coupling.

In a world in which the power available for travel was constituted by the muscles of quadrupeds, Leonardo devised projects for the creation of four-wheeled automatons, machines capable of vertical take-off and robot soldiers. We are in the 1400s but, nonetheless, a modern terminology speaking of drones, robotics, and self-driving vehicles would be quite fitting.

Four centuries later, in the second half of the 19th century, when the industrial revolution had already begun to inject into mankind an almost unlimited faith in its own capacities to progress, a French writer born in Nantes in 1828 would make commonplace to the masses the concept of mobility as a driver for dreams, explorations and gaining knowledge.

Jules Verne, one of the most translated authors in the whole world, left us masterpieces capable of awakening dreams in the child and also in the adult, masterpieces all developed around the multiple facets of the concept of travel, in which technology always plays a key role as an enabling factor for travel itself.

Machines that make it possible to cross the skies and the depths of the ocean, machines that cancel the distance between us and the moon, journeys that in a matter of weeks take us across the entire surface of the earth and acquaint us with nations and cultures.
Man is, insofar as he knows, insofar as he meets, insofar as he travels.

Today, in this moment in history, we have at our disposal a technology that brings to maturity the futuristic designs of Leonardo and the visionary machines of Jules Verne.
Today, and increasingly over the next decades, and less, we will witness a profound transformation in our very conception of mobility, with powerful impacts not only on "what" we will use to travel about but also on precisely "how" our journeys will be organized.

Just as the magnetic compass was indispensable to the navigators for charting routes and keeping their bearings within the four cardinal points, we too will equip ourselves from here on with a conceptual compass that will permit us to classify, analyze and represent, in an effective fashion, the transformations underway in the ecosystem of the means of transport and their related support infrastructures.

The Mobility compass, too, has 4 cardinal directions:

- Electric
- Connected
- Autonomous
- Shared

The approach that we have adopted in the development of this treatise moves sequentially along each of these axes, providing individual examinations since each dimension has its own significance, with different degrees of maturity in terms of the technological substratum, of the ecosystem that sustains its development and of the adoption and varying levels of acceptance and familiarity in common thinking.

These profound vertical analyses are also complemented by a holistic vision, which considers all the combined phenomena in play and highlights the synergies that make each dimension not only an independent phenomenon but an enabling factor in the growth of the other dimensions too.

Beginning the exploration along the Electric Mobility axis, it will soon become apparent that the transformation underway, extremely topical in terms of media coverage and of debate among enthusiasts, is, in truth, a predominantly technological and organizational phenomenon: when vehicles with electric powertrains no longer suffer from shortcomings in autonomy and ease of charging compared internal combustion engine vehicles, the drivers of choice will be merely ones of economy and environmental ethics, with relatively few differences in the user experience.

The transformation underway, extremely topical in terms of media coverage and of debate among enthusiasts, is, in truth, a predominantly technological and organizational phenomenon

The model of use of the vehicle does not change, nor do the services that are provided on board or around it and nor does the driving experience in terms of vehicle control.
It is not so, however, for the other three dimensions of analysis.

How many times in the course of a day do we hear repeated that we live in a hyperconnected world? The transport sector is no exception, rather, thanks to the imminent introduction of 5G in mobile networks, it will soon undergo a marked acceleration and a radical transformation.

Communicating in real time with tens of other vehicles whose paths cross at every moment and maintaining a constant exchange of data with the roadside control systems present, in the subsoil and in the stratosphere, not only enables intelligent and predictive management of the vehicle and of traffic flows, but also opens up the way to high-value services provided to the occupants who, on any occasion, are on board a specific vehicle or transiting a particular area, on the basis of a record of decisions taken and journeys made by each of these in any chosen time range.

No less of a breakthrough will be represented by Autonomous Mobility, perhaps currently the least mature of the four dimensions.
Knight Industries Two Thousand, alias KITT, in the early 1980's 'embodied' on the small screen the cinematic feats of a car well beyond Level 5 in the current scale of autonomous vehicle classification, as, apart from enjoying total driving capacity, it was also possessed of full consciousness.
Four decades have passed and, even though the commercial products currently available do not go beyond Level 2, means of transport that move in total autonomy are no longer merely a chimera or something from science fiction.

Progressively, as the driving function increasingly becomes a practically atrophied instrument, cars will assume the appearance and functions of a living room, favouring relaxation and entertainment.

Progressively, as the driving function increasingly becomes a practically atrophied instrument, cars will assume the appearance and functions of a living room, favouring relaxation and entertainment.

Broadening our field of vision to the entire transport ecosystem, next we can see that already today there are large commercial vehicles that can move in platoons and currently being designed we have not only largely small drones for last mile deliveries, but also totally crewless enormous container ships able to sail the seas in complete autonomy.

If, in what has been covered so far technology plays a key role in the evolution of mobility, the fourth dimension along whose axis we focus our analysis is, instead, mainly cultural and behavioural in nature.

Last but not least, Shared Mobility is going to turn on its head the very concept of the car as a personal possession.

Viewing the car as no longer an object to purchase, to personalize, to take care of over time, to show off to one's

circle of friends and acquaintances, but rather as a tool that makes more sense the less it is left idle and thus the more it can be shared among different users and that it can, on any occasion, be chosen in different types to meet the specific needs of the moment.
This, then, is, more than anything, a cultural shift and a profound change in social behaviours and in the hierarchy of values.

A zero-emissions mobility will make it possible to shift traffic flows underground, on several levels and over long distances.

If we now leave the four examples of horizontal analysis covered to board a drone and send it up into the air to obtain an overview of the situation, just as the road arteries of a city become visible and reveal its topology, similarly the technological and functional connections among the four dimensions of mobility manifest themselves in their extended ramifications and complexity.

We will not be able to have swarms vehicles moving about in total autonomy without these being tightly and constantly connected together and with the control systems.

A zero-emissions mobility will make it possible to shift traffic flows underground, on several levels and over long distances.
And many other correlations are developing before our very eyes.

By the middle of the current century, little more than 30 years from now, a third of a person’s life, the world will be inhabited by almost ten billion individuals.
70% of these will be concentrated in urban agglomerations that, if they are not to implode, will have to fundamentally change the rules and modes of access and movement applied therein.

In the excursus that follows, we attempt to a provide some readings of how such a transformation may come about.

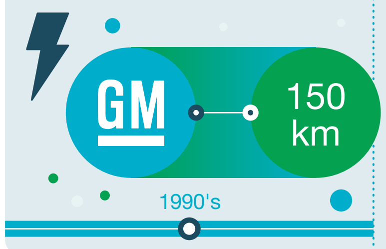
Electric mobility

2

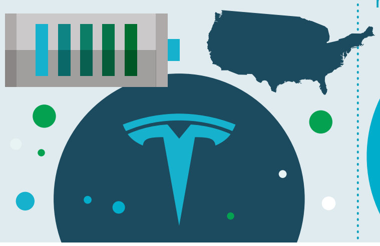
Electric mobility

The electric vehicles market

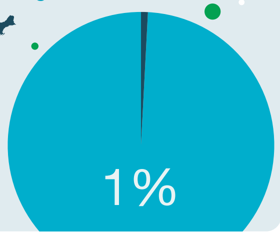
Interest in electric mobility was rekindled by General Motors thanks to its EV1 model launched in the mid-1990's: an electric car with an autonomy of approximately 150km.



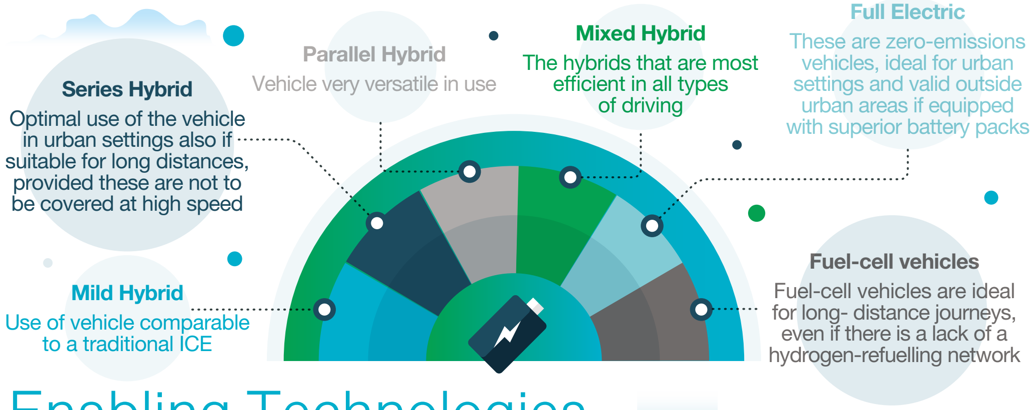
The "Tesla effect" is spoken of following the 2008 entry into the market of the futuristic Roadster, a sports model powered by a lithium-ion battery.



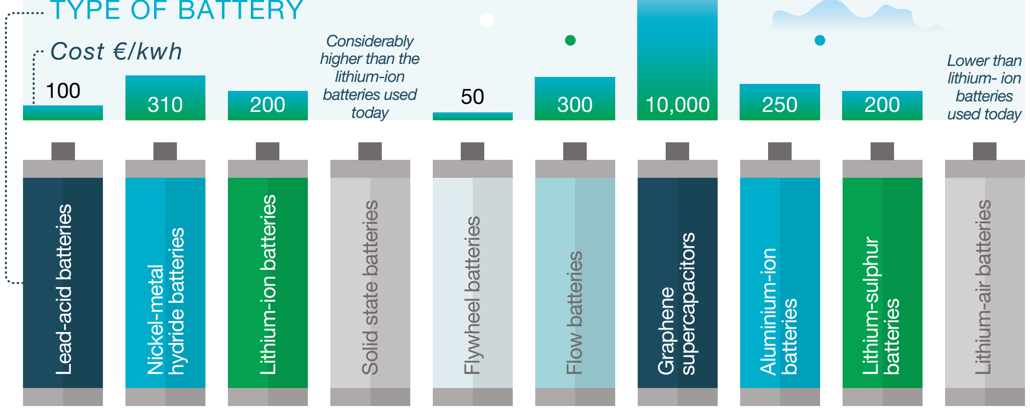
Despite the interest surrounding electric vehicles today, these only represent approximately 1% of total new car registrations



New propulsion technology

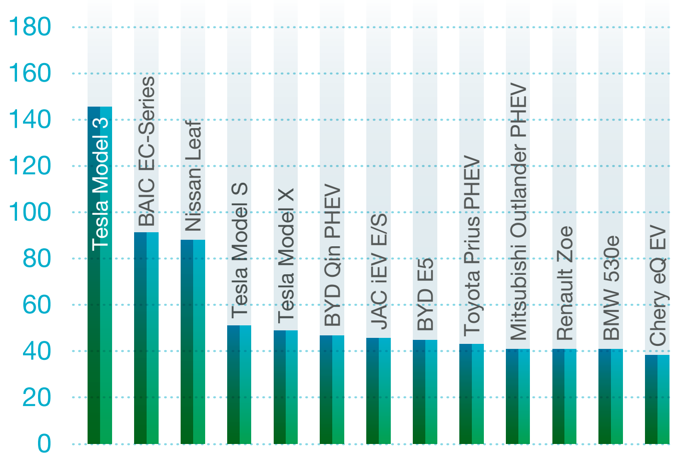


Enabling Technologies

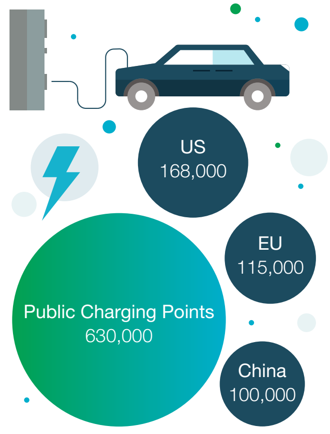


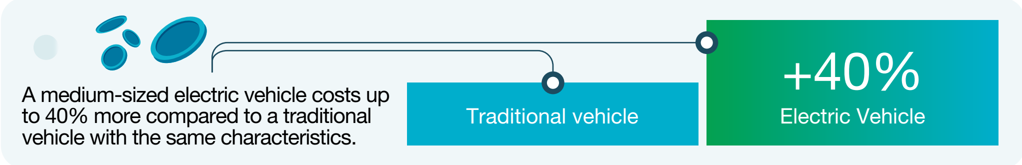
The e-mobility ecosystem

Worldwide plug-in electric vehicle sales in 2018, by model (in 1,000 units)

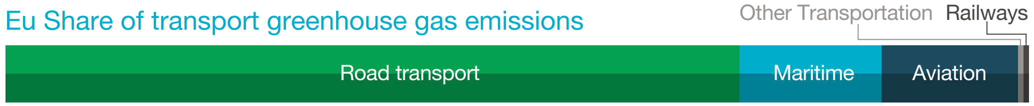


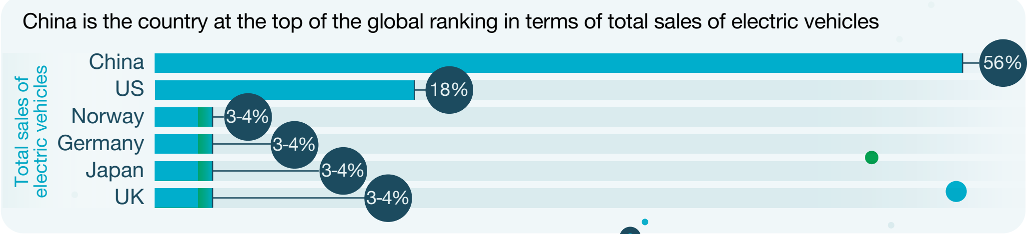
Public charging points globally in 2018 divided by countries



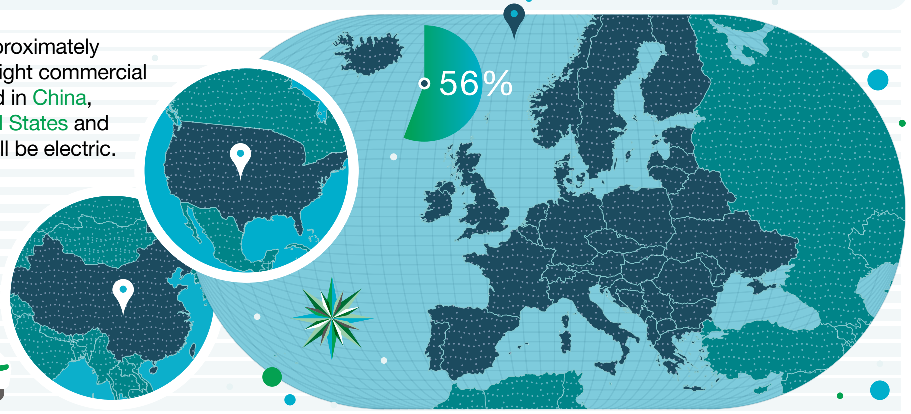


Eu Share of transport greenhouse gas emissions





By 2040 approximately 56% of the light commercial vehicles sold in China, in the United States and in Europe will be electric.



Introduction

When speaking of "electric mobility", reference is generally made to the transformation, across the whole transport system, of a predominantly heat-engine powertrain into a predominantly electric one. The changes regarding electric mobility involve both the sector of "electric cars", understood as private or company cars, and, in a broader sense, "electric vehicles", that is any other means of transport – commercial vehicles, buses, ships, aeroplanes, trains, motor scooters, motorcycles, kick scooters – that make use of one or more electric engines for its propulsion. This category includes both the so-called "pure" electric vehicles and the "hybrid" ones, which possess an internal combustion engine (ICE) powered by petrol or diesel, in combination with an electric engine.

The history of electric vehicles goes back as far as the 19th century, but the technology only really took off with the entry into the market of Elon Musk's Tesla, and the subsequent reawakening of public interest in this type of car. Since 2010 – when global sales of electric cars could be counted in the thousands, electric mobility has continued to grow rapidly, benefitting from supportive public policies in many countries (for example, investments in the charging infrastructures), from important regulatory changes and, not least, from public opinion pushing for more sustainable mobility.

With regard to the electric car market, 2018 saw the global market exceed 2.1 million units, an increase of 1 million on the previous year. In North America, Asia and Europe, many countries are promoting an increase in electric car numbers and in electric micromobility on the roads; at the same time, car manufacturers are launching new models of electric cars with increasing frequency and have ambitious projects for the future.

Looking further afield to other electric mobility segments, according to the International Energy Agency the global vehicles market at the end of 2018 numbered 260 million, already including over 460,000 electric buses. In the same year, for the transportation of goods, electric vehicles used mostly as light-duty commercial vehicles - with a weight of no more than 3.5 tonnes and that do not require special driving licences - reached 250,000 units, while medium-size commercial EV's recorded sales of between 1,000 and 2,000 units.

The change underway, however, does not exclusively concern the vehicles as such, but also affects the whole "transport system". Electrification does not merely revolutionize all the processes of production, distribution and storage of the energy necessary to power vehicles in circulation, but also concerns "physical infrastructures" (roads, railways, airports, ports, service stations and charging stations, etc.).

More generally, the whole "mobility ecosystem" (car manufacturers and OEM's, new entries and start-ups, battery producers and of charging technologies, but also the whole sphere of the aftermarket and of spare parts) is involved in the change. The need to face up to huge investments, with returns that are still uncertain, has redrawn the map of alliances between car manufacturers and has ignited competition in the global market.

Analysing the demand side, according to the report "*The Race For The Electric Car 2019*" produced by CB Insights, approximately 80% of consumers have explained their choice of an electric vehicle on environmental grounds. Among the obstacles cited, on the other hand, are the high cost of EV's, the at-times limited battery autonomy, due to which the term "range anxiety" has entered the language to indicate the fear that a vehicle does not have sufficient autonomy to reach its destination, and the critical issues connected with charging operations, such as the times necessary for charging, the uneven distribution of charging points, the still limited number of the same and the malfunctions deriving from software incompatibilities between vehicle and charging unit.

Last but not least, considerations of a geopolitical nature come into play in the debate: dependency on oil and the associated increase in price are open and sensitive issue. In the American context, the demand for oil specifically for vehicles “for passengers” in 2016 represented approximately a quarter of the total and 19% of the crude oil consumed was imported.

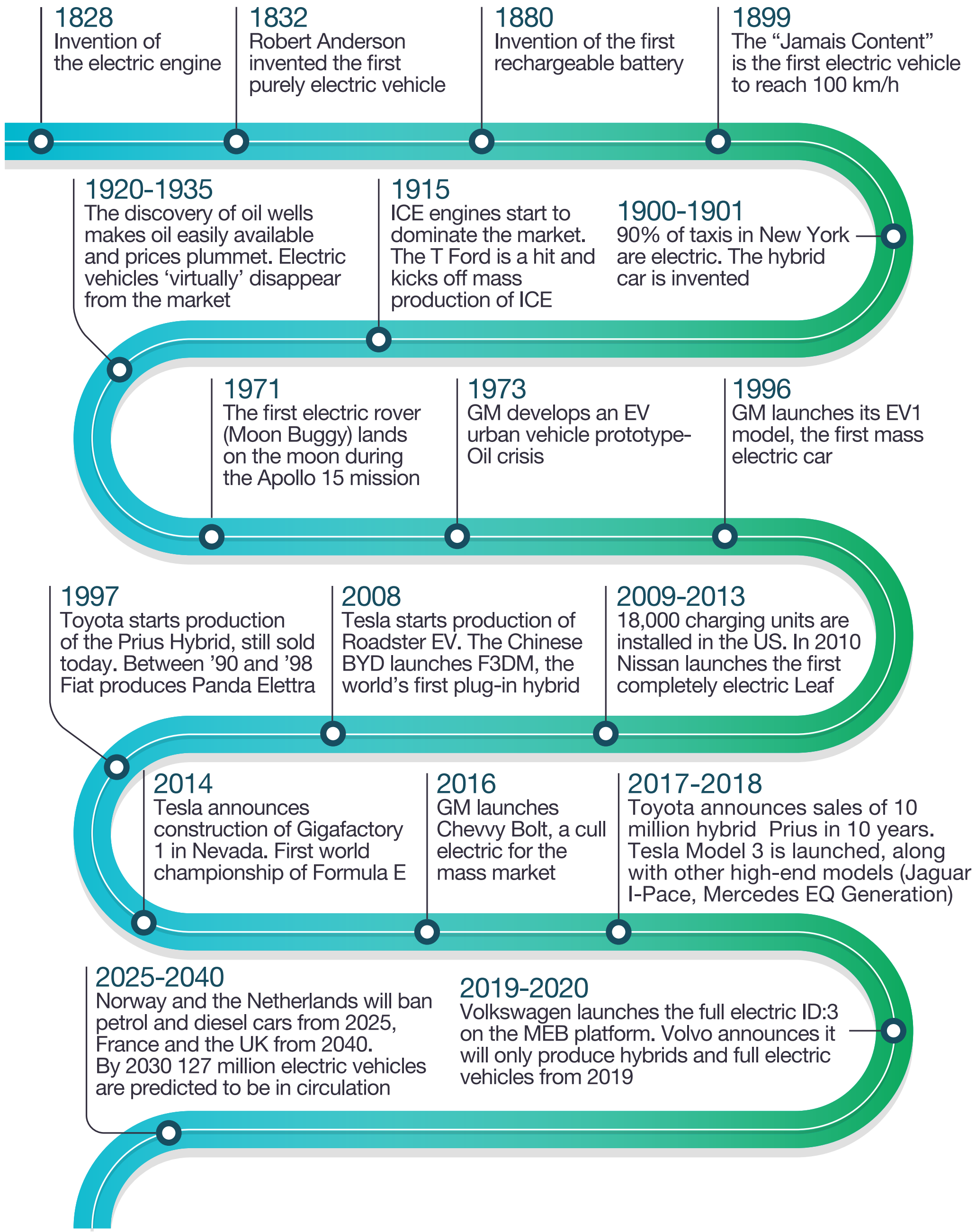
Still in 2019 Italy presents no clear model of programmatic development in the field of electric mobility and this hampers the full benefits of the related opportunities for modernization and growth. At present, there exist indirect incentives, such the reduction in costs of vehicle circulation, and direct ones, such as tax breaks. These initiatives can be seen as valid “accompanying” early-stage measures suitable for increasing competitiveness in the market; there remain, however, the shortcomings in terms of infrastructures.

The electric vehicles market

The electric vehicle, in the collective immagination, has always seemed a distant technological milestone and unlikely to replace traditional internal combustion vehicles any time soon. Despite the fact that the first electric models were contemporary with their combustion engine counterparts, the rise of the latter as the dominant model nullified their interest for the public and consequently for the market, thus compromising since the early 1900’s the research and technological improvements required to compete in the private transport market.

Interest in electric mobility was rekindled by General Motors thanks to its EV1 model launched in the mid-1990’s: an electric car with an autonomy of approximately 150km. These, however, were produced and sold in limited numbers and the project was abandoned.

It would take another decade before a genuine revolution in the electric vehicles market would be seen thanks to the rise of Tesla. The “Tesla effect” is spoken of following the 2008 entry into the market of the futuristic Roadster, a sports model powered by a lithium-ion battery, designed and devised to show the private transport ecosystem the true potential of the technology, not only in terms of its lower environmental impact but also of its performance. Despite the interest surrounding electric vehicles today, these only represent approximately 1% of total new car registrations; it is, however, opportune to examine market trends in different countries in order to gain a sense of the true dimensions of the phenomenon.



World

The global market has recorded an increase in the registrations of new electric vehicles to an average CAGR of 61% (+76% in 2018 only compared with the sales of 2017), rising from 118 thousand vehicles in 2012 to approximately 2.1 million in 2018. Maintaining this rate

of growth, EV’s would reach 5% of the light vehicles (for private and commercial use) globally by 2020.

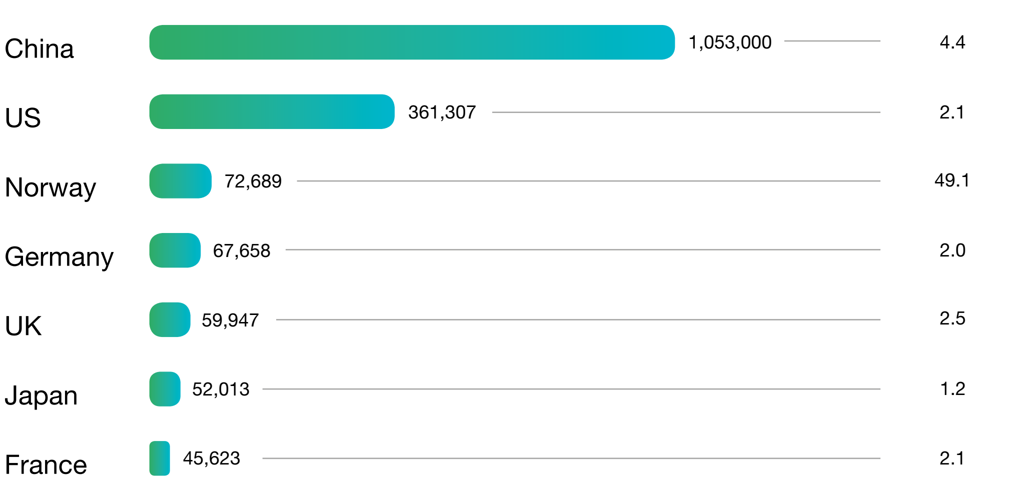
In the current state of affairs, pure electric vehicles (BEV) represent 66% of the global EV market, but this percentage is destined to increase as their sales are growing at a greater rate than those of hybrid vehicles. There is hard data confirming the trend delineating the shift in the registrations mix from PHEV to BEV vehicles, which reached approximately 70% of total registrations in 2018. According to Bloomberg estimates, the revolution will not be limited to private transport: it is predicted that by 2040 approximately 56% of the light commercial vehicles sold in China, in the United States and in Europe will be electric.

Studying the details of the different geographic markets, it is apparent that China is the country at the top of the global ranking in terms of total sales of electric vehicles. Around 56% of global EV sales in 2018 (+78% on the previous year) are attributable to the Chinese market, which in the period under discussion placed over a million of electric vehicles on the market. Behind China there follows the US market with 361 thousand electric cars sold in 2018 and a global share of 18% of electric vehicles. Norway, Germany, United Kingdom and Japan sold approximately 100 thousand vehicles each in the same period, with individual shares of global sales of around 3-4%.

2.1 mln new electric vehicles sales in 2018 (+76% on 2017)

Who leads the charge towards electric mobility?

Largest markets in terms of plug-in electric passenger car sales/registrations in 2018*



* including plug-in hybrids and light trucks. Source: Statista

Europe

Pure electric vehicles: +70% 2019/2018

In Europe the electric vehicles market is experiencing a strong expansion: the largest growth rates are being recorded in the category of pure electric vehicles, a category that saw an increase of 70% in sales from April 2018 to April 2019. In the European market the winning factor is the stringent emissions policy, which is incentivizing the progressive abandonment of combustion engines fueled by diesel (-12% of new diesel sold on an annual basis).

The countries leading European market growth of electric vehicles are Germany, in absolute terms, and Norway, a country in which approximately 50% of new vehicles sold are electric. In general, it is countries in continental and northern Europe that are leading the way.

According to the projections in the Statista report entitled "*Electric Mobility in Europe*", by 2025 the European market will be the the number one in the world by number of new electric vehicles sold (6.3 million), ahead of China and the United States.

Italy

Italy: +120% new electric vehicles 1H19 on 1H18

As far as Italy is concerned, according to the data emerging from the 2019 edition of the Repower's White Paper "Sustainable mobility and electric vehicles", the full electric vehicles registered in the coure of 2018 were slightly above 5,000, with a percentage variation of +147% on 2017, in stark contrast with the fall in total registrations (-3,3% on 2017). The greater propension of Italians to buy electric falls above all on hybrid solutions, currently a more economical choice than pure electric vehicles. The size of the market for the latter remains small: in 2018 approximately 4,500 PHEV were registered (+60% on 2017).

These positive trends are confirmed by data regarding registrations of pure electric cars in the first seven months of 2019, with an increase of 113% (approximately 5,900 vehicles) on the same period of 2018. This result shows the decisive contribution made by the enactment of the Ecobonus in the month of April of this year.

Although there are signs of the penetration of electric vehicles into the Italian market, there are also many signs of slowness compared to the rest of Europe. In terms of infrastructure, for example, currently in Italy there are approximately 8,200 "charging points" available, which, by 2020, should increase to 13,000 accelerated charging points and 6,000 ultrafast charging stations; over the same period, the German development plan anticipates the installation of approximately 1.2 million stations. A key role in the development of the domestic market will be played by government incentives and infrastructure construction for the development of an effective and extensive network of charging stations.

New propulsion technologies

At present it is not yet clear which type of electric propulsion will have the greatest success in the short and medium term. For this reason it is necessary to examine the various technologies linked to electric mobility in detail so as to clarify their related optimal areas of use.

Firstly, the market supply must face up to growing environmental concerns and strict government regulations, for which reason car manufacturers find themselves obliged to improve the consumption efficiency of their cars. For manufacturers this may entail optimizing their current internal combustion engines (ICE) through downsizing or hybridization, or attempting to develop exclusively electric propulsion, that is to say, pure "Battery Electric Vehicles" (BEV).

Here below we provide a brief classification of the various types of electric drive, with the intention of casting light on the distinctive features of each and their related areas of optimal vehicle use.

TYPE OF ENGINE	OPTIMAL USE	TECHNICAL FEATURES
Mild Hybrid	Use of vehicle comparable to a traditional ICE.	Batteries and electric engine are compact. Not designed for "plug-in" charging and assists the ICE in the first stages of acceleration.
Series hybrid	Optimal use of the vehicle in urban settings also if suitable for long distances, provided these are not to be covered at high speed.	Batteries and electric engine large in size, ICE of reduced dimensions. The latter's job is to recharge the batteries while traction is supplied by the electric engine alone.
Parallel hybrid	Vehicle very versatile in use.	Simultaneous use of the ICE and the electric engine. Both the engines supply torque to the wheels.
Mixed hybrid	The hybrids that are most efficient in all types of driving.	It combines the characteristics of the series hybrid with the parallel hybrid: it can use the heat engine to charge the battery or power the electric engine, as it can have the two engines work together to provide traction.
Full Electric	These are zero-emissions vehicles, ideal for urban settings and valid outside urban areas if equipped with superior battery packs. Charging infrastructure can be a limit on long journeys.	Vehicle powered solely by electric engine. Due to its lack of an ICE, it requires a larger battery pack in order to ensure an adequate autonomy.
Fuel-cell vehicles	Fuel-cell vehicles are ideal for long-distance journeys, even if there is a lack of a hydrogen-refuelling network.	Hydrogen vehicles come under the definition of electric vehicles since, by chemical reaction, the electrical energy necessary to power the engine is produced. Unlike other EV's they do not require charging with electrical energy and have a hydrogen tank instead of a battery pack.

Hybrid (Hybrid Electric Vechicles)

Mild Hybrid (MHEV)

A small electric engine and a battery combined with an internal combustion engine (ICE) allow for assisted acceleration and regenerative braking. The car cannot, in any case, move by using the electric engine alone. Despite the predominance of the ICE in them, MHEV cars are classified as hybrid, benefitting, in many countries, from advantages relating to circulation and to vehicle tax. The Mild Hybrid solution does not allow for a plug-in option for battery charging at all.

Full Hybrid

An electric engine of standard size and a battery combined with a reduced-size heat engine allow for greater efficiency in regenerative braking, and also for short distances to be covered purely using the electric power supply. The three variations described below can also be of the plug-in type (PHEV), that is, the battery can be charged from an external source:

• Series hybrid (BEVx – Extended Range Electric Vehicle)
In the series hybrid system, also known as the "range extender", both an electric engine and a heat engine are present, but the traction is provided by the electric engine. The heat engine's only task is thus to generate the current transformed into movement by the electric engine. The surplus energy is used to recharge the batteries. In this way, it is possible to guarantee lower consumption and avoid needing an oversized heat engine. These vehicles are ideal in an urban setting (for example, for public transport vehicles, buses, taxis) but suffer from reduced efficiency at constant high speeds, for example on the motorway.

• Parallel Hybrid Electric Vehicle
This type of vehicle uses simultaneously a heat engine and an electric one. Both engines supply torque to the wheels, with the possibility of using the heat engine to recharge the batteries in case of need. Availing itself of the instant support of the electric engine, the parallel hybrid vehicle makes it possible to reduce the volume of the combustion engine, thus lowering emissions. This vehicle is suited to many situations thanks to the coexistence of the two engines.

• Mixed Hybrid
This sophisticated, and more-widely diffused, mixed system combines the characteristics of the series model with that of the parallel model. From the former it inherits its capacity to use the heat engine to generate current either for the battery or for the power supply of the electric engine, leaving the latter the task of operating the wheels. From the parallel model, it inherits, on the other hand, the capacity to have the heat engine and the electric one work in tandem to produce traction, as well as the capacity to recover energy while braking.
This flexibility leads to increase in complexity in the mechanical couplings between the heat engine and the electric part, nonetheless it allows the advantages of both models to be harnessed: for this reason, the mixed hybrid is the most efficient in all driving situations.

BEV (Battery Electric Vechicles)

By Battery Electric Vehicle (BEV) or Full Electric Vehicle is meant the now well-known vehicles that move the wheels by means of one or more electric engines, without generating any kind of internal combustion. Vehicles of this type must be able to mount a larger battery pack compared to those previously described in order to ensure adequate autonomy.

Fuel-Cell Vehicles (FCEV)

This type of vehicle, commonly defined as a hydrogen one, exploits the conversion of the element's chemical energy, due to its reaction with oxygen (from which is produced water and electricity), first into electrical energy and then into mechanical engine (for which reason these are included among electric vehicles). Their main advantage resides in the speed of charging - approximately 3 minutes for a full charge – and in their autonomy determined by the size of the tank just as in traditional internal combustion engine vehicles. The three models present on the market in 2019 are the Toyota Mirai, the Hyundai Nexo and the Honda Clarity.

↳ "The evolution of hydrogen: from the Big Bang to fuel cells"

Among the main problems of this type of power supply (with zero emissions) is the low energy density by volume in relation to other traditional fuels. One solution could be to liquefy the hydrogen, but this process involves extremely high energy costs, production costs, as well as problems of storage, transport and huge investments in distribution infrastructures.

In-wheel Motor System

The less well-known and still prototype "*in-wheel motor*" system is represented by an electric motor fitted within the vehicle's wheel hub. The advantages that make this solution appealing to car manufacturers are the limited size, the elimination of the transmission and the optimization of energy recovery during deceleration. In addition, the motors can apply, as needed, a vigorous "motor brake", allowing for the elimination of the braking system and particulate matter produced by the rubbing of the blocks against the disc. Among the disadvantages is the increase in mass and weight of the wheels making it necessary to enhance the performances of suspensions and steering.

PROTEAN ELECTRIC

Protean Electric designs, develops and manufactures Protean Drive in-wheel motors, an integrated in-wheel drive solution which converts electricity directly into power and eliminates energy waste in power transmission to propel hybrid and electric vehicles for both passenger and commercial vehicles.

Total Funding
$194 mln

Last Round
May 2019 Acquired

Country
United Kingdom

proteanelectric.com

Protean Electric is one of the few companies specialized in the technology of in-wheel propulsion with plants in the United States, United Kingdom and China. The *Protean Drive in-wheel motor* is a traction solution integrated into the wheels that converts the electricity directly into energy to drive the wheels, eliminating energy wastage due to a transmission. The company was bought by Swedish car manufacturer National Electric Vehicle Sweden (NEVS) at the end of May 2019.

Enabling technologies

Currently, a large part of the production costs of electric vehicles resides in battery production, even though market analyses highlight a reduction in their cost over time, strongly linked to vertical integration of battery production within the sector and to large-scale production thanks to superplants (on this subject, see the focus on gigafactories).

Furthermore, numerous players in the energy sector are increasing their investments in the infrastructures necessary to charge electric vehicle batteries, by enabling new domestic charging methods, public charging and the much-desired fast charging, functional, in particular, for the motorway travel.

At this juncture, it is necessary to examine in detail the technologies that characterize the electric vehicle battery segment and of the various charging methods of the same, in order to understand the main advantages and disadvantages of each.

Batteries: dominant technologies and alternative innovations

Put very briefly, a battery can be described as an object able to accumulate chemical energy and to release this energy in the form of electricity, which, once transferred to the electric engine is transformed into mechanical energy to drive the wheels.

The basic principle of today's batteries derives from Volta's pile: a chemical process generates a flow of electrons from one substance that releases them to another that receives them. The flow occurs within a third substance, called an electrolyte. The electrons then pass from the anode (negative pole) to the cathode (positive pole), generating a direct current.

From the lead battery to the lithium-ion battery

From Volta's first battery onwards, great progress has been made and innovation continues to pursue improvements in efficiency. The electric and hybrid cars in commerce mount various types of batteries, some obsolete and others still undergoing experimentation. Here below is a chronological overview of a universe, that of batteries, in rapid evolution:

- Lead-Acid Batteries

  These date back to the second half of the 1800's and represent the first type of rechargeable battery. They function thanks to a lead anode and a lead peroxide cathode immersed in a solution based on sulphuric acid (electrolyte). Today these are used in traditionally-powered cars to aid ignition, but until the 1990's they were also used to power electric cars. Classic examples of this were the Fiat Panda Elettra and the EV1 produced by General Motors.

- Nickel-metal hydride (NiMH) batteries

  In this battery type the anode is composed of by a metal alloy, while the cathode is made of nickel. The rechargeable penlight of AAA and AA types belong to this category. In the world of cars, these were fitted in the first models of the Toyota Prius, before being replaced by lithium-ion batteries. In general, the smallest and low-cost hybrid vehicles will continue for some years to come to use this type of battery. One of the greatest shortcomings of NiMH batteries is the so-called "memory effect", that is the progressive reduction of charging capacity and of autonomy from partial recharging; it suffers, moreover, from a percentage of self-discharge of the order of 12.5% daily and above all from a high temperature of functioning. As regards the life cycle of these batteries, this is of around 5 years.

- Lithium-ion (Li-ion) batteries

  Lithium-ion batteries cover various chemical mixtures used in various combinations of materials for anodes and cathodes. Each combination has different advantages and disadvantages in terms of safety, efficiency, costs, and other parameters. The most common combinations in the automotive sector are NCA (lithium-nickel-cobalt-aluminium, NMC (lithium-nickel-manganese-cobalt), LMO (lithium-manganese), LTO (lithium-titanate), and LFP (lithium-iron-phosphate). The batteries destined for vehicles require complex monitoring, balancing and cooling systems to control the release of energy, to prevent chemical leaks and to ensure an adequate durability of the cells. The electrolyte used is usually in a liquid state, even though new research is developing solid polymer systems, more stable and less volatile: these batteries display a very high energy density, which means that the same quantity of energy can be produced by batteries of lesser size and weight. Offering a better cost-efficiency ratio, Li-ion batteries become widespread in the world of cellular and portable devices, before also spreading into the automotive sector. Apart from their energy density and low rate of self-discharge (5% monthly), they offer the advantage of not suffering from the aforementioned "memory effect". Noteworthy is the life cycle (on average, car manufacturers guarantee a duration of 8 years or a kilometrage of approximately 200,000 km), due to a progressive deterioration from the moment of manufacture and irrespective of use. They are moreover moderately inflammable and function at an optimal capacity only within a range of temperature of between -10° and +30°. The first car to mount one was the Nissan Leaf in 2007.

  Other players such as Tesla and Panasonic have, instead, opted for a more radical approach to the problem: to reduce as far as possible the dependency of lithium-ion batteries on cobalt itself. In 2018 they announced a progressive abandonment of cobalt in the production of their batteries. The use of the nickel-cobalt-aluminium (NCA) technology developed by Panasonic – a technology that goes against the grain in the EV sector where

Lithium-ion batteries are the most used ones in BEVs.

Panasonic NCA technology allows to use 75% less cobalt.

the dominant model continues to be nickel-cobalt-manganese (NCM) – allows the Tesla Model 3 to use 75% less cobalt than the batteries used, for example, by Volkswagen.

The future: solid-state and lithium polymer batteries

Almost all the electric automobiles currently on the market are equipped with lithium-ion batteries. Nonetheless, the charging times, weight, dimensions and energy density are limits that can no longer be ignored: since 2012

TYPE OF BATTERY	ENERGY DENSITY in Wh/kg	COST €/kWh	AVERAGE DURATION (in # of discharge cycles)	LIMITS	PRODUCERS	VEHICLES
Lead-acid batteries	30-42	100	500-800	Environmental problems connected with materials used; low specific energy	Varta	Forklifts and pallet jacks
Nickel-metal hydride batteries	60-140	310	180-2000	Memory effect; self-discharge;	Varta; Panasonic; Energizer; Duracell	Toyota Prius (until 2016)
Lithium-ion batteries	100-406	200	500-7000	Requiring the circuit to be protected against overheating and explosions	Panasonic; LG Chem; CATL; Samsung	Audi and-tron, Volkswagen ID.3, Mini Cooper SE (in general all current hybrid and full electric models), Tesla
Solid state batteries	2x that of lithium batteries	Considerably higher than the lithium-ion batteries used today	Roughly 10 years	Cost still too high.	R&D [Samsung SDI; LG Chem, A123 Systems]	-
Flywheel batteries	-	50	Decades	Safety issues in event of casing breakage	Chakratec (start-up)	Mounted on some trams; prototype on Volvo S60 of 2013
Flow batteries	Up to 1400	300	Almost unlimited duration	Bulky in size and complex system	Green Energy Storage (start-up)	-
Graphenes upercapacitors	1-30	10000	1 M	Very low energy density and high cost, self-discharge considerable	General Electric; Maxwell Technologies	-
Aluminium-ion batteries	1060	250	>7500	Short “Shelf-life”	R&D and projects	-
Lithium-sulphur batteries	500	200	>1500	Rapid deterioration	R&D and projects	-
Lithium-air batteries	4500	Lower than lithium-ion batteries used today	-	Impossible to charge autonomously and particular optimal functioning conditions	Mullen Technologies, Inc., PolyPlus Battery Company	-

approximately 60% of car manufacturers’ investments have been directed to the development of solid-state batteries or to lithium polymers.

These batteries use solid materials for the electrolyte, thus minimizing failures and combustion as well as dependency on expensive cooling systems, all of which benefits extend the battery’s life cycle.

> *“Solid-state batteries are preferable because they are expected to provide 40% more energy density than the top-level lithium-ion solutions due by the end of this decade.”*
>
> Thomas Sedran
> Head of Corporate Strategy/M&A Volkswagen

Other batteries currently being developed

Research and technological advances in the world of batteries have also identified other technologies - still in varying stages of maturity but, which, in the future, could be valid alternativesto lithium ions – are here below described briefly:

↳ “Chakratec Boosting eMobility Anywhere”

- **Flywheel Energy Storage (FES)**

Flywheel Energy Storage is a electromechanical device for the storage of energy in the form of rotational kinetic energy: the battery accumulates energy as the flywheel rotates and this is then released until the rotation ceases. This makes it possible to accumulate large quantities of energy in an object which is, all things considered, small in size and there are no drops in autonomy deriving from the deterioration of chemical compounds. Still in the prototype stage, it presents hazards in the event of damage to the casing housing the flywheel. The Porsche 911 GT3 R Hybrid, presented at the Genova Motor Show in 2010, mounts a system of this type, while start-ups like Chakratec have decided to harness this technology to make more efficient and enhance EV charging methods and stations.

• Flow Batteries

In this type of battery the electrolytes are stored externally, generally in tanks, in such a way as to be able to "charge" the battery rapidly replacing the liquid electrolyte, while simultaneously the spent material is recovered so that it can be re-energized. There are different types of flow batteries: the redox (reduction-oxidation) flow batteries are the most common and allow electricity to be generated thanks to the difference in potential of the two tanks, one containing an electrolyte with a positive charge and the other with a electrolyte with a negative charge. When the battery is discharged, both tanks end up containing the same electrolytic solution, a mixture of positively and negatively charged ions.

In *hybrid flow batteries*, one or more electroactive components are deposited as a solid layer. The electrochemical cell contains one battery electrode and one fuel cell electrode.

Membraneless flow batteries make use of laminar flow, a model of fluid flow that occurs through the flowing of microscopic and infinitesimal layers one on top of the other without any mixing of the same, to guarantee the separation of the two electrolytes in the common nucleus, eliminating the need to insert a membrane, which is one of the most delicate parts of the technology.

The disadvantages of these batteries include the need to provide for the insertion of pumps, which determines an increase in size, and a low energy density.

• Graphene Supercapacitors

Batteries do not represent the only way to accumulate electricity. There exist, in fact, capacitors, an electric component that stores energy in an electrostatic field and that allows for very rapid charging. The release of energy too occurs more rapidly than from batteries. Capacitors have, however, a considerably lower energy density (approximately 7% of that of lithium-ion batteries), which translates into a greater size for the same quantity of energy stored. Graphene supercapacitors seem to be a valid solution to the problem, having an energy density almost equivalent to that of lithium-ion batteries. A second advantage of graphene is its efficacy at room temperature, which does not require continuous cooling as in the case of superconductors, particular materials that, if cooled to very low temperatures (close to absolute zero, 0 K = –273 °C), lose almost all electrical resistivity.

• Aluminium-ion batteries

Aluminium-ion batteries are a class of rechargeable batteries in which the aluminium ions provide energy by flowing from the negative electrode of the battery to the positive one.

Aluminium-ion batteries are similar in concept to lithium-ion batteries, but possess an aluminium anode rather than a lithium one. The theoretical potential energy density of aluminium-ion batteries is of 1060 Wh/kg compared with the limit of 406 Wh/kg of lithium-ion.

Due to their atomic structure, lithium ions can supply a single electron at a time while aluminium can produce three. Other advantages include the natural abundance of aluminium, which makes the material less expensive than lithium, the greater charging speed (approximately one minute) and the lower fire risk. Among the problems not yet resolved are the reduction in energy capacity which they undergo even if unused (the so-called shelf-life), which, at present, excludes their application in electric cars.

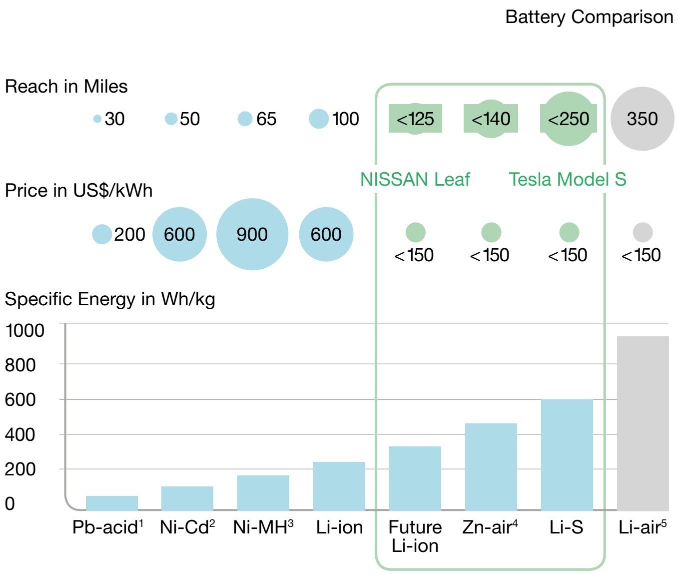
• Lithium-sulphur Batteries

Lithium-sulphur batteries could replace lithium-ion batteries on account of their greater energy density and their greater efficiency in terms of production costs thanks to the use of sulphur. At present the best Li-S batteries reach a density of the order of 500 Wh/kg, decidedly higher than most lithium-ion batteries. Li-S batteries have been developed with approximately 1,500 charge and discharge cycles, but further tests are still necessary on duration and on the best electrolyte to use before they can be produced on a commercial scale. Compared to lithium, the sulphur used is not toxic and is considered a safer material. The great still unresolved problem is that these batteries (on average) still tend to deteriorate after few charging cycles.

- Lithium-air Batteries

In lithium-air batteries the cathode is formed of atmospheric oxygen, while the anode of zinc. The separator is an insulator allowing only the transformation of ions. Thanks to the configuration of the open battery, which uses air as a reagent, lithium-air batteries have a much greater energy capacity (up to ~ 12000 Wh/kg, which is comparable to that of petrol), making them very attractive for the automotive industry.
Like the other experimental projects described this category too must deal with important limits. First of all, lithium-air batteries are based on oxidation of the lithium on the anode that is thus exposed to deterioration over time. Secondly, they emit harmful by-products resulting from the combination of the lithium-ion with carbon dioxide and water vapor in the air. Lastly, they are not suitable for use at high altitude, where the concentration of oxygen in the air is lower.

Tesla Models S currently with best battery specifications



1: Lead-Acid batteries
2: Nickel-Cadmium batteries
3: Nickel-metal hybride battery
4: Zinc-air batteries
5: Lithium-Air batteries

Source: Statista

Charging methods

Having analysed the main technologies, and those emerging, linked to batteries, light must be cast on two intimately related questions that undermine consumer confidence in electric vehicles: the methods and times of battery charging.

First of all, the difference between station and charging unit must be clarified. A station consists in a number of charging points or pillars that, in turn, allow for a number of simultaneous connections (two connections per pillar if we consider the Italian average).

↳ "The Battery Revolution. Ultra Fast Charging"

From a technical point of view, the current supplied can be alternate (AC) and therefore requires the presence of a convertor (rectifier) on board the vehicle able to transform the alternate current into direct current (DC). If the pillar also functions as a rectifier and therefore suppliers DC directly, the problem illustrated above does not present itself and the supply of electrical current is more powerful. There are then four main charging methods supported by current pillars:

MODE 1	• Standard power lead plugged into normal outlet • Charger in Vehicle coverts AC to DC and controls battery charging • Note: Mass manifactures no longer use this mode as the lead is always live.
MODE 2	• In-line EVSE control box (blue) is part of lead. • Lead is plugged into normal outlet (usually 15A) • EV will generally charge at maximum of 2.4kW (10A) • Charger in vehicle converts AC to DC and controls battery charging.
MODE 3	• Delicated wall box with control electronics built-in • Choices between 3.6kW (16A, single phase) to 22kW (30A x 3 phase) and even 40kW (63A x 3 phase) depending on EVSE chosen and EV charging capacity. • Charger in vehicles converts AC to DC and controls battery charging
MODE 4	• Charger is in the wall box • Connects via a different socket (three main types) depending on standard adopted by manufacturer. Currently up to 50kW (CHAdeMO), 120kW (Tesla) or 150kW (CCS).

The following table compares the characteristics of the 4 charging methods currently used:

	MODE 1	MODE 2	MODE 3	MODE 4
System of regulation and safety	Not provided	Present in the connection cable	Installed in the pillar	Installed in the pillar
Main use	Private for light vehicles/ micromobility	Private	Public	Public
Current supplied	Alternate	Alternate	Alternate	Direct
Average charging times	6 – 8 hours	4 – 8 hours	Variable according to the method (30 min – 8 hr)	20 – 30 min
Mode	Slow (domestic socket)	Slow (domestic or industrial socket)	Slow/Accelerated	Fast

What is evident is that direct current charging (DC) guarantees time advantages, and also allows integration of vehicles into the grid (VGI=Vehicle to Grid Integration): vehicles can return electrical current to the system in the event that grid loads required it.

A second rather important issue concerns the great variety of connectors and sockets for the charging of electric vehicles. These standards tend to vary according to the geographic market and to vehicles. The debate about one universal standard is somewhat heated: the majority of European and North American car manufacturers support the CCS (Combined Charging System), a socket that combines an AC connector with an optional DC, hence the resulting connector is called Combo Coupler, while the standard for the Japanese market is the CHAdeMO connector and that for the Chinese is the GB/T. The CCS is based on the SAE J1772 connector (the CharIN consortium standard) and is supported by the following producers: Volkswagen, GM, BMW, Daimler, Ford, FCA, Hyundai and the Model 3 for the European market for Tesla.

BATTRION

Battrion offers a storage solution for lithium-ion batteries aimed to increase the charging speed of high energy density cells.

Total Funding
$0.11 mln

Last Round
Mar 2019 Biz Plan Competition $0.11 mln

Country
Switzerland

battrion.com

Tesla not only produces and disposes of chargers for its proprietary charging, but also its own connector: the Tesla Supercharger. To prevent this becoming an obstacle to market penetration, the US company includes an adaptor for the J1772 connector with every vehicle.

The scenario is further complicated when considering the standards for fast DC charging. Since the fast chargers are able to supply up to 480 volts (from 2 to 4 times the power supplied by a normal charger), a “boosted” adaptor is necessary: rather than just two different connectors as for the J1772, fast chargers require three different connectors.

The SAE International, an organization for the definition of engineering standards, has, for this reason, defined its own standard for fast charging, on the basis of the traditional SAE J1772 connector currently used for Mode 1 and Mode 2. This modified connector makes it possible to use the same connector for all charging methods and is available for certain models like the Chevrolet Spark.

Other electric vehicles, such as the Nissan Leaf and the Mitsubishi i-MiEV, use a different type of connector for fast charging based on the CHAdeMO standard, even if an ever increasing number of fast battery chargers dispose of sockets both for the SAE standard and for CHAdeMO fast charging.

From what has been outlined so far, it is obvious that the absence of standardized modes, systems and sockets for charging may represent one of the main inefficiencies in the current EV ecosystem, in particular for non-domestic charging methods. It should also be highlighted that not all the plug-in hybrids are able to make use of fast charging on account of the small sizes of the batteries.

Battery disposal and regeneration – an open question

Shifting the focus onto the life cycle of electric cars from the perspective of the circular economy, attention should be paid to the battery aftermarket phase: the recovery of the material present in the cells, with particular reference to lithium, represents one of the main problems linked to the environmental impact of electric vehicles.

Despite the progress in this field, many improvements are still necessary if their production is to be made sustainable.

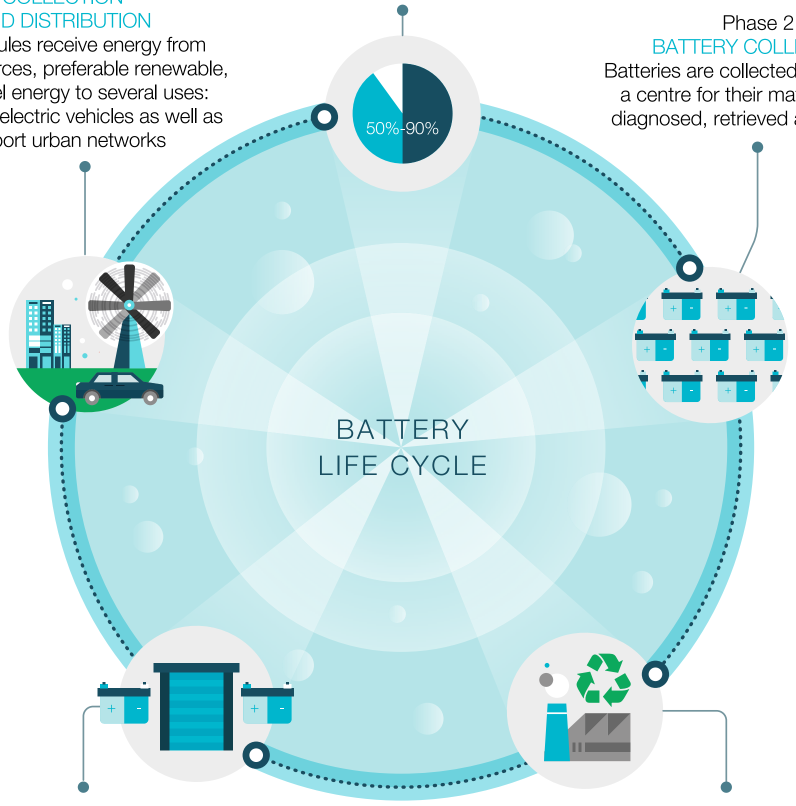
To give an idea of the life cycle of the battery of an electric car (or hybrid), it is a widely-shared opinion that these are no longer usable when their efficiency drops below 80% of their potential (calculated on the basis of various performances of this component). In the case of a Nickel-metal hydride (Ni-MH) batteries, this limit translates into 5 years of life or 100,000 km covered; as regards lithium-ion batteries, the average duration guaranteed is of 8 years or 200,000 km.

One of the main ways to give batteries a second life (another ten or twenty years) is the reuse of the same in storage plants: old battery packs removed from vehicles and reused in electric storage plants, accumulate energy from renewable sources releasing it at critical moments, relieving the load on the plants themselves.

Phase 1
END OF BATTERY FIRST LIFE CYCLE
As mentioned, the life cycle of a battery for electric vehicles is about 5-10 years, 100k-200k kilometres. At the end of this first cycle batteries retain an energy capacity ranging from 50%-90%

Phase 5
COLLECTION AND DISTRIBUTION
The modules receive energy from various sources, preferable renewable, to channel energy to several uses: recharging electric vehicles as well as support urban networks

Phase 2
BATTERY COLLECTION
Batteries are collected and taken to a centre for their materials to be diagnosed, retrieved and recycled



Phase 4
INSTALLATION OF MODULES IN STATIONARY STORAGE UNITS
At this point the modules become part of the storage units placed in various parts of the city to support the charging phases of the network with stored energy

Phase 3
BATTERY RETRIEVAL AND RECYCLING
After diagnosis, batteries with the same level of energy density and capacity are taken apart and reassembled in homogenous modules

To cite some concrete examples of solutions, a pilot project launched in Germany in 2016 permits the use of spent batteries in renewable energy plants (predominantly wind and solar) for the domestic grid. The car manufacturer Mercedes-Benz was the first to testify to the fact that, after a further useful life of ten years, the accumulators guarantee an efficiency, in any case, above 80 percent.

The French Renault, too, has established an agreement with Powervault, a company specialized in energy stor-

↳ "xStorage Home helps you store and control energy in your home"

age technologies, for the reuse of batteries from BEV's that are thus destined for use in domestic energy storage units in homes equipped with solar panels. xStorage Home is instead the project that Nissan has realized in partnership with Eaton, with the aim of accumulating energy when costs are low or when it is produced by solar panels.

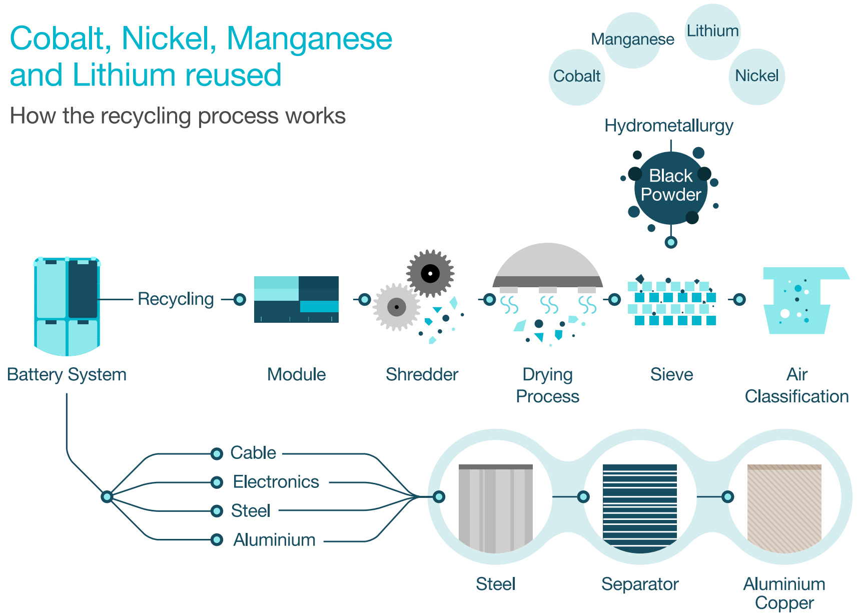
In general, energy storage for domestic use represents a very favourable segment since it requires a level of power lower than the automotive sector.

The second approach, which is often complementary to the first, is instead based on battery recycling starting from the chemical elements of which they are composed. This approach is, for example, pursued by Tesla, in a perspective of minimizing the demand for new raw materials and of integrating vertically the stages of the aftermaket into the production process, in what is defined as closed-loop battery recycling process.

In Europe most of the spent lithium batteries are processed in Germany where there are over 15 industrial operators specialized in the recovery of components such as cobalt and nickel. These processes, however, do not allow for total recovery of the materials contained in the so-called "Black Mass".

Cobalt, Nickel, Manganese and Lithium reused

How the recycling process works



Source: Statista

"In the process of battery recycling, after the plastic, copper and aluminium has been removed, there remains a viscous compound of lithium, manganese and cobalt. This compound is known as "black mass".

↳ "Le sfide e le opportunità della mobilità elettrica"

What is certain is that the regeneration and reuse of spent batteries can activate new supply chains in the area of electric mobility. Recently the Volkswagen Group announced that it wished to participate in the industrial race for the recycling of lithium batteries, with the recent construction of a pilot plant for the production of batteries and recycling of materials.

In Italy, the remarkable progress made by COBAT (Mandatory Consortium for Batteries), a consortium that has at its disposal 70 collection points and 24 plants specialized in treatment and recycling of batteries, stands out. In 2016, the consortium signed an agreement with Enel and Class Onlus based on the definition of an optimized process for the collection, safe storage, assessment of residual efficiency and regeneration of accumulators disposed of as waste. In this regard, the collaboration between COBAT and the CNR, initiated in 2014 with a feasibility study into the treatment and recycling process for spent lithium accumulators, has recently reached an important milestone with the filing of the European patent and of other partial patents for individual stages in the process. COBAT has studied a treatment for components allowing the elements of the battery (plastics, electric circuits, copper and aluminium collectors) including the black mass to be separated and, subsequently, allowing the chemically-active metals to be recovered. All this performed low temperatures in the interests of generating a lesser environmental impact.

To date, the question of the recycling of EV batteries for a secondary use is not regulated in legislative terms, if not by the dated European Directive 2006/66/CE that governs the management of the end of the life cycle of accumulators (currently being amended). It is necessary to establish a regulatory framework concerning the standardization of the criteria for assessing the conditions of batteries and the Principle of Extended Responsibility on the management of these at the end of their "second life".

Focus – Modular design for electric vehicles

Where a traditional internal combustion engine contains more than 2,000 components, an electric engine has about twenty: there derives a lower cost for car manufacturers in production, but also greater "internal space", due to the absence of a mechanical transmission and to the smaller size of a battery in comparison with that of a traditional engine. This allows car manufacturers to exploit vehicles' internal spaces differently, innovatively rethinking both the design and the aftermarket from a "modular" perspective.

Modular design is a design method in which a system is subdivided into smaller independent parts usable in different systems. In the sphere of electric mobility, the advantages that derive therefrom are multiple: from the reduction in EV production costs, to the speed of design, from easy and quick maintenance to greater possibilities to personalize the vehicle than standard products, from the rapid replacement of worn-out components to the possibility of "updating" one's own vehicle by choosing and installing latest-generation components. This means that, with the evolution of the technology and of consumer needs, the vehicle can be adapted, updated, completed, and not necessarily replaced.

↳ "Il veicolo elettrico che cambia forma a seconda di quanto spazio ti serve"

With the advent of the EV, the value chain is destined to a concentrate on batteries and on "after sales" management of customers, who will no longer purchase a product that is "made and finished", but a vehicle serving current and future needs.

One "modular vehicle" prototype is that presented at the Geneva Motor Show in 2019 by FCA with its Fiat 120 electric. Exploiting the modular design, the entire Fiat 120 electric can be personalized in its every last part, both inside and outside the car. Inside the car small holes are arranged thanks to which it is possible to add 120 different accessories sold separately by the dealers or printed in 3D by the customer. Modularity also concerns the battery pack, which can be adapted to the customer's travel needs, offering, moreover, the possibility to perform an upgrade subsequently.

NOBE CARS

Nobe is an electric three-wheeled, three-seater all-wheel-drive car designed by a group of ex students of the Technical University of Tallin, Estonia.

The vehicle combines the design of the vintage car with the technological innovation of a completely electric vehicle devised for urban mobility. The "electric tricycle" is able to reach a maximum speed of 130 km/h and can accelerate from 0-62 mph in only six seconds. It is equipped with 3 electric engines (one per wheel).

↳ "MyNobeCar"

It mounts a "battery pack" with a a dual-battery system: the first is considered the main one and supplies energy to the wheels, while a separate battery provides energy for the vehicle's support systems (lights, heating and cooling, audio devices).

The innovation in the design and the extreme lightness - 600 kg in weight, less than half that of a petrol-powered city car – also provide the possibility to park on a vertical wall "gecko style" thanks to a specific support mechanism.

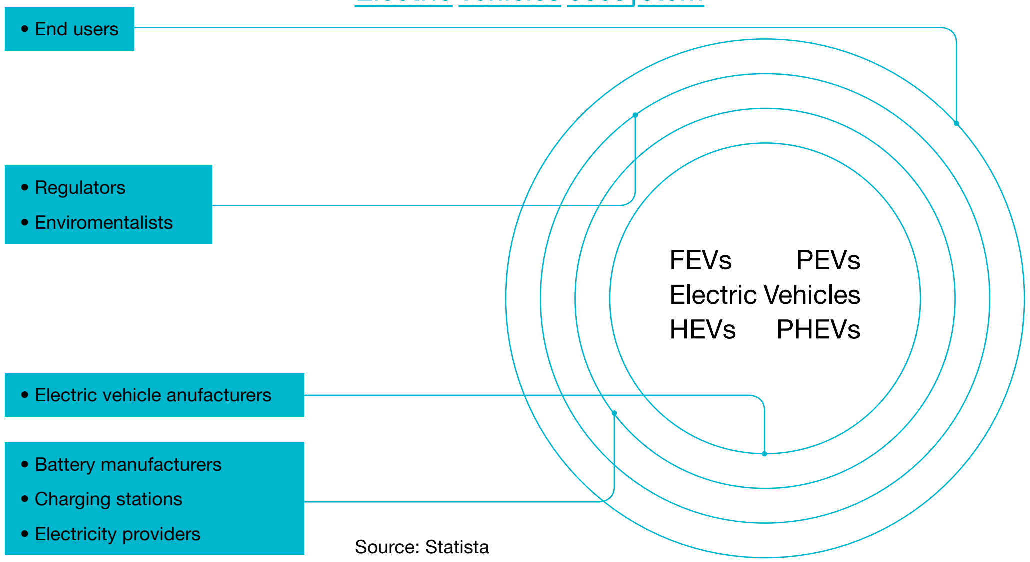
The Estonian start-up presented the prototype vehicle at the Geneva Motor Show 2019 and launched a crowdfunding campaign to produce the first 10 examples of what its devisors themselves define as "the most sustainable car in the world", thanks to its complete recyclability. The completely replaceable components are designed to be upgraded, in this way extending its life cycle.

The company's aim is to is "decentralize" the construction process in order to facilitate a more rapid expansion globally. Nano Cars indeed seeks to build "nano-factories" in Estonian cities with an industrial past, producing vehicles and technologies that have a "positive net" impact on the local economy and on the environment. It also looks to create low-tech jobs and new business opportunities for the local population.

The e-mobility ecosystem

In the process brought about by the advent of electric mobility, there is an ongoing transformation of the automotive supply chain and more generally of transport: new market segments are facilitating the entry of new players attracted by the potential profits (producers of electric vehicles for private transport and commercial vehicles, producers of vehicles for micromobility, companies producing batteries and dealing with their disposal and regeneration, suppliers of components for the spare parts and aftermarket sectors, systems integrators, etc.), but, at the same time, they require reappraisal of infrastructure solutions and of services offered.
The ecosystem generated by this technological revolution includes, in fact, new component producers (OEM's) necessary for EV's, suppliers of charging stations and of electrical energy, the electric vehicle producers themselves and stakeholders, understood as regulators and consumers.

Electric vehicles ecosystem



Source: Statista

Car manufacturers: the big automotive players

Car manufacturers are making huge investments in technologies, on the one hand, and in new business models, partnerships and acquisitions, on the other. This requires a long-term vision of objectives, differentiation strategies and of the technologies that are desired to be implemented and integrated.

While, in the course of 2018, many "incumbents" implemented strategies designed to conquer EV market share, only three companies succeeded in assuming a leadership role in this segment.

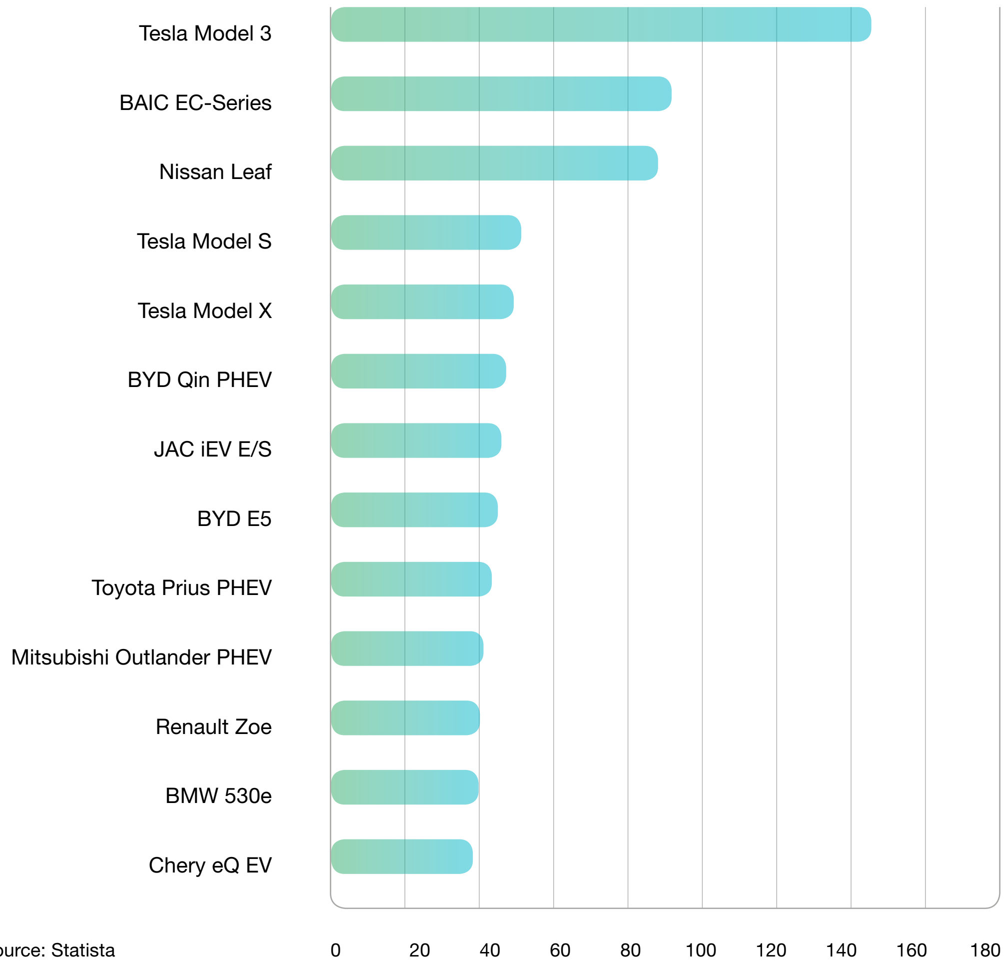
The car manufacturer that sold the largest number of electric vehicles in the world in 2018 is Tesla, with almost a quarter of a million of cars delivered, in part, thanks to the entry into the market of the new Model 3 and Model X, of which 191,000 vehicles in the United States, 30,000 in Europe, approximately 17,500 in Canada and 6,500 in the Asian markets (predominantly China).

Tesla sold 250,000 cars in 2018.

The Chinese BAIC, for its part, was the second-placed manufacturer of electric cars globally with 152,000 new vehicles, although almost 100% of its turnover is attributable exclusively to the Chinese market. Renault-Nissan also had a propitious 2018 thanks to the 150,000 new electric vehicles that it sold, albeit losing at the same time its world record in production.

BYD, one of the best recent bets made by famous investor Warren Buffett, sold 105,000 vehicles, even if predominantly in the Chinese market, ranking as the fourth electric car manufacturer in the world. Following behind is another Chinese company experiencing strong growth: Zoyte, with 64,000 new cars delivered in 2018, in 2019 will begin production of electric vehicles for the Chinese domestic market in a joint venture with Ford.

Worldwide PHEV & BEV sales by model (in 1,000 units)



Source: Statista

207 EV models in 2018, almost double the 2017.

The race has only just begun however: overall, in 2018, there were 207 models on the EV market (143 Battery EV and 64 PHEV), almost double the previous year, and the forecasts for 2019 anticipate the launch of another 45 EV models globally.

There are five areas on which EV producers must concentrate in order to maintain a competitive edge and to stay in the market:

Brand	A globally consolidated customer base can prove advantageous for the “incumbents”, but also presents potential threats. Investing in branding and positioning in the EV market are crucial: car manufacturers and “new entries” must be credible to consumer eyes in terms of eco-sustainability.
User Experience	The “customer experience” (understood as both the drive experience, and as the experience connected to purchase and “aftermarket”) is one of the key elements of differentiation strategies in the automotive sector. Overcoming the complexities linked to the maintenance of electric vehicles and of infrastructures and also capitalizing on unique post-sales needs can benefit the traditional player over emerging companies.
Production Strategy	The battery is the most expensive and most indispensable part of an electric vehicle. It is fundamental to build a strong strategy for battery production: creating strategic partnerships with battery producers but also with companies operating in the field of battery disposal and regeneration is of vital importance both for parent companies and for “new entries”.
Skills and specializations	In the EV market technological innovation and skills make the difference between one final product and another: investment in training and human resources, on the one hand, and innovative production technologies, on the other, constitute distinctive factors and could benefit emerging companies, less tied to traditional skills and systems.
Business models	New consumption models are ever more imbued by the idea of the “use” of a good, rather than of its acquisition as personal “property”. Business models must adapt to new models of consumption, by building new partnerships among parent companies, start-ups and utilities.

The "new entries" too are required to adopt a strategic approach that makes it possible to identify and leverage their own strengths. Versatility, agility, flexibility, independence and the experience gained in other sectors – including ones very distant from the automotive one – are necessary to compete with incumbents and with other start-ups.

On the start-up front, in fact, many are manufacturing completely hybrid and electric vehicles ranging from saloon cars to commercial vehicles, to bicycles, scooters and kick scooters. Those start-ups working on the design and production of electric cars and commercial vehicles for end customers and corporate fleets are competing directly with the main car manufacturers. Among these the Chinese NIO, the American Faraday Future, Rivian (which is working on the launch of an electric pick-up) and Lucid Motors. The last received an investment of $ 1 billion from a Saudi Arabian public investment fund in the autumn of 2018 and has scheduled the launch of a completely electric saloon car by 2020.

In the area of two-wheeled vehicles such as motorcycles and scooters, the start-ups in this sector are designing compact electric vehicles that do not exceed a speed of 25 km/h for passenger transport. Some of these companies, such as Cowboy, sell their personal PEV's directly to consumers, while others, such as Ninebot, sell to operators of shared fleets. This category also includes start-ups, such as GP Motion, that are developing electronic devices and retrofit kits (see the focus on Retrofitting later in this section) to convert traditional bikes and scooters into electric ones.

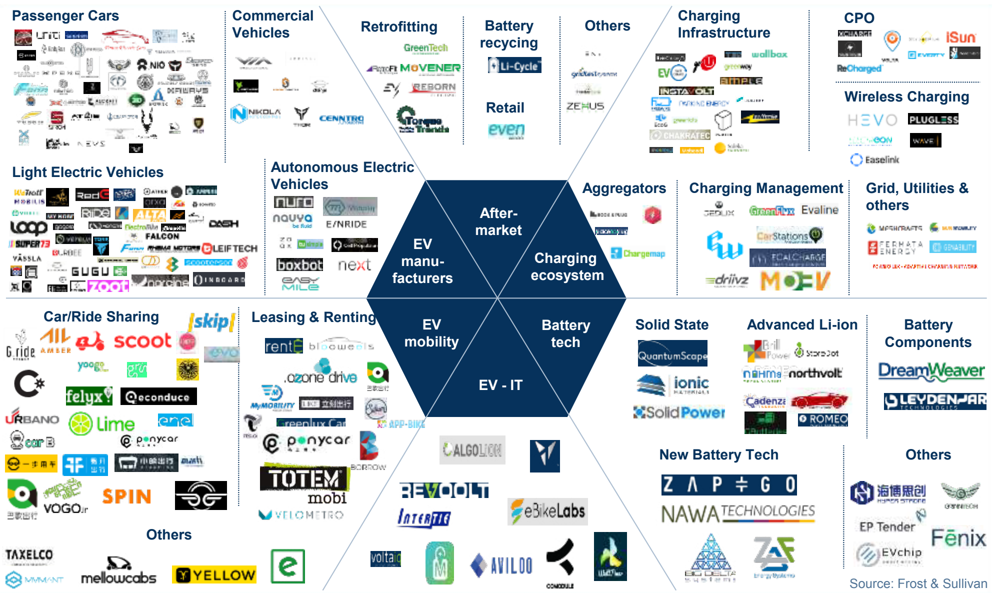
In the area of commercial vehicles and vehicles for the smart city, some start-ups are developing electric vehicles for commercial use, such as electric tow trucks and electric buses for public transport. Among these, the Detroit company Inventev is developing electrification solutions for medium-size hybrid commercial trucks (PHEV). UPS has announced that it wishes to trial a fleet of commercial electric vehicles provided by the English Arrival in London and Paris, while, still in the area of electric corporate fleets, FedEX announced at the end of 2018 that it had ordered 1,000 electric vans produced by the Chinese Chanje.

Focus – The EV start-up ecosystem

According to Frost&Sullivan, at the end of 2018 the start-ups involved in the ecosystem of electric mobility numbered approximately 270, subdivided into the following categories:

- *EV Manufacturers* - producers of electric and full hybrid vehicles, electric commercial vehicles and electric autonomous vehicles;
- *EV mobility* – start-ups that have launched on-demand platforms for the sharing of electric vehicles and for facilitating their diffusion (car sharing, ride sharing, leasing, renting, etc.);
- *EV – IT* – companies that are working on IT support infrastructures for electric mobility (diagnosis and maintenance of vehicles and batteries, IoT networks and cloud platforms for management);
- *Battery tech* - start-ups that are developing energy storage solutions for electric vehicles, from the most commonly used lithium-ion battery to emerging technologies such as a solid-state batteries and fuel cells;
- *Charging ecosystem* – companies that are building the charging infrastructures necessary to support electric vehicles, as well as the platforms and services necessary to facilitate the management and interoperability of charging stations. These are also developing the Vehicle-to-grid technology to balance the exchange of energy between electric vehicles and the grid;
- *Aftermarket* – start-ups that deal with spare parts for electric vehicles, and also with disposal and regeneration of batteries and with retrofitting.

Key EV Start-up landscape highlights



Focus – Retrofit

The advent of electric propulsion has led to the emergence of new market segments linked to the so-called “Retrofitting”.

Retrofitting consists in adding new technologies or functions to an old system– in this case a vehicle -, in order to extend its useful life, to increase its efficiency or often also for merely aesthetic reasons. The most common examples in the field of mobility are the addition of a catalytic converter or of an antiparticulate filter to an endothermic engine or the electric rehabilitation of an old vehicle, by replacing the ICE with an electric engine.

Retrofitting for e-Mobility is becoming a common phenomenon, since the conversion of a conventional vehicle into an electric car requires the intervention of a simple mechanic’s workshop, and this the very added value of the retrofit: the negative impact of electric mobility on the aftermarket ecosystem (due to the smaller number of components in the engine) may be mitigated by new specialist segments in mechanical workshops; the retrofit may be considered a valid opportunity for the European automotive supply chain from a perspective of economic development and environmental sustainability. At the same time, from the point of view of the consumer, retrofitting makes it possible to reduce the still high purchasing price of a new electric vehicle, while not forgoing the efficiency in terms of consumption and emissions that characterizes EV’s.

In Italy, the retrofitting market was regulated thanks to the “Retrofit” Decree, no. 219 of 1st December 2015, that permits the electric requalification of used vehicles that belong in the “M” category (combustion engine vehicles for private transport and light commercial vehicles under 3.5 tonnes). Furthermore, in order to obtain post-intervention approval, vehicles must be converted with certified retrofit kits, composed of an electric engine, a battery pack and a grid interface for the charging thereof. The most delicate aspect of retrofitting is linked to the preservation of the vehicle’s original safety standards.

Activities	Estimated cost (€)
Removal of ICE and mechanical parts	1.000
Installation electric engine	1.000 – 4.000
Installation of electronic components	1.000 – 3.000
Battery pack	4.000 – 5.000
Labour	1.000

The “Retrofit” decree has enabled many companies to enter this market segment. For example, Mobility r-Evolution is a network of companies meeting the need to bring together Italian SME’s dealing with the production, installation and maintenance of the retrofit kits, thus creating a collaborative ecosystem able to withstand the competitive pressure of international players.
The cost of a retrofit ranges from 8,000 to 14,000 euro (for some vintage cars or those in the premium segment it can exceed 20,000 euro); the retrofit involves removing the engine, fuel tank, exhaust, radiator and cooling system to make space for the electric engine and battery pack.

↳ “New energy for the Beetle”

In September 2019 the German automaker Volkswagen announced its collaboration with the German company eClassics to convert its Beetle and vintage minivans into electric vehicles.

Vintage cars and vans of automaker to be converted to electric

Photo: Trendwatching

→ Aiways

Aiways of Shangai is the first Chinese start-up intending to enter the European market with its U5, an electric SUV with 125 Kw and 500 km of autonomy (NEDC cycle) thanks to its 63 kWh batteries.

The aim of Aiways, whose estimated value is over 1.6 billion dollars, is to enter a market dominated by combustion engine vehicles otherwise produced by German, French, American, Italian etc. companies.

The Chinese start-up seeks to enter the “race” in Europe with an aggressive pricing policy and an innovative business model, offering the SUV only online and only on a leasing contract – with a competitive monthly charge – thus eliminating dealerships as intermediaries.

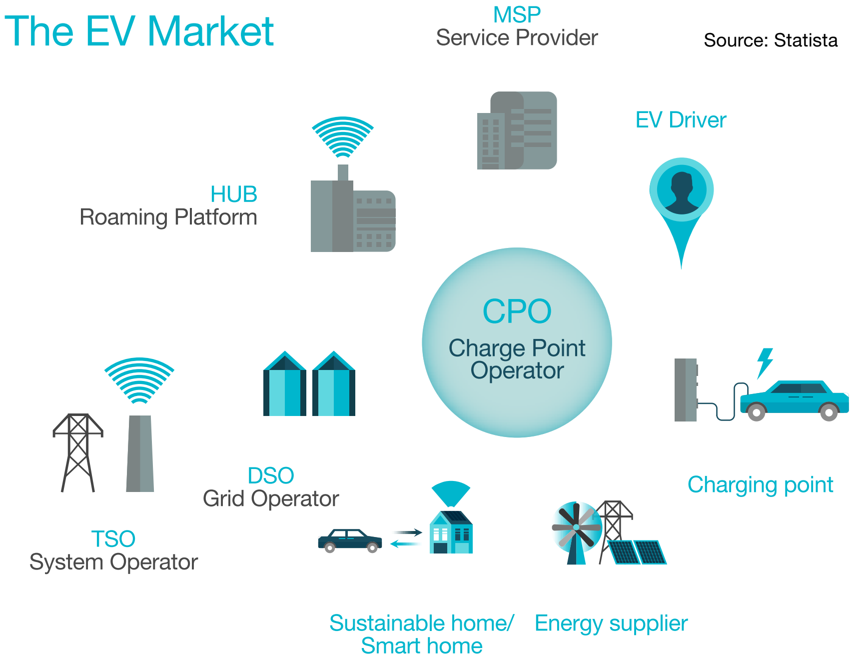
In addition to adopting cutting-edge onboard and electronic control systems, Aiways is also focused on a user experience that fully harnesses the possibility of being permanently connected, by providing an app that makes it possible not only to remotely control car functions, but also to use its video cameras to monitor what is happening around the vehicle.

“Mobile Home” is the Chinese company’s payoff for its first product, that will initially be delivered free of charge only in Germany.

Electric infrastructure

The EV Market

Source: Statista

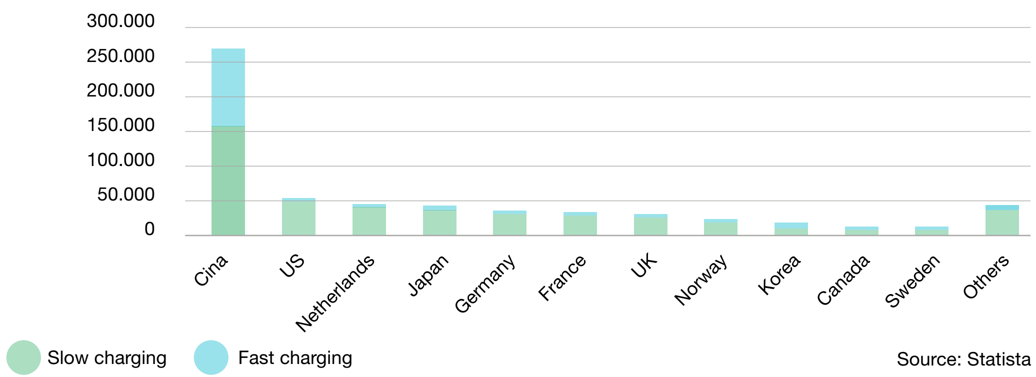


In operating terms, the electric infrastructure ecosystem for EV’s requires the intervention of various players. In first place, there are the Charge Point Operators (CPO), that is those organizations responsible for the management, maintenance and functioning of the charging stations. Another player involved, who does not often coincide with the CPO is the Charge Location Owner; this is the owner of the physical space on which the charging station stands.

Also part of the ecosystem are the Energy Supplier, that is, the supplier of energy for the charging points, and the Mobility Service Provider (MSP), with whom the owner of the electric vehicle has a contract for all services relating to the EV. Usually the Mobility Service Provider includes some other players, such as the energy supplier or the CPO, maintaining close relations with the operator of the distribution system and the meter operator. There is also a roaming platform, usually handled by a central organization that enables an efficient exchange of information among the different market players. These platforms, connecting the various parts, create a digital cross-border charging network.

As regards, in particular, public charging points through the chargers spread around the territory, globally the country that has invested substantial sums of public and private money in the growth of charging points is China, which, at the end of 2018, could boast 275 thousand charging stations within its national borders, compared with the 256 thousand stations in the rest of the world.

Number and type of charging points by country



Source: Statista

↳ "Does The Renewable Energy & EV Wave Include Shell & BP?"

According to the estimates of the "National Renewable Energy Laboratory", the annual investments necessary to support the mass diffusion of EV's are of the order of 7 - 8 billion dollars. The players currently best placed to invest in the supply of charging points are the oil companies and utilities. Their advantage derives from the great amounts of capital at their disposal, but also from their experience in energy distribution and, in part, from their need to re-convert their traditional business model because of the fall in the demand for fossil fuels.

In 2018 there were approximately 630,000 public charging points globally. This number is beginning to be comparable with the numbers of petrol or diesel filling stations: 168,000 distributors in the United States, 115,000 in Europe and 100,000 in China. Nonetheless, there still remains a strong concentration of EV charging points in urban areas, which inhibits the choice of electric transport for long distances, especially in rural areas.

8,300 public charging points in Italy, as of late 2019.

It is estimated that in Italy in 2019 there are over 8,300 public charging points, but there is a constant increase in the number of companies, above all utilities, that are working to catch up with traditional filling stations, for which Italy holds the European record: 20,800 fuel distributors compared to 14,400 filling stations in Germany, 11,000 in France and 8,400 in the United Kingdom.

Enel X, for example, is looking to install approximately 28,000 electric car chargers by 2022. The "National plan for the installation of electric vehicle charging infrastructures" presented in November 2017 provides for widespread coverage across all Italian Regions (including the islands) and is looking to growth in the numbers of electric and hybrid vehicles in circulation. Enel X's investment of approximately 300 million euros seeks to create a network composed of Quick chargers (22 kW) in urban areas, and Fast (50 kW) and Ultra Fast (up to 350 kW) for fast charging, outside urban areas.

The latter include charging stations in the European EVA+ (Electric Vehicles Arteries) project, co-financed by the European Commission and coordinated by Enel in collaboration with the Austrian utility Verbund and car manufacturers Nissan, Renault, BMW and Volkswagen.

Observing the start-up horizon, many of these are working on the construction of charging infrastructures, platforms and services to facilitate the management and interoperability of stations, including models of Vehicle-to-Grid (V2G) to balance the energy between electric vehicles and grid. In the sphere of public charging networks, aside from designing charging systems for homes and workplaces, ChargePoint is developing solutions for public and residential charging by raising huge investments. In addition, there are start-ups supporting the interoperability of charging stations and services such as network management and advanced invoicing functions. For example, Driivz has developed a cloud platform that provides station operators with a real-time "dashboard" that displays what is happening at every station and every single charging point.

NUVVE

Nuvve offers a commercially available V2G solution that enables any electric vehicle battery to generate, store, and resell unused energy back to the local electric grid.

Total Funding
$10 mln

Last Round
Apr 2019 Incubator/Accelerator

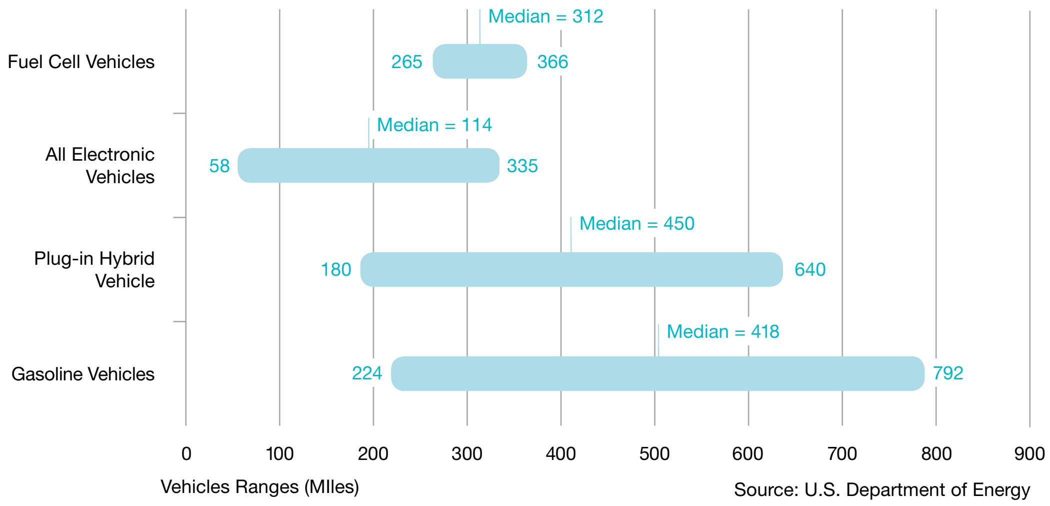
Country
United States

nuvve.com

As regards V2G, start-ups are developing a technology enabling electric vehicles to balance the energy distribution grid thanks to their storage capacity, generating, at the same time, revenues deriving the resale of unused energy on the grid. Nuvve provides software that calculates how much energy stored in an electric vehicle can be sold to the grid.

Battery producers

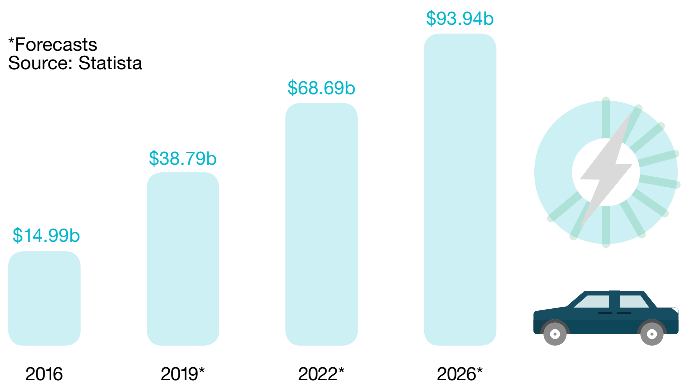
Breadth of fuel cell, AEV, PHEV and gasoline light vehicles ranges, MY 2017



Electric vehicle autonomy has always been a strong functional and psychological barrier to the consumer, as well as the greatest limit of EV's in relation to traditional internal combustion engines. For this reason the duration of the batteries is one of the parameters of differentiation between electric cars and thus one of the main elements in support of EV market penetration. The introduction and technological improvement of lithium-ion batteries are enabling of electric vehicle producers to market cars and other vehicles that, in terms of autonomy and kilometres covered with a single charge, are beginning to be comparable with the ICE.

The Electric vehicle battery market's enormous potential

Size of the global electric vehicle battery market from 2016 to 2026 (in USD)



According to forecasts reported by Statista, the volume of the global electric battery market is destined to grow exponentially over the next five years.
The main factors to which this growth is attributable are the ever more numerous collaborations between component producers (OEM's) and the producers of electric vehicles. A significant contribution comes also from falling battery prices, in large part determined by two factors: the developments in research into the ideal combination of chemical components in batteries, on the one hand, and the increased dimensions of production plants (observe the gigafactories), capable of reducing the per kWh production costs of the battery pack for the automotive sector, on the other.

Since 2010 the price of batteries has decreased by over 80%.

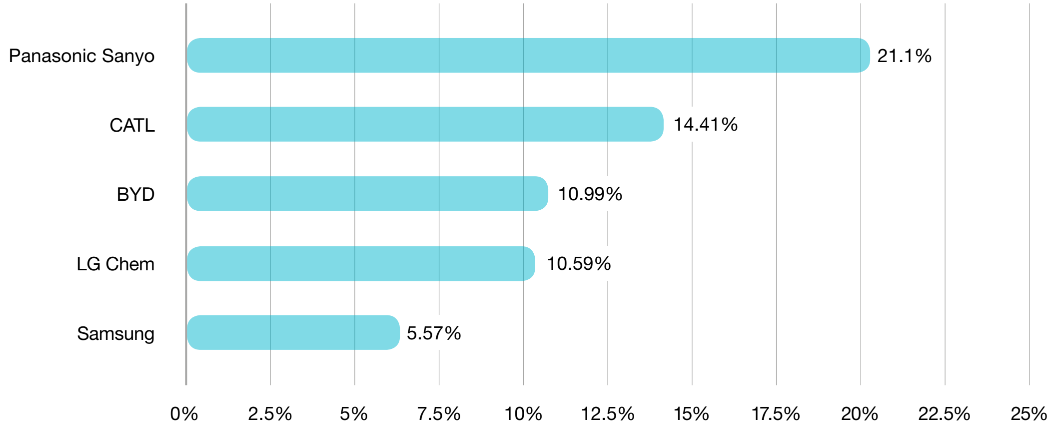
According to Bloomberg New Energy Finance (Statista), it is essential that battery costs halve for EV's to be considered competitive. The experts assert that the equalization of the prices of EV's and of ICE vehicles depends largely on the value of the battery and this will become possible in the next decade.

By 2025 the construction of 8 new plants with an individual capacity of over 5 GWh is planned.

As regards the current production of lithium-ion batteries, it is possible to observe a strong market concentration, there being only five players possessing over 60% of the lithium batteries market.

Global market share of Lithium ion battery makers in the 1st quarter of 2018

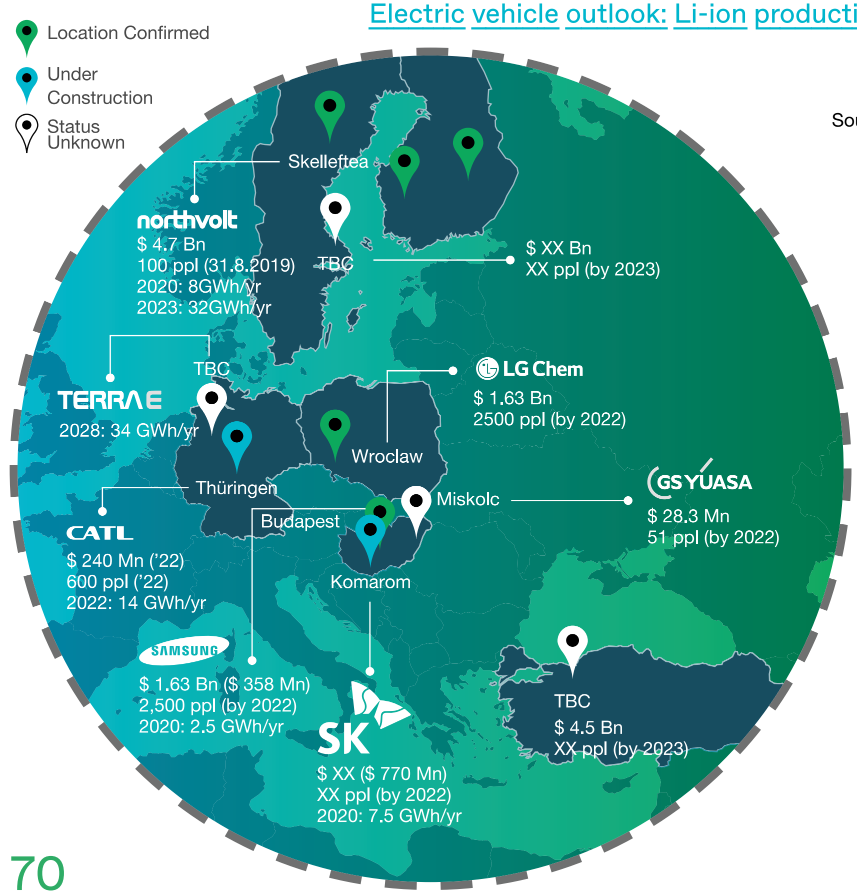
Source: Statista



Moreover, there exists a strong geographic polarization of production plants: there are approximately 390 Asian plants for battery production for the electric vehicles forecast for 2020, as opposed to 38 North American plants and 23 European production plants.

Electric vehicle outlook: Li-ion production expansion, EU, 2018

Source: Frost&Sullivan



To deal with this migration of the value chain, Europe is seeking to promote, through co-investments by the Commission, the localization of plants specialized in the production of batteries for electric vehicles, in such a way as to be able to compete with Asian markets. It is forecast that by 2025 approximately 8 new production plants with an individual capacity of over 5 GWh must be completed.

EVs batteries value chain

Manufacture of components	The first added value process in producing batteries for EVs comes from the manufacture of individual components that make up a cell: cathodes, anodes, electrolytes, separators and collectors of current
Manufacture of single cells	The second process in the value chain of batteries is the production and assembling of single cells
Production of batteries of cells	Cells are then configured in larger modules (batteries of cells) that also include a component for electronic management
Assembling the battery pack	Assembling the battery pack requires modules (batteries of cells) to be aggregated into systems that can manage energy distribution, charge and temperature. These systems are also called Battery Management Systems (BMS).
Integration into vehicle	Finally, the battery pack is ready to be fitted into the vehicle.

Lastly, focusing attention on the start-up ecosystem, since in the current state of the art of the dominant lithium-ion technology there exists a strong trade-off between autonomy (proportional to the size and volume of the batteries) and weight of the "battery pack", new market players are coming through with the aim of making their mark in this competitive environment with their own technologies in the field of energy storage.
In regard to the most common lithium batteries, start-ups like Sila Nanotechnologies (in collaboration with Sam-

sung) are seeking to increase battery energy density, by replacing part of the graphite used in the anode with silicon, a material that can contain up to 25 times more lithium ions than graphite.

Pellion Technologies, in contrast, has opted for the technological development of lithium metal batteries, an innovation that has made it possible to develop an anode composed entirely of lithium atoms, doubling the energy capacity of the traditional lithium-ion battery while halving its weight.

Another alternative, explored by the start-up Skeleton Technologies, is the use of ultracapacitors, that is, high-capacity condensators capable of reducing the charging times when compared to the traditional chemical materials present in batteries: the ultracapacitors are claimed to be able to double duration and to reduce the size of the battery itself.

Lastly, there are also market players exploring the option of solid-state batteries, the advantage of which is to replace the highly reactive liquid electrolyte with a solid one capable of supporting higher temperatures temperature. Thanks to its extensive research in this direction, Ionic Materials has received financing from car manufacturers including Hyundai, Mitsubishi and Nissan.

SILA NANOTECHNOLOGIES

Sila Nanotechnologies develops portable energy storage that is lighter, smaller, and cheaper than lithium-ion technology. This technology uses low cost nano-composite materials that could cut energy storage cost in half or more.

Total Funding
$246.83 mln

Last Round
Apr 2019 Series E $170 mln

Country
United States

silanano.com

Focus - Gigafactory

As we have seen, batteries in their life cycle starting with the precious raw materials of which they are composed and going right up to the delicate management of their “end of life”, are the most important and costly components in electric vehicles. The main producers of electric vehicles - often in partnership with other companies - have therefore made moves to reduce the main production cost of EV’s and to produce enough batteries to satisfy a demand in growth.

Tesla has once more stolen a march on many other players by announcing a co-investment of 5 billion dollars with Panasonic for the construction of the Gigafactory 1 production plant (from which other plants of similar size take their name), the goal of which is to reduce production costs by 30% by exploiting unprecedented economies of scale.

Tesla Gigafactory 1 will be able to produce 50 GWh per year.

The Tesla and Panasonic Gigafactory 1 increased its capacity to 22GWh in 2018 with a rate of plant use of 92%, by far the largest in the lithium-ion battery sector. Once the plant is completed in 2020 it will be able to produce more lithium batteries in a single year than the total produced globally in 2013 (50 GWh per year from 2020). On the back of this success, Tesla has begun construction of its Gigafactory 3 in China, in order to bring part of the production process closer to the largest electric vehicles market in the world.

In general, the demand for, and consequent production of, lithium-ion batteries has risen from 19 GWh in 2010 to 221 GWh in 2018, and it is forecast that the multi-terawatt (TWh) scale will be reached in the next few years, considering the growing number of mega-factories projects on globally. According to the estimates of Benchmark Mineral Intelligence in 2019 there are 68 gigafactories under construction with target production of 1.45 TWh by 2028, compared with only three gigafactories at the beginning of 2015.

Again according to *Benchmark Mineral Intelligence*, it is LG Chem that earns the record thanks to its construction of five gigafactories on three separate continents, an expansion that took the South Korean producer to a production capacity of 51 GWh in 2018.

Also the recently-listed CATL (China), has built two new lithium-ion battery plants in Germany and in Guangzhou, while expanding its primary production base in Ningde and, in 2018, even tripling its own battery plant in Jiangsu. CATL’s total capacity is around 40 GWh per year, even if the question of the actual quality of their batteries in comparison with those of their competitors remains controversial.

The production of lithium-ion batteries has risen from 19 GWh in 2010 to 221 GWh in 2018.

SKELETON TECHNOLOGIES

Skeleton Technologies is a manufacturer and developer of high energy and power density ultracapacitors. The Company provides green and cost-effective energy solutions for the automotive, transportation, industrial, and renewable energy markets. Skeleton Technologies’ patented graphene-based ultracapacitors provide four times higher power density and up to two times higher energy density than its closest competitors.

Total Funding
$52.28 mln

Last Round
Feb 2017 Loan $15.93 mln

Country
Estonia

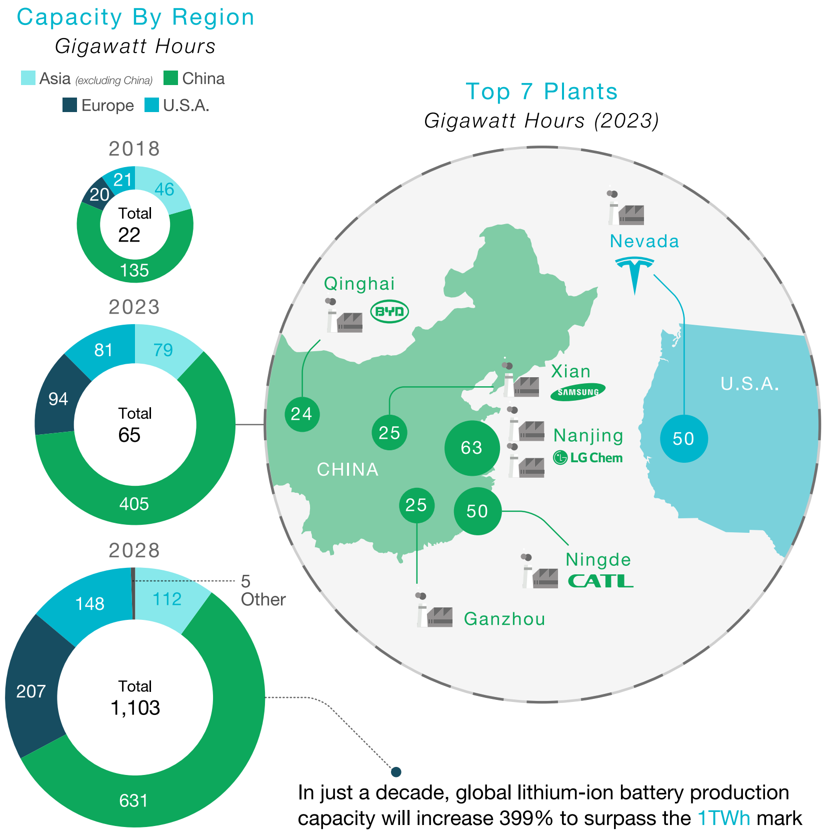
skeletontech.com

The first Chinese producer of EV's, BYD, opened its new lithium-ion battery mega-factory in Qinghai in 2018, thus doubling its own production capacity. BYD has also announced two new plants in Shaanxi and Chongqing and will thus dispose of a total of five mega-factories.

Lithium-ion Revolution

Battery production to ramp up drammatically with the equivalent of 22 Gigafactories online by 2028

Source:
visualcapitalist.com



Aftermarket

As previously highlighted, electric vehicles have 80% fewer components than traditional internal combustion engine vehicles. The greater part of internal combustion engines transmissions are composed of approximately 2,000 different moving parts, the combined friction of which, while in part reduced by oil, causes a 70% loss of engine efficiency. In comparison, the electric vehicle and its 20 (if not even fewer) moving parts in the engine block, present a lesser mechanical complexity and thus a lesser probability of having to expensive and unforeseeable repairs and replacements of mechanical parts. The only exceptions are the replacement of tyres, and the ordinary and extraordinary maintenance of batteries.

It follows that also the world of the aftermarket, that is to say, spare parts and maintenance, is affected by the electric car revolution: car mechanics will have to be ever readier to "get hands-on" with these types of cars, the maintenance of which, compared to that of an ICE vehicle, requires different care. An electric vehicle does not require, in fact, the replacement of spark plugs, injectors or filters, nor must it undergo testing for polluting emissions. Maintenance is instead concentrated on all that touches on the electrotechnical side. Paramount is the verification of the efficiency of the battery (key element for vehicle function), of the control units and other components (inverters, electric engines, etc.). With the diffusion of electric mobility, the whole aftermarket sector will have to focus on various specializations and on training and upgrading skills.

The carMD® Vehicle Health Index™ is an index that has been published annually since 2011 and provides data on car repairs, displaying the most common problems linked to the engine and the related repair costs thanks to a sample of over 11.4 million repairs. According to the 2019 Vehicle Health Index, the US repairs and spare parts market, has experienced an increase in repair costs of 6.5% (from 2017 to 2018): the average cost of repairs in 2018 was of around 380 dollars. This increase was associated to an increase in the numbers employed in the sector of 11% and in component costs of 3.5%, hence it can be deduced that the spare parts market is a high added value one.

According to Frost&Sullivan, the advent of EV's will have a many impact on demand and on the supply of many components (all players in the supply chain will experience an average contraction in revenues of between 1% and 2%), but will also help some segments grow.

The segment that will be most strongly affected by the contraction in demand will be that of motor oil. According to McKinsey's analysis, in 2015 52% of world demand for lubricants came from the automotive industry, hence the gradual migration towards electric mobility will have strong implications for the whole lubricants market. According to the same analyses, by 2030 approximately 5% of the vehicle pool could be HEV/PHEV, while up to 12% of the vehicle pool could be BEV. Such a scenario of the penetration of pure electric vehicles, that do not use motor oil at all, would have a strong impact on demand for lubricants (-3.1% in revenues by 2025 according to Frost&Sullivan forecasts).

The second segment of the aftermarket that will undergo a major contraction is that of spark plugs. According to Frost&Sullivan, the absence of combustion mechanisms in the electric engine will lead, in this segment, to a 1.6% fall in revenues by 2025.

The third segment by significance in the fall in demand (-1.5% in revenues) is represented by brake discs: electric cars often use the engine for regenerative braking, taking part of the work away from the braking system, and hence the brake discs tend to wear down less and last longer. Nonetheless, since the brakes are used less, moisture tends to accumulate more readily, making necessary more frequent brake fluid changes.

According to Frost&Sullivan's analysis, other market segments will undergo expansion, above all the battery market, which will experience a growth in revenues of 7.2% by 2025.

↳ "The Obsessive, Secretive Race to Make the Perfect Tire for Electric Cars"

The second area in terms of potential for growth is that of tyres: as they represent the "contact point" between the vehicle and the road; on account of the greater torque and the weight of the batteries, EV's tend to wear out their tyres much more quickly than ICE vehicles, which entails their frequent replacement. This particular need in electric vehicles has only recently been covered in specific research and development programmes of multinationals such as Pirelli or Hankook.

Looking to the Italian market, according to *The European House – Ambrosetti*, which has analyzed the Italian electric mobility supply chain, in the five-year period from 2013 to 2017 all the diverse activities linked to maintenance and after-sales services have recorded growth, stimulated by the progress of electric vehicle registrations and by the consolidation of new styles of life and consumption (leasing services, shared mobility). In contrast, the rate of development of activities of battery recycling and regeneration remains low, influenced by the reduced proportion of electric cars within the total number of vehicles in circulation in Italy and by the effective life cycle of batteries installed on vehicles.

The Energy Group of the Politecnico di Milano, too, in its report on Smart Mobility published in September 2019, dealing with the subject of the electric car supply chain, highlights that "battery management" – which includes both battery production, and the management of the "end of life" - is still little covered by Italian vehicle and component producers. Although it is perceived as highly strategic by most players in the supply chain, it, in fact, requires huge investments and skills that are a long way away from those traditionally possessed by the traditional players in the automotive sector.

Opportunities and challenges of e-Mobility

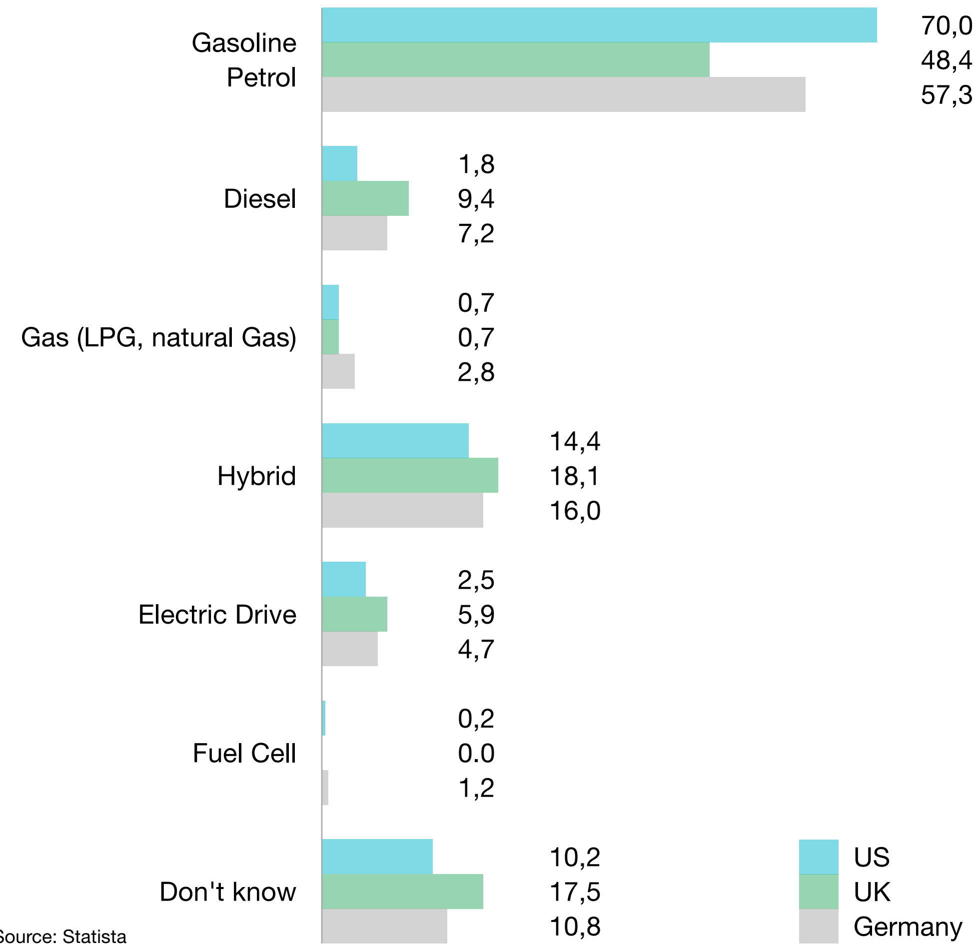
Consumer perception and consumption choices

Although the public’s interest in electric mobility is evident, there endures considerable scepticism regarding autonomy, safety, battery autonomy and the initial high cost of such vehicles. It follows that the diffusion of EV’s globally is strongly influenced by consumers’ commonly-held perceptions in this regard. It is also necessary, in fact, to assess the end user’s perspective on electric mobility in order to orient the choices of the players in the ecosystem and to understand what are the predominant consumer choices.

According to the “*Statista Survey Cars & Mobility 2018*”, a survey conducted in the USA, the United Kingdom and Germany on a sample of the population that owns a car or intends to purchase one in the next 12 months, only 18% of the US public believes that electric mobility is better than traditional mobility.

In terms of the cars already in use, from the Statista survey it emerges that in all three countries the most common cars are those that run on petrol and diesel, even if in the USA in 2018 the hybrid had already overtaken diesel. If, however, we look at the data relating to consumer preferences concerning the next car purchase, we observe a loss of interest in the diesel cars of 25%, in favour of hybrid and of pure electric vehicles. The latter, in particular, are seen as more sustainable from an environmental point of view in all the countries considered, as well as being suited for everyday journeys – thus, short in range and predominantly in urban areas.

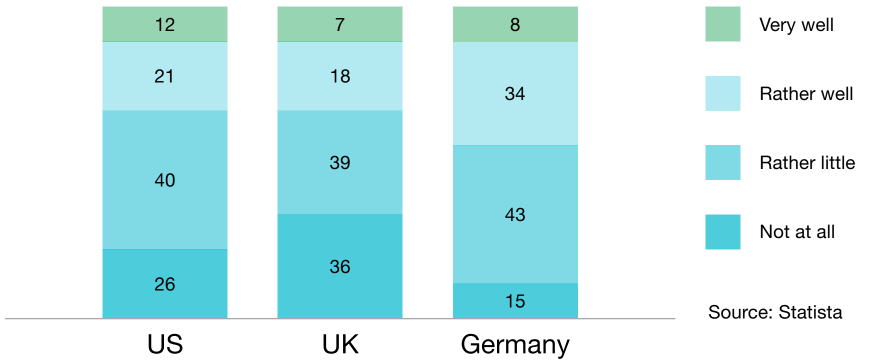
Probable drive in a future car purchase in %



Source: Statista

From the point of view of the diffusion of information regarding e-Mobility, Accenture’s global studies of (on 7,000 interviewees in 13 different countries) have highlighted how, despite the fact that almost all the interviewees have heard of electric mobility, only a third of these declared that they were sufficiently well informed on the subject to be able to make an aware consumer choice.

Level of information about electromobility in %

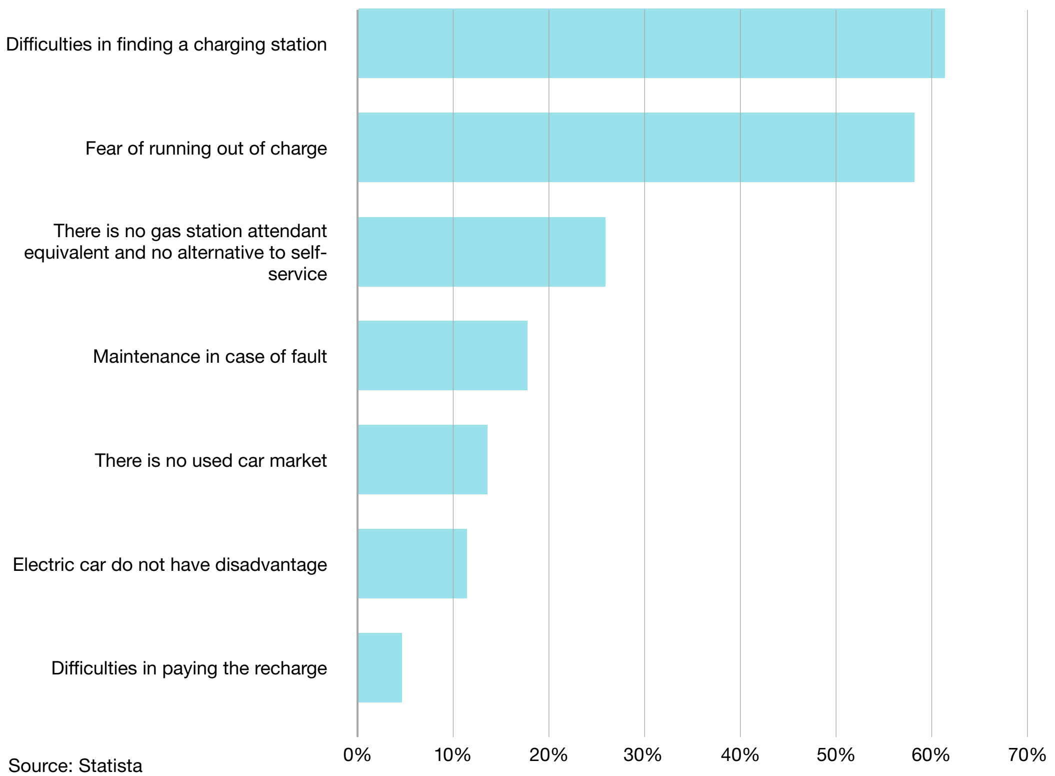


Source: Statista

Statista, too, in 2018 investigated the level of information familiar to consumers. The public's knowledge of the subject, in particular with regard to technological developments, to aspects relating to safety (for example, that of rechargeable batteries), as well as to the real autonomy of EV's, influences purchasing choices.
A 2016 survey commissioned by the "Consumer Federation of America" shows that 55% of interviewees who declared themselves to be particularly well-informed on the subject of EV's said that they favour electric mobility with regard to future purchases, while 22% of the interviewees were "poorly informed".

In the Italian context, according to a survey conducted by the *"Elettricità Futura" (Future Electricity) association*, a general and shared appreciation of hybrid or electric cars is manifested. In particular, e-Mobility is attractive to the new generations, to motorists with a medium-high educational background and to inhabitants of big cities: it is necessary to improve the overall strategy to direct consumer behaviour and related purchasing choices.
According to the findings of the survey carried out by Politecnico di Milano's Energy Strategy Group and contained in the 2019 edition of the report on Smart Mobility – on an Italian sample of 200 interviewees who own electric cars or who intend to own one -, the main impediments to the purchase of an EV are the high initial cost (thus the economic barrier) followed by "range anxiety", understood as inadequacy of the charging network and of battery autonomy. Compared with the data presented in the 2018 edition of the same report, there is to be observed a 10 percentage-point reduction (from 49% to 39%) concerning the inadequacy of the charging network by those who still do not own an electric car, but who declare that they are inclined towards a future purchase of an EV. It emerges, moreover, that 81% of the consumers that have already purchased an electric vehicle consider that the charging network is adequate or in part adequate (the previous year more than 60% considered it inadequate).
Statista, too, whose 2017 data regarding EV "weaknesses" is to be found in the graph below, highlights how "range anxiety" is perceived by Italians as the main barrier to the purchase of an electric car.

Weaknesses of electric cars in Italy in 2018, by reason



Source: Statista

As regards, in contrast, the motivations of those who have decided to purchase an EV, for the sample interviewed by the Energy Group of the Politecnico di Milano, the main driver is consumer perception of the positive environmental impact of electric mobility. The second motivation in order of importance is the lower costs represented by an electric vehicle from a *Total Cost of Ownership* perspective, considering therefore both the initial purchase costs and the operating costs linked to management, maintenance and disposal.

Price premium and total cost of ownership analysis

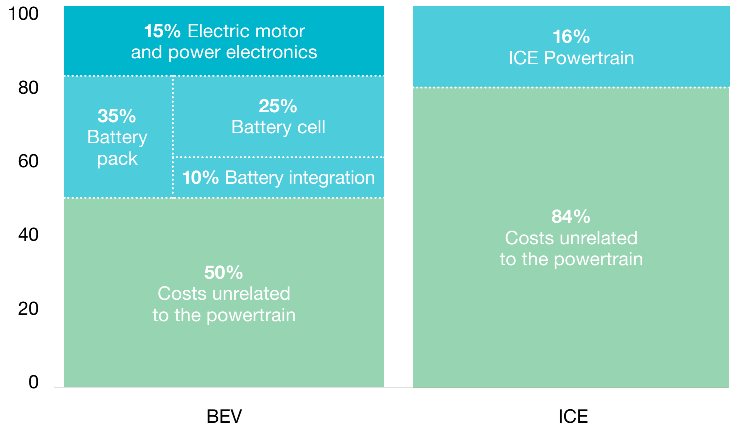
A medium-sized electric vehicle costs up to 40% more compared to a traditional vehicle with the same characteristics.

If it is true that consumers still harbour fears about issues relating to the autonomy of distance, to the warranty for the vehicles purchased, to maintenance and to the actual existence of a network for spare parts and to the residual value of the used vehicle, as well as to the adequacy of public charging infrastructures, the economic barrier linked to the high initial cost of the electric car (in absence of incentives) also plays a vital role. The "price premium" – understood as the extra percentage that the consumer must spend on an electric vehicle compared to the list price of a traditional vehicle - represents a crucial element in orienting the purchasing choices of potential consumers.

The most significant contribution to the production costs of electric vehicles comes, as observed previously, from the battery; the initial purchase cost of the vehicle will fall in the next few years, thanks to the reduction of the cost of the batteries themselves due to economies of scale and to the development of new technologies.

Incidence of powertrain on the total vehicle cost

Powertrain accounts for 50% of BEV costs versus 16% of ICE vehicle costs



Source: JP Morgan Chaise, BCG Analysts

Partially offsetting the higher initial purchase price when compared to a traditional vehicle is the fact that electric vehicles incur, throughout their life cycles, lower costs of management and maintenance than internal combustion engine vehicles; tax breaks and road circulation benefits are important elements in this calculation.

Given all of the aforementioned considerations, it is worth assessing the electric mobility market on the basis of the cost throughout the useful life of the vehicle, the so-called "*TCO-Total Cost of Ownership*", which makes it possible to compare the cost of ownership of a vehicle by taking into account the combined effects of purchase cost and operating costs.

For an analysis of the TCO it is necessary to take into consideration a broad set of variables:

- the country of reference with relevant electrical energy and fuel prices;
- models of consumption and habits linked to getting about (exclusively urban mobility, medium or long range, high or low speeds, frequent "stop&go");
- charging habits for vehicles (domestic charging, free public charging, public charging "normal charge", public charging "fast charge");
- average annual mileage;
- car depreciation;
- maintenance.

The factors that go towards calculating the Total Cost of Ownership can be subdivided between annual costs not proportional to a user's average distance covered annually and those costs that are, instead, a function of the actual distance covered.

	Elements for the calculation of the TCO
Annual costs not proportional to distance covered	Amortization of the initial cost of the vehicle (net of any incentives for the purchase)
	Amortization of the initial cost of the charging infrastructure (domestic wall-box)
	Registration tax or tax bonus
	Vehicle tax
	Insurance
Costs proportional to distance covered by kilometre	Cost of fuel or of power supply
	Cost of fuel or of power supply
	Statutory servicing
	Maintenance and repairs

Regardless of the method of calculation adopted for the TCO, in Italy a number of additional, local advantages combine to influence the choice to purchase an electric vehicle, such as the possibility to park free of charge on blue lines, the possibility to enter free of charge the Limited Traffic Zones in some big cities as well as to enter city centres without limitations – also in the event of traffic restrictions due to polluting emission thresholds being exceeded.

At the end of 2018 the cost of li-ion battery was 175$/kWh.

The International Energy Agency (IEA) has performed a comparative analysis of the costs of use of an ICE and those of a BEV. For this calculation a number of parameters were established: a battery production cost 175$/kWh at the end of 2018, an average period of vehicle ownership of 3.5 years and a fuel price higher than that of electricity per kilometre.

The results show that:

- A medium-sized BEV with 36 kWh of battery (allowing a distance of approximately 200 km to be covered) has a lower TCO than a traditional automobile or a hybrid vehicle with a fuel price equivalent to 1.5$/L and 12,000 km annually in the case in which the price of the battery falls below 150$/kWh. In the case in which the range of the vehicle reaches 400 km, the TCO would become competitive with a battery price of around 70$/kWh.

- Competitiveness is also achievable despite higher battery prices for larger vehicles (such as SUV's) on account of the greater benefits brought about by the electric powertrain on heavier vehicles.

Also according to the Energy Strategy Group, calculating the TCO of an electric vehicle equipped with leased battery, which also includes maintenance, this business model is effective in reducing initial outlay to such a point that the two solutions become practically equivalent.

Observing Italy, with it peculiar characteristics, according to the analyses performed in 2018 by the Energy Strategy Group of the Politecnico di Milano (and in the subsequent update of 2019) in comparing the TCO of a traditional car and that of an electric one, only after 10 years do the two solutions become comparable (5 years in the event that tax incentives on the purchase are worth at least € 6,000). In Italy, where the average vehicle life is 11 years, this result appears scarcely adequate to justify the purchase and is not very sustainable.

The last interesting case relates to the TCO of corporate fleets purchased through long-term leasing contracts, where the lower costs of management offset both the initial outlay and the monthly charges for the cars. Considering also the lower cost of charging and the fact that the installation cost of chargers is a one-off, the equalization of the costs of the vehicles occurs around the third year. By way of example we display below the comparative table of the Energy Strategy Group of Politecnico di Milano (report 2018), which, for the purposes of its Total Cost of Ownership analysis, compared two segment B cars, one petrol-driven and the other electric, considering a time frame of 10 years.

Item of expenditure	Petrol (Renault Clio)	Electric (Renault Zoe)
Initial cost of vehicle and infrastructure (€)	€ 23,00	€ 34.300
Annual kilometrage (km)	11,000 km	11,000 km
Theoretical consumption (l/100 km – kWh/100 km)	06.03.00	13.03.00
Cost of power supply (€/l – €/kWh)	€ 1.60	€ 0.20
Vehicle tax first 5 years (€/year)	€ 180	€ 0
Vehicle tax from 6th year (€/year)	€ 180	€ 45
Third party insurance (€/year)	€ 500	€ 350
Maintenance (€/year)	€ 500	€ 150
Annual cost referring to hypothesized distance covered (km 11,000)	€ 4,588,80	€ 4,245,10

Focus – Battery leasing models

The issues linked to the effective life of batteries, estimated in the range of 5-10 years according to the producers and to the type of anode, cathode and electrolyte used, have raised doubts not only regarding environmental sustainability but also about the advantage linked to purchasing the battery itself in an integrated package along with the vehicle.

The advantage, in the event of purchasing an EV with leased battery, can be dual. There is first of all the advantage for the consumer who is entitled to a replacement at the end of the first life cycle, and thus not incurring the purchasing cost of the battery. There is moreover an advantage for the producer represented by the recycling of the raw materials deriving from old withdrawn batteries. This leads to a significant drop in the production costs linked to a greater self-sufficiency vis-à-vis new raw materials. Still on the supply side, the leasing of the battery reduces the final vehicle, since the parent company is guaranteed exclusive rights on the aftermarket, therefore making EV's more competitive than ICE vehicles.

Generally, the customers who choose this option feel better protected against the eventuality of battery degradation: extreme weather conditions and high-power recharging no longer represent a real problem. A further advantage for the consumer deriving from the leasing model is the possibility to upgrade the battery with ever more advanced models and with greater capacities.

As regards the monthly fee for the leasing of the battery, the sums requested by automotive companies often do not differ from the fuel costs that the customer would incur each month and tend to include accessory fees and the insurance necessary in case of damage or theft of the leased accumulator.

Most car manufacturers have, nonetheless, chosen not to follow this approach, relying rather on traditional car sales practices in an integrated solution and leaving the purchaser to deal with the devaluation of the vehicle linked to the reduced useful life of the batteries themselves.

One exception is represented by Renault, which has decided to embark on the path of battery leasing, with over 100,000 batteries leased already by mid-2017. This option has allowed the French car manufacturer to mitigate the negative effect of battery deterioration on consumers' perceptions of EV's and has constituted one of the main reasons behind the great success of the Renault Zoe (the most sold BEV in Europe). In this way, Renault guarantees its customers a battery with a constant charge capacity always above 75% of the initial one, as well as a continuous maintenance or replacement service and free assistance. Specifically, it makes it possible to purchase a Zoe at 23,700 euro to which is added a monthly fee of 49 euro approximately for the leasing of the battery. Alternatively, the battery pack can be purchased at a cost of an additional 8,900 euro on the final price.
In the area of public transport, Proterra, too, an American start-up specializing in

PROTERRA

Proterra is a clean technology and clean energy company that provides zero emission vehicles that enable bus fleet operators to reduce operating cost while delivering clean, quiet power to the community.

Total Funding
$565.8 mln

Last Round
Sep 2018 Series G
$155 mln

Country
United States

proterra.com

energy storage and in the design and production of electric buses, has decided to opt for battery leasing for its vehicles. The great advantage for the purchaser of the buses is that the initial cost of the bus with leased batteries is approximately the same as that of a diesel bus, where the battery-leasing fee is equivalent to the cost of the fuel. In total, on an annual basis, the fleet owner makes savings of 8,000 dollars over the diesel alternative and Proterra guarantees itself exclusive rights on the aftermarket of its own batteries.

Environmental sustainability and polluting emissions

The actual contribution of electric mobility in terms of environmental sustainability and efficiency is still a disputed and controversial issue. If, on the one hand, the concept of "zero emissions" represents a lever used to promote electric mobility to the public at large, on the other, many critics consider it a "false myth". This due to the fact that the energy necessary for the charging of vehicles comes globally in large measure from fossil fuels. Both points of view, however, overlook key aspects regarding the primary sources used for the power supply, regarding charging methods and medium- and long-term developments in these sectors.

↳ "How Much Oil is in an Electric Vehicle?"

From a regulatory point of view, in the last few years the European Commission has oriented its own strategies towards the decarbonization of the economy, sustainable mobility and the relaunch of renewable sources. The ultimate goal of all these initiatives is the attainment of the European target to improve air quality and to reduce greenhouse gas emissions by 20% in the transport sector, by 2020 (on the basis of the 1990 threshold).

In the wake of the data tampering scandals concerning car emissions, the transport sector is under regulatory scrutiny in many countries. Against this backdrop, electric mobility represents, for now, a partial solution to the reduction of harmful emissions, to noise pollution and to impacts on the ecosystem.

A first assessment of the environmental impact of the various types of vehicles, whether electric or traditional, can be elaborated on the basis of the emissions, direct or indirect, of CO_2 in the air.

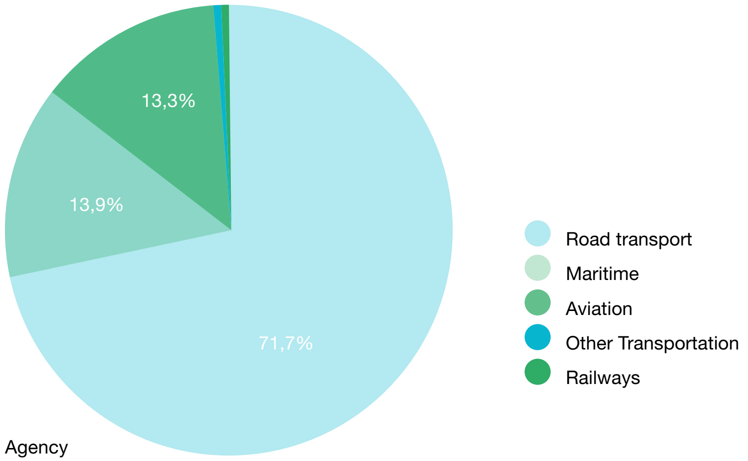
The transport sector is amongst those most responsible for air pollution, globally accounting for 25% of total emissions, with a markedly upward trend in stark contrast with the virtuous results of other sectors.

In the USA and Europe, the transport sector represents respectively 29% and 27% of the total CO_2 emissions, significantly higher than the rest of the world.

The European Environmental Agency (EEA) recorded between 1990 and 2017 an overall contraction of 23% in the levels of greenhouse gases on our continent. Among the factors that have led to this result are the increasing use of renewable energies, a greater energy efficiency and structural changes in the European economy, as well as the change in demand for energy on the part of private consumers.

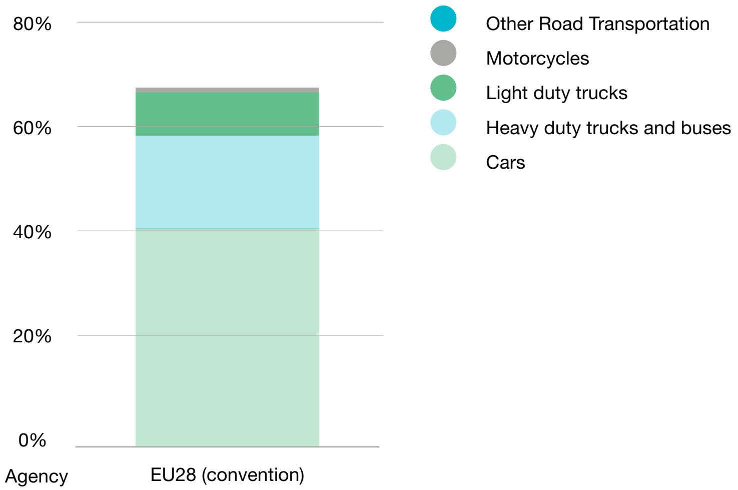
EEA data show, nonetheless, an increase in emissions from road transport of 170 million of tonnes of CO_2, in stark contrast with the reduction of 433 million tonnes obtained in the sector of electricity and heat production. In terms of polluting emissions, on-road mobility does indeed assume a key role, due, in particular, to vehicles for private transport and to heavy-goods vehicles; in addition, there has been an increase in the figures relating to emissions caused by maritime and air transport.

Eu (Convention)
Share of transport greenhouse gas emissions



Source: European Energy Agency

Road transport
Share of transport greenhouse gas emissions



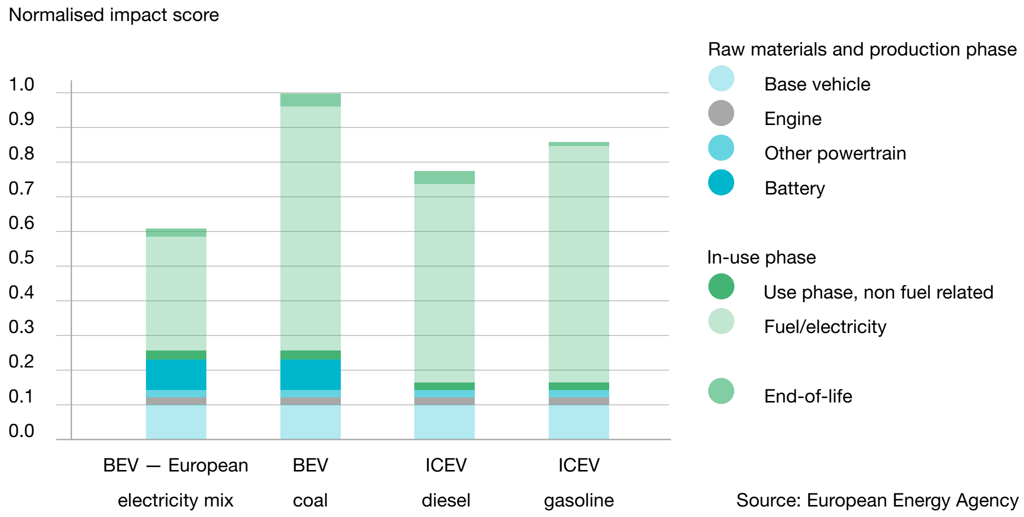
Source: European Energy Agency

In Italy, emissions of greenhouse gases increased progressively from 1990 to 2005 but have fallen in the years since, a reduction that has also affected the transport sector. In our Country, too, road transport is responsible for the highest percentage of GHG emissions (equal to 93% of the emissions attributed to the transport sector) and with automobiles accounting for two thirds of this percentage and followed in volume by heavy vehicles.
In such an unideal scenario as the one described, the electrification of vehicles of transport represents a real opportunity in as much as it is free from direct carbon dioxide emissions.

The mass adoption of electric vehicles would provide the possibility to reduce greenhouse gas emissions and improve air quality above all locally. Arpa Lazio and Legambiente emphasize, though, that in urban areas motor traffic is the most polluting source not only because of exhaust fumes, but, indirectly, because of the wear on brakes, on tyres and on the road surface itself, and also because of the resuspension of the particulates that have come to rest on the ground.

As regards the impact of direct and indirect emissions – caused by energy production and varying according to the primary sources used- of electric mobility, the study conducted by the European Environment Agency regarding the so-called "*well-to-wheel*" performed a comparison between the greenhouse gas emissions (GHG's) relating to the whole life cycle of an ICE vehicle and that of an EV. It should be noted that this analysis has taken into account different parameters such as the size of the vehicle in question, the mileage over its useful life span, the energy production mix and whether the ICE vehicle runs on petrol or diesel. The findings demonstrated that despite the fact that the GHG's associated with the extraction of raw materials and with the production process of the BEV are 1.3-2 times higher than an ICE, these are completely amortized during the lifespan of the vehicle. In fact, considering the whole life cycle of the various types of vehicles, the overall emissions of electric vehicles, on the basis of the average European electricity mix, are respectively of 17-21% and 26-30% lower than the same vehicles running on diesel or petrol.

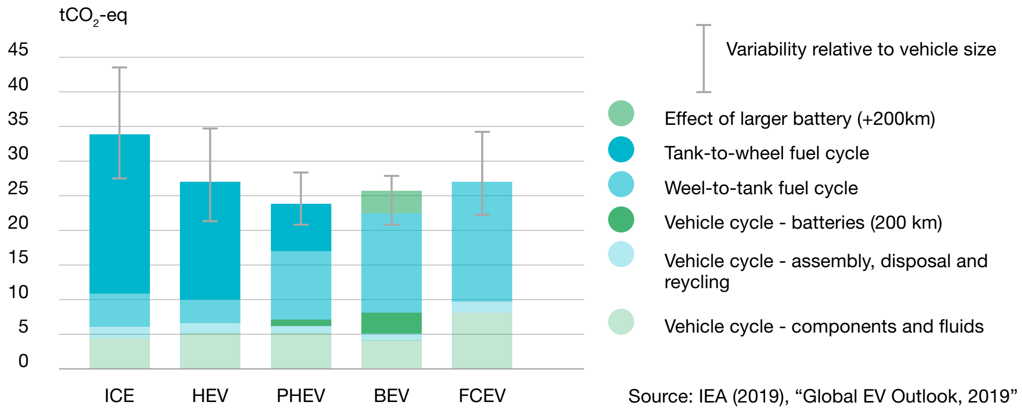
Climate change impacts: example comparison of BEVs with ICEVs



Source: European Energy Agency

Underlying these considerations, there is nonetheless an equally important premise: the method of electrical energy supply used for the production and the circulation of electric vehicles is the most important facto influencing final performances.
If it is indeed true that the stages of raw material extraction and vehicle production entail high demands on energy, drawing upon energy sources with low carbon emissions would reduce GHG's in the whole ecosystem. The savings in terms of CO2 emissions are in fact significantly higher for electric cars used in those countries in which the production of energy is characterized by a predominance of renewable sources and by low carbon emissions.

Comparative life-cycle GHG emission of a mid-size global average car by powertrain, 2018



Source: IEA (2019), "Global EV Outlook, 2019"

Politecnico di Milano's Energy Strategy Group, in its report on Smart Mobility published in September 2019, also analyzed the environmental impact of electric cars throughout the whole life cycle of a vehicle. The findings from the comparative analysis of ICE vehicles and electric vehicles confirm the EEA's analysis: it emerges, in fact, that the CO2 emissions of electric vehicles over the whole life cycle are lower than those of ICE vehicles, but also that the greatest contribution of emissions occurs during vehicle use itself. This value is influenced by the energy source powering the EV's. In the other stages of the life cycle of the vehicles – in particular in production and in the management of their "end of life" - EV's are responsible for a higher percentage of CO2 emissions than ICE's, primarily due to the production of batteries, which account for a percentage that varies from 35 to 55% of the total emissions linked to the production of a vehicle.

Focusing on the Italian scenario, the very same analysis highlights the central role of the geographic location of the vehicle production supply chain: an entirely Italian supply chain – in which all components, including the battery, are produced and assembled in Italy - would in fact reduce CO2 emissions, thanks to the lower-emissions factor linked to our country's broader electrical energy generation mix when compared with the other countries analyzed (China, Germany, USA).

“A radical transformation of our mobility is required since we cannot expect the Euro 6 emission limits to bring about a significant reduction in health-damaging pollutants, much less, a reduction in CO2: the hybrid and electric (or fuel cell) automobile are an obligatory path, but alone are not sufficient”

European Energy Agency

Energy transition and its implications

According to Politecnico di Milano’s Energy Strategy Group in its 2019 report on *smart* mobility, an energy generation mix that sees a progressive increase in the share of energy produced from renewable sources determines a significant reduction in the CO2 emissions produced by an electric vehicle throughout its whole life cycle. The evolution of the energy sector thus assumes a decisive role in the reduction of greenhouse gas emissions, not only on account of the energy used by electric vehicles for the circulation, but also throughout the whole life cycle.

The benefits of the electrification of transport, among which the reduction in environmental pollution and the fight against climate change, will be greater if the diffusion of electric vehicles takes place in parallel with the decarbonization of power supply systems.

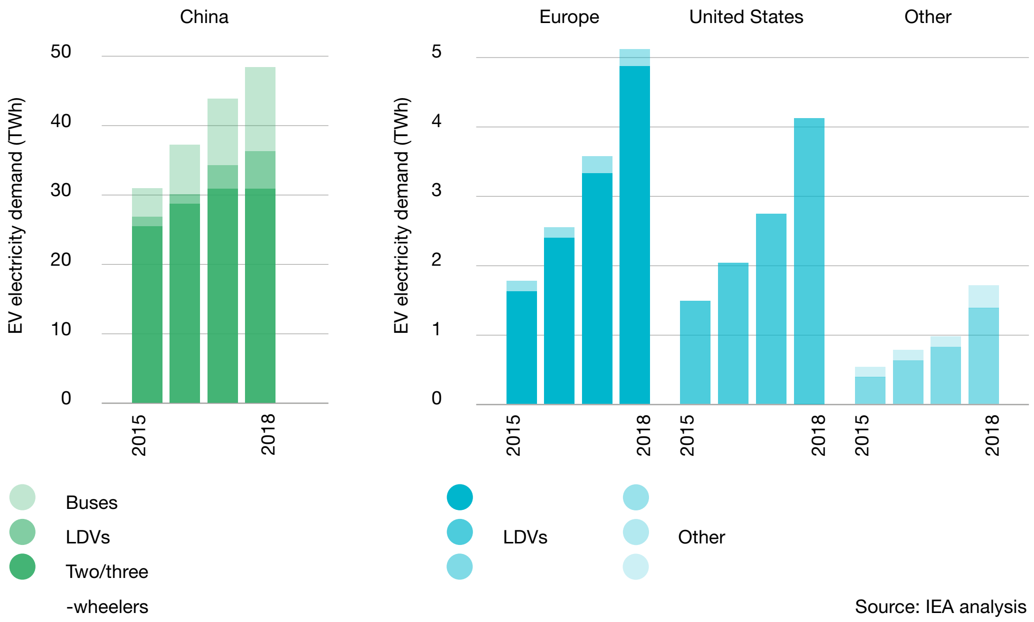
A notable contribution in terms of environmental sustainability can derive from renewable sources (wind and solar) despite the fact that, currently, these are not capable of standing autonomously since they do not guarantee a standard and continuous supply over time.

Denmark represents one of the most virtuous examples in Europe for the use of renewable energy sources: by 2020 it intends to use these for 35% of the country’s energy requirements, with the aim of reaching 100% in 2050.

According to the International Energy Agency (IEA), by 2030 the total number of EV's in circulation will ensure a reduction in the demand for oil products equivalent to 127 million tonnes of oil (approximately 2.5 million barrels per day). In contrast, it is forecast that the demand for electricity for the circulation of the global fleet of electric vehicles will see significant growth, reaching almost 640 TWh in 2030 (equivalent to ten times the consumption of 2018, which was of 58 TWh), particularly concentrated in China and in Europe. McKinsey studies highlight, moreover, that demand for electrical energy for road transport will increase to a CAGR of +38,8% in the period between 2015 and 2030.

Demand for electrical energy for road transport will increase to a CAGR of +38.8% in the period between 2015 and 2030

Electricity demand from EVs by region and type of technology 2015-2018



Source: IEA analysis

According to Enelx estimates and comparing energy consumption over the whole life cycle of the EV with that of the ICE - on the basis of the Terna and Enerdata data estimates for the Italian market - an electric vehicle requires a third of the energy of a traditional one. Internal combustion engine vehicles in fact require energy in the refinement and transporting of oil and in the conversion into mechanical energy of the petrol through the engine. In contrast, in electric vehicles, consumption regards the various stages in the production of energy, and of its transmission via the grid and the transformation of that accumulated in the batteries in mechanical engine through the engine. The efficiency of the whole ecosystem of the two cases considered is respectively 18% in the case of ICE vehicles against the 52% of electric vehicles (with the energy mix considered being equal).

In this scenario, an increase in energy distribution will be necessary to meet the needs linked to powering the vehicles and to respond to consumer needs in terms of charging times and battery autonomy: there might indeed occur problems in terms of the power load demanded of the charging infrastructures.
The most significant effect on the sector will be that on grid load, since it is anticipated that there will be considerable increases in loads during evening peak hours, when the owners of the electric vehicles tend to re/charge their cars. If, across the system, the increase in the load is sustainable overall, there is, however, a strong geographic concentration of the distribution of electric vehicles – much more common in some urban areas– that could have extreme load effects on local distribution grids.
In order to maximize the advantages of electric mobility, it is thus essential to manage charging correctly.

> **Vehicle charging methods (slow and of low intensity or rapid and high in energy) can significantly affect energy use, in particular the exploitation of the renewable sources.**

A Harvard study focused on the city of Beijing has confirmed that consumer charging habits can affect the energy impact of the vehicles themselves and their environmental impact, too. For emissions to be reduced, it is, in fact, necessary that there be an incentivization strategy such that owners charge their electric vehicles slowly and during off-peak hours. The main solutions for energy suppliers for an optimal management of the networks are the implementation of a system of charges that incentivizes the charging of vehicles before or after a particular time band, and the use of storage units.
There are, in fact, in different countries battery storage systems that exchange huge quantities of energy in quick time, giving rise to a collaboration between grid infrastructure and vehicles (the so-called Vehicle-to-Grid model, to which will be dedicated specific attention in the next chapters). The batteries of electric vehicles can together be exploited as a storage system with widespread distribution across the territory, able to stabilize the grid and to support a model based on 100% of the energy deriving from renewable sources.

Urban and local mobility: public transport and the management of corporate fleets

The changes emerging relating to mobility will significantly transform not only private but also public and shared transport, with important implications for the electrification of vehicles themselves.
It is in the urban setting that the main effects are expected. The characteristics of today's electric transport appear particularly suited to local mobility, ideal for short journeys, with greater possibilities for rapid recharging.

The close cooperation between producers of electric vehicles and fleet managers will be important in ensuring that electric vehicles can effectively satisfy the operating and technical standards of shared mobility services, comprising both public transport, and mobility in sharing schemes, with the aim of taking advantage of the high rates of use of the vehicles. Ensuring that shared vehicles are electric requires that the financial barriers to the purchase of more expensive vehicles and to providing access to charging infrastructures be broken down. The combination of policy and regulatory measures, on the one hand, and of investments by the companies of transport on the other, might accelerate the electrification of fleets.

Urban public transport

Apart from the world of private mobility, the electrification of vehicles also increasingly concerns public transport, local but not only: there is a constant growth in the numbers of initiatives from of national and local government in support of investments and of undertakings in this direction.

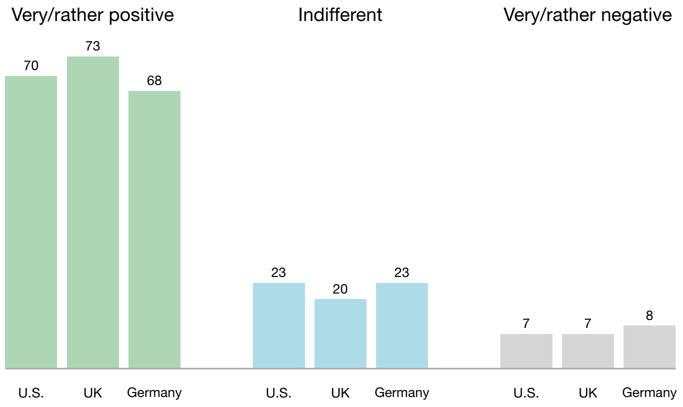
The global number of electric buses will go from 2017's 386,000 to 1.2 million in 2025, with an increase of 300%

According to Statista, the global number of electric buses will go from 2017's 386,000 to 1.2 million in 2025, with an increase of 300%. The increase in pollution levels, the potential savings in terms of operating costs and growing dependency on public transport are the three main factors driving the gradual switch from hydrocarbons to electrified public transport.

Cities are setting themselves ever more ambitious targets in terms of environmental sustainability: in 2017 thirteen cities signed the "C40 Fossil-Fuel Free Streets Declaration" the goal of which is to depend exclusively on zero-emission buses from 2025 onwards.

From the point of view of consumers, according to Statista's 2017 survey conducted in the United States, the United Kingdom and Germany, the perception of urban dwellers is, on the whole, positive vis-à-vis the potential introduction of a system of electric public transport. Only 7.8% expressed opposing positions, mainly for economic reasons (possible increase in the price of bus tickets, financing through increased taxes, but also due to the proliferation of urban roadworks).

Attitude towards the switch of public transport to less polluting drives in %



Source: Statista

99% of the electric buses in operation around the world are to be found in China, where an average of 9,500 new units are introduced every five weeks. Once more according to Statista, the financial support offered by the Chinese government, the strong concentration of the population in urban areas and the resulting pollution, the shortage of transport infrastructures existing in many Chinese cities, global trade and a strong awareness on the part of public opinion are the five main reasons for Chinese dominance. Since 2017 cities like Shanghai and Shenzhen have ceased buying any more ICE vehicles for local public transport. Beijing, too, is speeding up the revolution in its country-wide public transport system with the aim of becoming world leader in technological innovation in the field of high-level electric vehicles. The Chinese Council of State has established a plan of action in line with which, by 2020, all public buses should be replaced with electric models, thus reducing global carbon emissions by 15% compared with five years previously.

99% of electric buses are in China.

Arising from the first large-scale applications of electric urban transport, there are emerging issues similar to those affecting private vehicles. Autonomy, in particular, is also a critical factor for public transport, with the aggravating factor of the need to circulate for the entire day, without interruption and for distances on average two or three times greater than those of an automobile. The issues linked to vehicle charging are magnified when it comes to public transport. It is not, in fact, imaginable that vehicles run uninterruptedly without being able to power up while, at the same time, anticipating using fast charging, since the latter requires the supervision of a worker and thus manpower.

Scandinavian countries are testing the first hybrid plug-in buses with inductive charging.

The comparison drawn on the Moscow bus network speaks volumes when it reveals that to guarantee service on four lines without modifying frequency of service, they have gone from using 42 ICE trolley buses to using 82 electric ones.

One solution that is being experimented with is that of the trolley bus with charging on the move. These vehicles are equipped with small batteries and with a system for charging on the go. The producers of these solutions assert that the wire infrastructure is necessary for only 60-75% of the route. This type of public transport vehicle is spreading around Europe, in particular in Switzerland.

In the field of vehicle autonomy, the Scandinavian countries are testing the first hybrid plug-in buses with inductive charging. Scania's basic idea is to travel “electric” by regenerating battery energy during stops, without the need to interrupt the service: this thanks to the interaction of the two engines (one a combustion engine and the other a battery one) and to the powerful rechargeable accumulators during deceleration and through the grid. Seven minutes' charging guarantees an autonomy of at least ten kilometres.

In 2018 this system for wireless charging was also installed for the first time in the city of Washington. The manufacturer, Momentum Dynamics, guarantees that in five minutes this system provides the vehicle with enough energy to cover a route from start to finish.

MOMENTUM DYNAMICS

Momentum Dynamics is a clean technology company developing a technology system that will permit electrically powered vehicles to be recharged without the use of a wire. This wireless technology can be operated automatically, allowing both passenger-class and commercial fleet vehicles to be charged safely and effortlessly in all weather and without direct supervision.

Total Funding
$31.64 mln

Last Round
Feb 2019 Convertible Note $17.45 mln

Country
United States

momentumdynamics.com

Azienda Trasporti Milanesi (ATM)

The Milanese Transport Company (ATM) has played an exemplary role in the promotion of a model of “green” city and of sustainable mobility.

The Urban Plan of Sustainable Mobility (PUMS) approved in November 2018, has set itself the objective of guaranteeing improvements to the service of urban mobility, to environmental quality and to economic efficiency, thanks to the investment of 2 billion euro in a *fossil-fuel-free* perspective.

2019	goals 2022	goals 2030
27 Electric Bus	215 Electric Bus	1200 Electric Bus
120 Hybrid Bus	295 Hybrid Bus	4 new depots full electric
40 Trolley Bus	80 Trolley Bus	3 depots converted
80 Tram	-6,5 millions of litres diesel/year	-30 millions of litres diesel/year
	-16 thousand of tons of CO_2/year	-75 thousand of tons of CO_2/year

In 2019 approximately 70% of Milanese public transport makes use of electric vehicles, thanks to the extensive underground network and to the trams, trolley buses and buses. The *full electric plan* intends to raise this percentage to 100% in a decade, and also to rejuvenate the entire fleet of transport vehicles and to reduce the citizens' dependency on private vehicles.

In the month of July 2019 an order for 250 electric buses was placed with Polish Solaris Bus and one for 80 trams with Stadler, as well as one for a further consignment of 120 hybrid buses with Iveco Bus.

From 2020 on the city council of Milan will invest in the purchase of exclusively electric vehicles, accelerating the undertakings made in Paris at the *Together4Climate* summit. Among the ambitious objectives is also the total elimination of diesel from the fleet by 2030, thanks to a total deployment of 1,200 electric buses.

Innovative charging methods will require a widespread charger service (with charging points located at the ends of the lines), as well as the refurbishment of exiting depots and the construction of three new facilities equipped with plug-in connectors.

Thanks to the investments made, the average age of the ATM fleet, which is already the lowest in Italy, will be ever more in line with that of the major European capitals. These initiatives will make Milan one of the first cities in Italy, and in Europe, to provide a totally electric transport service.

Corporate fleets and urban mobility

Electric mobility also finds fertile ground in all those corporate organizations that wish to be exemplary in innovation and in their respect for "green" policies. One of the main interlocutors of the industries of the automotive sector is, in fact, the corporate sector, which has contributed significantly to the increase in registrations of electric vehicles in Italy in the last few years. To this must be added the advantage of the electric vehicle for corporate fleets in terms of savings on fuel expenditures.

68% of corporate fleets vehicles run in the urban area only.

According to the data published in Fleet Manager's report "Survey of electric and hybrid 2018", adoption of electric vehicles in corporate fleets continues to increase, notwithstanding their small numbers as a total of the market, reaching 1.6% in 2018; the daily average distance travelled by vehicles belonging to corporate fleets is 58 km and the geographic area concerned is largely an urban one.

Many companies have declared that they are still "experimenting" with electric vehicles and have expressed caution regarding this change. Here too, the lack of adequate infrastructures and the times required for charging are some of the principal barriers to the spread of EV's within fleets. In this regard, although companies do offer spaces dedicated to charging, whether via chargers or wallboxes, the percentage of agreements with the energy Utilities remains very low at around 16%.

Ever more pronounced, in contrast, is the advance of hybrid vehicles within fleets, since these appear to represent a more flexible and economical solution than full electric vehicles. There are no few criticisms, however, regarding the adoption of this type of vehicle, largely related to motorway consumption and to the lack of incentives.

A further benefit is evident in the field of Corporate Social Responsibility (CSR), where the adoption of electric vehicles influences brand positioning and can be a strength in terms of internal and external communication.

Car manufacturers and new entries: competition and partnerships

The advent of electric mobility has offered new players the possibility to enter the automotive market with alternatives to traditional ICE vehicles. For this reason, emerging economies and Asian countries with a mature domestic market have decided to launch themselves into the EV segment, in which the terrain having been less explored by the traditional colossuses allows for the acquisition of market share in return for strong investments in research and development.

A shake-up in the car industry

According to Deloitte forecasts, in 2022 the electric mobility market will reach a "turning point", when technological progress will make it possible to buy an electric vehicle at a cost comparable to that of its petrol or diesel counterpart.

A market analysis both on the side of the supply and of the demand, nevertheless, shows, for the time being, a "gap" associated with automotive industry expectations: when comparing the number of electric vehicles that will be produced by 2030 with estimated consumer demand, there emerges a surplus of 14 million units.

Although many automakers already have production targets and investment strategies for the development of a division dedicated to electric vehicles, it is not at all certain that they will be able to maintain their current market shares. Similarly, it is wrong to take for granted that start-ups and companies coming from other sectors – the so-called "new entries" - will be able to wrest parts of the market away from the traditional players.

On the basis of sales forecasts for the next 10 years and with the current rate of "birth" and development of new players on the market, the number of EV producers is bound to contract: those that survive this competition will presumably have had to modify their business models – and perhaps even radically.

On the basis of sales forecasts for the next 10 years, the number of EV producers is bound to contract.

Investments

According to a Reuters projection, over the next five-ten years the big car manufacturers will invest 300 billion dollars in the launch of mass production of electric cars in China, Europe and North America, in particular in the development of new charging technologies and of batteries that are more economical and have greater capacities. More than 45% of this flow will concern China, whether directly or indirectly (thanks to international joint-ventures and trade deals); this estimate also includes investments in the partial electrification of models (PHEV).

300 billion dollars invested by big car manufacturers in next 5-10 years.

The graph produced by Reuters shows investment flows for plug-in cars (EV, Electric Vehicle) by country of origin and destination.

It illustrates that China is the country that will attract the greatest number of investments in the automotive sector, equivalent to 135.7 billion in few years, coming in large part from Germany, as well as from the Asian giant itself, and, to a lesser degree, from other countries including the United States and Japan.

Indeed Germany – and, in particular, Volkswagen, followed by Daimler - will be the main source of investments in mobility with zero polluting emissions accounting for a total of 139 billion dollars, of which slightly more than 70 billion will remain in the country, while the rest will be invested in China.

On the front of the "announced" investments, according to Alix Partners (automotive & industrial consulting firm), heading the rush at the end of 2018 was the Renault-Nissan-Mitsubishi Alliance, with approximately 66 billion dollars, followed by the Volkswagen (49 billion) and Hyundai-Kia (25 billion) groups. Ford, Daimler, GM and FCA anticipate investments of between 8 and 12 billion each, ahead of Toyota and Jaguar-Land Rover on 6 or 7 billion each.

Car manufacturers must improve their self-financing capabilities, rethink their investments in their own core activities and establish partnerships with companies with access to capital.

In order to gain an understanding of how car manufacturers are navigating the electric sector from a financial perspective, CB Insights has mapped investments in the market – the car manufacturers that have financed or acquired at least one company between 2014 and 2018 are twelve in number - in the start-ups developing EV technology, in particular electric automobiles and commercial vehicles, BEV technology, charging infrastructures for electric vehicles and shared mobility services that mainly use electric vehicles.

The analysis casts light on how car manufacturers are prioritizing investments in batteries and charging technologies. BMW, Daimler and Volkswagen have led the way with the greatest numbers of single investments. It is anticipated that the next few years will see huge investments being made by the major German players, spurred in large part by European standards on polluting emissions.

CB Insights highlights how few have invested in producers of electric vehicles outside of BMW, Daimler and of GM's coinvestment in the electric bus producer Proterra. As far as charging infrastructure is concerned, BMW and Daimler have co-invested in ChargePoint, a start-up that has created a global charging network for electric vehicles and that has signed a partnership with Volkswagen for the creation of a public network of charging stations in the USA.

Start-ups working on batteries have also received increasing attention from car manufacturers, in particular those conducting research and develop solid-state batteries. Among these QuantumScape, SolidEnergy, Solid Power, Ionic Materials.

Focus China

Three of the main producers of full electric cars in the world, more than half of the charging stations installed globally, 135 gigafactories for the production of batteries for the EV's on a total of 231 currently active, 55% of the global market of the electric vehicles. The data regarding the Chinese market in 2018 express clearly China's will for, and a strong governmental push towards a paradigm shift in mobility, as well as the country's will to assume the role of global leader in the field of e-Mobility.

In order to obtain these significant results, China has acted on three main fronts. Firstly, the government has favoured demand for EV's by offering subsidies for the purchase of such vehicles. Alongside this, a government credit system to support car manufacturers producing and marketing electric cars has been established. Nonetheless, the strategically most important aspect for the nation's technological progress is to be found in the "*Catalogue for the Guidance of Foreign Investment Industries*", the government document in which foreign investments are subdivided into three lists:

China has 55% of the global market of the electric vehicles.

- Industrial sectors for which the government encourages foreign investments (usually by means of tax incentives);
- Sectors with restrictions on foreign investments, in which a non-national partner can only operate through a Joint-Venture with a Chinese majority shareholder counterpart;
- "Forbidden" industrial sectors, reserved exclusively to Chinese enterprises and entrepreneurs.

One of the most recent updates of the aforementioned document (2017 edition) relaxed the government's grip on those specific sectors that are strategic for country's technological development. The updated list of manufacturing activities encouraged includes the production of rail transport equipment; R&D activities and production of

8 Chinese EV startups have each managed to raise over a billion dollars in investments

electronic networks automotive and electronic controllers for electric vehicles; the production of high-power batteries for new alternative power supplies; the production of low- and medium-speed diesel engines; the production of Blade Electric Vehicles (BEV).

The service sector has, for its part, seen openings for foreign investments in motorway services for passenger transport, in international maritime shipping services and in the exploration and development of oil sands, shale gas and other non-conventional oils and gases, and lastly in the extraction of lithium and the processing of minerals. The updated document includes additions to the catalogue of new industries supported by the government, such as the construction and running of urban car parks and the construction of hydrogen filling stations.

The Chinese industrial strategy clearly incentivizes foreign investments in activities and services linked to smart mobility, thus allowing Chinese production activities to take advantage of the technological, financial and relational contamination deriving from foreign partners. It is no coincidence that eight Chinese EV startups have each managed to raise over a billion dollars in investments: in order, NIO, WM Motor, NEVS, Fisker, Xpeng Motors, Youxia Motors, Singulato Motors, Lucid Motors.

Partnership

The traditional panorama of the automotive sector is changing: car manufacturers are joining forces in consortia, alliances and partnerships both inside and outside and the “auto world”, with OEM’s, suppliers and companies in the associated industries on the one hand, but also with “tech giants” and start-ups on the other. The aim of these partnerships is to enhance know-how and skills and to experiment new business models in order to keep up with technological innovation, to thus reduce time-to-market and to subdivide the enormous investments that electrification - but also autonomous mobility and connected mobility, as we will see below - requires.

The last months of 2018 and the first half of 2019 alone saw a rush not only to invest but also to create strategic alliances for electric and autonomous mobility.
By way of example, and not exhaustive at that:

- FCA has formed a partnership with EnelX, Engie and Aurora (which in the same period has also raised capital from the Hyundai Motor Group);
- Joint ventures have been signed between Toyota and Panasonic and Toyota and the Chinese BYD for the production of electric vehicles and batteries;
- A Ford-Volkswagen alliance has been established through investments in ArgoAI for the autonomous electric mobility;
- Renault has invested 144 million dollars in the electric vehicle sector in China through the joint venture with Jiangling Motors Corporation Group (JMCG).

Glossary
Electric mobility

Term	Acronym	Definition
Original Equipment Manufacturer	OEM	Company that produces equipment that will then be installed in a finished product, on which the final manufacturer (parent company) places its own trademark.
Electric vehicle	EV	A vehicle that uses one or more electric engines for its propulsion. This includes cars, scooters, buses, trucks, motorcycles and boats. This term covers completely electric vehicles and also hybrid electric vehicles. EV refers moreover, in general, to the electric mobility market and ecosystem.
Battery EV / full electric	BEV	A completely electric vehicle that has an electric engine and a battery, but no internal combustion engine.
Plug-in EV	PEV	An electric vehicle plug-in is a vehicle that can be charged from an external source and generally includes completely electric and hybrid plug-in vehicles. In this report we use a different term for completely electric vehicles to differentiate them from hybrid electric plug-in vehicles.
Hybrid EV	HEV	A vehicle powered by a combustion engine in combination with one or more electric engines that use the energy stored in the batteries. These vehicles cannot be charged from an external source, but harness the power of the internal combustion engine and regenerative braking.
Plug-in Hybrid EV	PHEV	A vehicle that can be powered by a combustion engine or by an electric engine. Unlike the normal hybrid electric vehicles, these can be charged from an external source.
Internal Combustion Engine	ICE	A vehicle powered by an engine with an internal combustion (or heat engine), in a general sense regardless of the fuel used (petrol, diesel, LPG or methane).
Gigafactory		The term gigafactory, Elon Musk's neologism, refers to the Tesla battery and EV production plant in Nevada, created specifically by the American car manufacturer in order to facilitate economies of scale in the costly process of electric battery production. By extension in the report and in the literature, it covers all plants with characteristics of size comparable to those of Tesla.

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Connected mobility

3

Connected Mobility

Audi has been the first car maker, in 2014, to offer “in vehicle” access to 4G LTE networks and Wi-Fi hotspot

4G · LTE

HARDWARE CONNECTIVITY

The first level of connectivity permits the driver and passengers to access data and view the information relating to real-time vehicle use and to the state of the vehicle and its components

INTEGRATED CONNECTIVITY

The second level of connectivity, which also goes by the name of “individual connectivity”, is based on the possibility of incorporating into the vehicle connectivity and digital application services, such as smartphone applications, music and multimedia content.

PERSONALIZED CONNECTIVITY

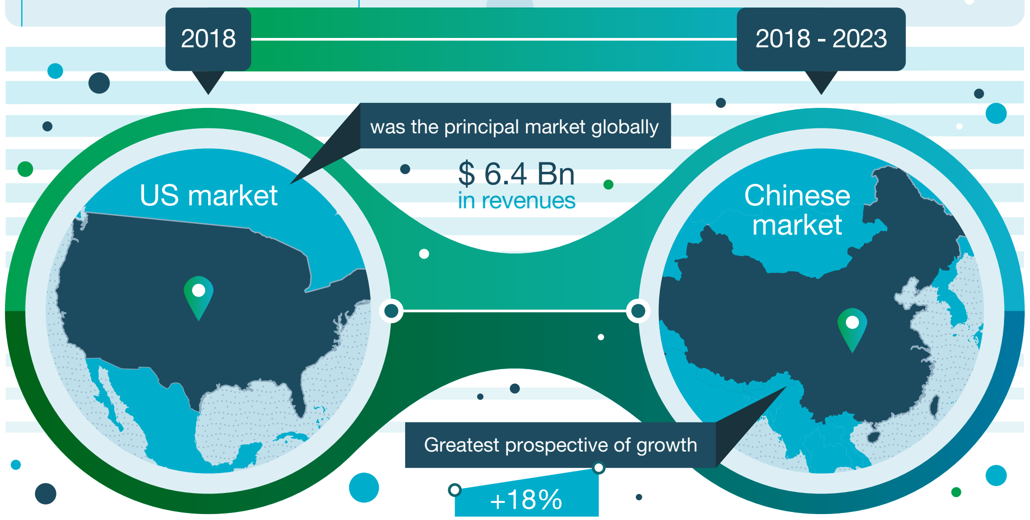
The third level of connectivity requires advanced passenger and driver profiling functions, with the objective of personalizing driver and passenger preferences and of improving the experience.

INTERACTIVE CONNECTIVITY

The fourth level of connectivity permits passengers and driver to interact with the vehicle's infotainment systems using “multimodal live dialogue”. Interaction is made possible by using, for example, voice commands, the advanced dashboard and the recognition of driver and passenger biometrics.

CONNECTIVITY FOR AUTOMATION

In the most advanced stage of vehicle connectivity, the massive use of Artificial Intelligence will enable sophisticated predictive capacities to be deployed. Passengers may not only be offered services on the basis of the needs expressed but needs not yet understood will be identified.



12.7 million connected vehicles in circulation by 2023

53%

By the end of 2023, connected vehicles in Italy will represent around 53% of the total vehicles in circulation for a market that will be worth more than a billion dollars.

V2X allows the vehicle to see beyond the “physical” limits of the on-board devices, offering the possibility to identify, detect and predict rapidly and accurately the actions of surrounding vehicles:

CURRENT SCENARIO

- In-vehicle operational data is collected to analyze potential causes of failure
- Early warnings/notifications are sent to the user and the dealership
- Repair/maintenance cycles are completed quickly

CONTRIBUTING FACTORS

- Driving style analysis
- Advanced on-board computers
- Artificial intelligence
- Machine learning algorithms
- Cloud data+real-time analytics
- Crowdsourced data
- Telematics data
- Increased sensors usage
- Nano technology

FUTURE SCENARIO

- Cars will be able to self-repair in certain scenarios
- Dealer/human intervention is partially or fully eiiminated for minor issues
- Automation of service stations will optimize part procurement and inventory

Descriptive maintenance · Diagnostic maintenance · Predictive maintenance · Prescriptive maintenance

Real-time information for Traffic Management

Most connected navigation systems are based on more than one data source

Cellular networks · GPS-navigation systems · Fleet management devices · IoT roadside sensors

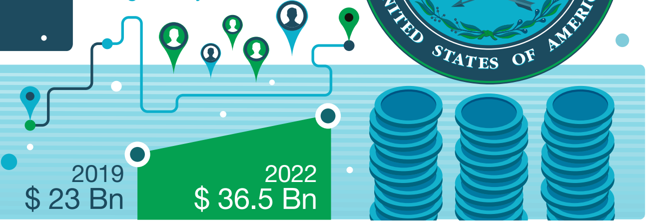
The first “driver monitoring” system was introduced by Toyota in 2006 on the last models of the Lexus and makes use of infrared sensors and video cameras to monitor driver concentration

Since 31st March 2018 all new vehicles registered in the European Union must be equipped with technology emergency call (eCall). It can be used in vehicles across the European Union (the 28 EU member states, Iceland, Norway and Switzerland) and is capable of automatically making a free call to emergency number 112

112

GPS (Global Positioning System) was introduced by the United States Department of Defence in 1973 with the intention of overcoming the limits of the previous navigation systems

Globally, the car sensor market, valued at 23 billion dollars in 2019, is growing at a CAGR of 6.71% and it is anticipated that it has the capacity to reach 36.5 billion dollars by 2022



Introduction

Connectivity, now considered essential by the majority of consumers, and a legacy of the sheer diffusion of mobile devices and smartphones, has established itself as one of the main differentiating factors in the car market, giving rise to a genuine rush to the "servitization" of mobility, understood as the switch from the supply of goods and services, to the supply of integrated added-value services.

The discovery of radio waves, the invention of the telephone and, naturally, of the internet have indeed all fuelled a desire to stay connected in any way possible, and the car is part and parcel of this very evolution. Even inside a car one expects to be connected, at all times and in all places, therefore making connectivity a primary need.

The first application of services of connectivity in motor vehicles dates to 1996, the year in which General Motors introduced its OnStar system - born of the partnership between GM and Motorola - on board some models of Cadillac. The first OnStar systems were concerned with passenger safety and allowed emergency or assistance calls to be made (in the event of an RTA), with the support of a call centre to which the request for help was directed; the service was then optimized thanks to the convergence with GPS as applied to the location of people and vehicles.

While the first services of "in-vehicle" connectivity focused on basic safety, the pervasive spread of mobile internet connections and smartphones has led to the creation of new digital services, from advanced vehicle control to infotainment services. On-board connectivity, which allows the driver to connect to network services and online platforms, in fact offers comfort, practicality, high-level performances, safety and add-on services. The growth in consumer demand for connectivity solutions, the need for connectivity everywhere in order to "always be on", the dependency on technology itself and the growing expert population are the key factors contributing to the growth of the global connected car market.

According to market research carried out by IBM, the supply of digital services for vehicles is the most effective instrument with which to face up to the predicted falls in sales caused by the increasingly marked diffusion of new models of business and of consumption, including shared and electric mobility, Mobility-as-a-Service, etc. Added-value digital services make it possible to enhance the experience of drivers and passengers and to radically alter the relationship with one's own vehicle.

Audi has been the first car maker, in 2014, to offer "in vehicle" access to 4G LTE networks and Wi-Fi hotspot

Competition among car manufacturers and the differentiation of vehicles offered on the market has traditionally been based on aspects such as road holding, design and engine power. With the advent of electric and connected mobility and the progressive transition towards autonomous mobility, however, the driver and passengers will devote less and less time and attention to driving: hence a greater importance will be placed on activities that can take place directly within the vehicle.

The possibility of making purchases online directly on board a vehicle, access to news and multimedia content personalized on the basis of passenger preferences and the supply of many other services dependent on vehicle connectivity will become ever more crucial in competition among car manufacturers and in consumer purchasing choices.

Almost all automotive sector executives believe that connectivity and self-driving vehicles will significantly alter their own business models, while 74% of drivers are already driving a connected vehicle or anticipate buying one in the very near future.

Against this backdrop, looking at the connected mobility ecosystem and at the players within it, there emerges a need to develop both infrastructures, and services to support connectivity: this is due to the fact that connected systems should not only be open and interoperable, but also meet the highest standards of reliability and safety. The development and widespread diffusion of 5G will allow real-time data exchange and will inevitably allow new partnerships and collaborations between car manufacturers, OEM's, mobile network operators, start-ups to be born, thus bolstering the overall ecosystem.

In general, the convergence between the auto and technology sectors is progressing at a rapid speed, and it appears that it is precisely the technology sector that is setting the pace. Although auto makers are reluctant to share their own data with Google, Apple and other tech companies (mainly out of fear of losing control over users and of seeing their own brands taking a secondary role to Big Tech), nonetheless we are beginning to witness a gradual change of gear, driven, above all, by consumers, but also by market data.

The connection between personal devices and vehicles and the possibility to interact on board the latter with voice assistants is becoming ever more important to users; a user-friendly and fluid experience is desired, with the possibility of using the voice to impart instructions or to ask the on-board systems for advice, using natural language. All this is possible thanks to the integration of car features with the operating systems offered by the big players such as Google, Apple and Amazon.

Will this lead to auto makers playing a secondary role in the market? Currently, it would be unwise to give a categorical answer. The risk for car manufacturers and OEM's, in the long term, is to keep watch on hardware alone, leaving apps, data and services – and the consequent revenues that derive therefrom – firmly in the hands of Big Tech.

Threats to the IT security of on-board systems, management of sensitive data, high installation costs and partial connectivity coverage are to be considered some of the critical factors limiting growth in this market. A Ponemon Institute survey conducted in 2018 reveals that 30% of car manufacturers have has no designated security team and that 63% test less than half of the technologies on board a vehicle. To not take into account security risks and IT threats is a mistake that ought not to be underestimated, because it can have important consequences for consumer confidence, for brand reputation and for privacy.
As illustrated, the concept of vehicle connectivity has always been associated with the services offered to driver and passengers, starting with the assistance provided by the first OnStar systems.

The 5 levels of connectivity – hardware, integrated, personalized, interactive and connectivity for automation.

We define "in-vehicle" connectivity as the total experiences that the driver is capable of having thanks to those services offered by the vehicle.

Thanks to new digital models for the supply of services, and thanks to the potential of data analysis technologies, it is expected that connectivity will be capable of generating new earnings for car manufacturers, of optimizing passenger experiences and of improving safety standards.

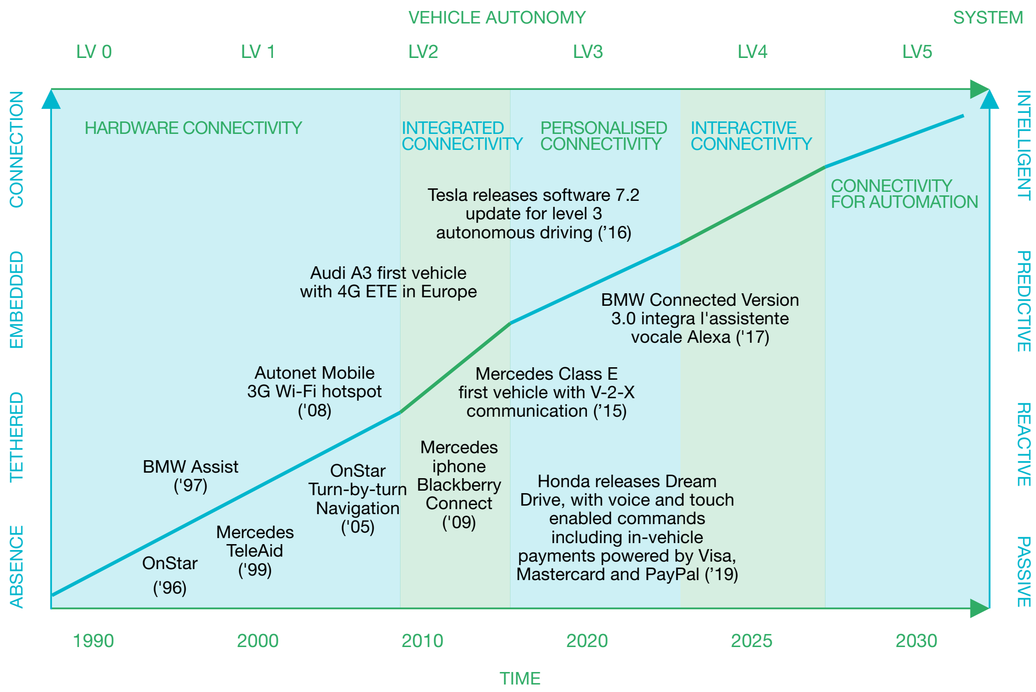
Artificial intelligence algorithms make it possible to anticipate and optimize passenger needs on the basis of data gathered from various sources: mobile applications, social media, online sales channels, biometric driver data and data obtained from various IoT sources – above all from the Smart Home and Smart Office -, these are only some of the sets of data available to the connected vehicle, thanks to which it is possible to personalize the on-board experience and to enable new services for the safety and infotainment.

Just as for self-driving vehicles, as we will see hereafter, five levels were identified that are linked to the degree of control that the drivers have over the vehicle (from level 1, that is to say complete driver control, to level 5, that anticipates the total absence of human intervention), so too for connected mobility: five levels were identified that correlate to the user experience on board the vehicle.

- **Hardware Connectivity**: the first level of connectivity permits the driver and passengers to access data and view the information relating to real-time vehicle use and to the state of the vehicle and its components. This degree of connectivity requires the installation of sensors or other hardware devices by means of which the information is transmitted to the dashboard or to assistance centres.
- **Integrated Connectivity**: the second level of connectivity, which also goes by the name of "individual connectivity", is based on the possibility of incorporating into the vehicle connectivity and digital application services, such as smartphone applications, music and multimedia content, SatNav, etc. This is possible by setting a driver user profile to which are associated specific digital services supplied by external platforms. When compared to the first level of connectivity, which requires exclusively basic hardware components, here it is necessary to have an internet connection of the "embedded" or "tethered" type. In the case of the use of "embedded" modules, the vehicle is connected with the internet by means of a SIM or of WiFi modules integrated directly into the vehicle communication module. "Tethered" connectivity instead refers to the connectivity obtained via an independent and external device, such as a smartphone or an insurance services black box, which functions as a hotspot and allows the car dashboard screen to act as an extension of the smartphone (an example of this is provided by Apple CarPlay and Android Auto services).
- **Personalized Connectivity**: the third level of connectivity requires advanced passenger and driver profiling functions, with the objective of personalizing driver and passenger preferences and of improving the experience. An "embedded" connection managed by OEMs or by the car manufacturers themselves, makes it possible, on the one hand, to manage the preferences of the users on board the vehicle (linked, for example, to favourite music, to the position of the seats and of the mirrors, etc.), and on the other, to optimize marketing campaigns for the supply of services, since the connection does not derive from third-party devices. This is the first degree of connectivity with predictive capabilities and is the most advanced stage of connectivity available today.
- **Interactive Connectivity**: the fourth level of connectivity permits passengers and driver to interact with the vehicle's infotainment systems using "*multimodal live dialogue*". Interaction is made possible by using, for example, voice commands, the advanced dashboard and the recognition of driver and passenger biometrics. Ultimately, the on-board systems may prompt users proactively regarding the services and functions available. This level of vehicle connectivity already necessitates the use of Artificial Intelligence associated with advanced "*recommendation*" systems.
- **Connectivity for Automation**: in the most advanced stage of vehicle connectivity, the massive use of Artificial Intelligence will enable sophisticated predictive capacities to be deployed.

Passengers may not only be offered services on the basis of the needs expressed but needs not yet understood will be identified. The vehicle will moreover be capable of carrying out complex tasks. It is anticipated that in the time span required for the technological developments necessary to reach this level of connectivity, as will be illustrated in greater detail in the chapter dedicated to autonomous mobility, almost all vehicles will also be "self-driving".

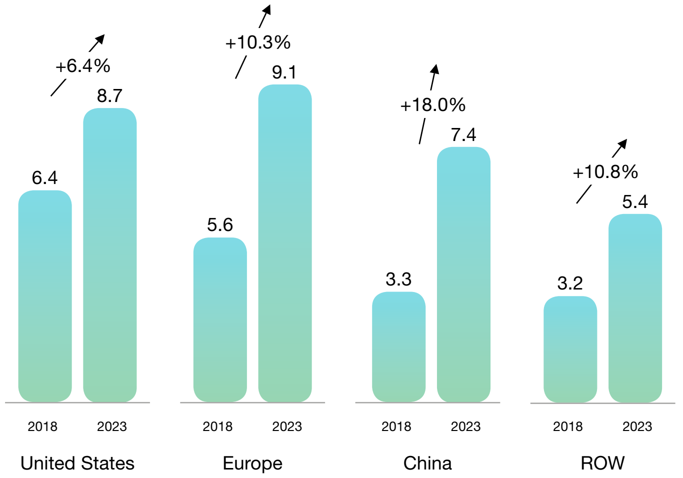
A significant evolution is expected in connected vehicles revolving around customer experience, for its part determined by the supply of new services and by the emergence of new models of consumption. For these reasons, car manufacturers will have to assume an active role in the definition of new standards, based on the integration of embedded solutions for internet connectivity, capable of providing an architecture functional to the supply of added-value services and to the improvement of the predictive capacities of vehicles.



The connected vehicles market

World

Connected Car revenue forecast in billion US$

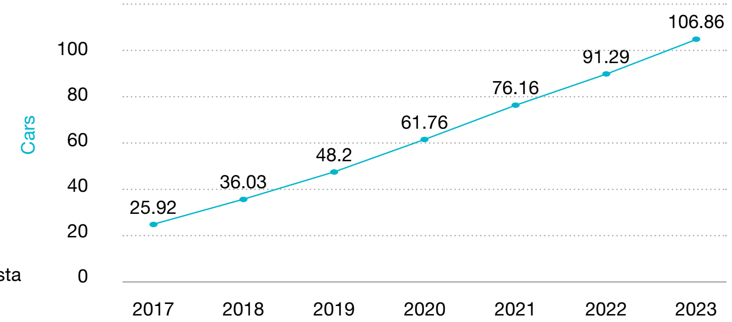


Source: Statista

The constant increase in the penetration of internet globally is leading to growth in the connected vehicles market: according to Statista's analysis, while in 2018 the US market was the principal market globally (6.4 billion dollars in revenues), the Chinese market, however, was that to which the greatest prospective growth was attributed (+18% from 2018 to 2023). Just as with electric vehicles, robust growth is anticipated in the European market over the next few years, with the potential of beating the world record in revenues deriving from connected vehicles by 2023 (9.1 billion dollars). In absolute terms, in 2018 over 116 million connected vehicles were in circulation globally, while 342.6 million is the number forecast for 2030.

Europe

Estimated stock of connected cars in Europe from 2017 to 2023 in million

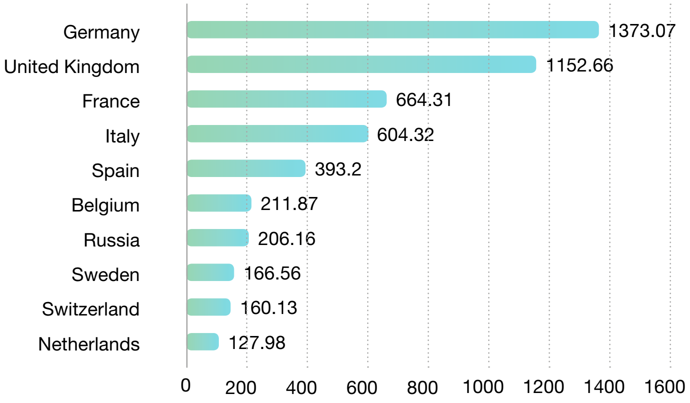


Source: Statista

At a European level, the trend for the diffusion of connected vehicles will place the old continent at the top of the global market for connected vehicles: by 2023 it is anticipated indeed that there will be 106 million connected vehicles in circulation.

Leading the European connected mobility market in 2018, in terms of revenue flows, were Germany, the United Kingdom, France and Italy. German primacy is due to the number of German car manufacturers, and to the number and size of the companies specialized in the production of hardware for connectivity and in the supply of services for connected cars. By way of example, one can mention Bosch and Continental, two of the three main groups in the global infotainment segment.

Forecasted connected car revenues in European countries in 2018



(in million U.S. Dollars)

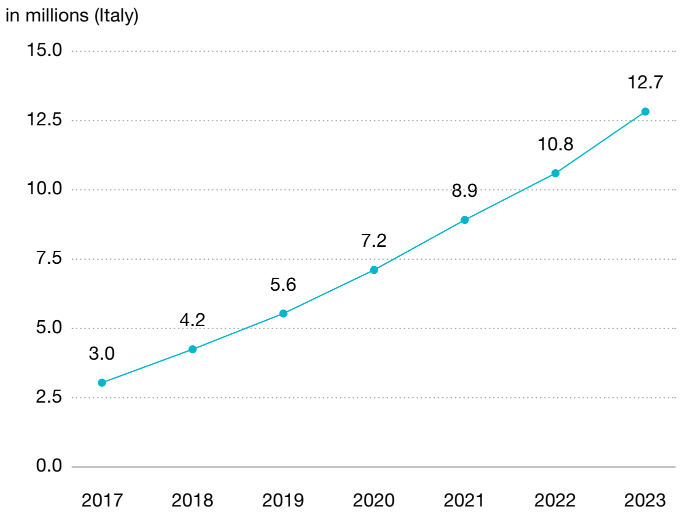
Source: Statista

According to the findings of the report "*The race for automotive data*" drafted by the European Commission, Europe is nevertheless behind in its offerings of digital platforms for the management of connected vehicles and of the data produced thereby. In the long run, 30%-40% of the chain of value of the automotive sector will be attributable to digital services, but European platforms do not operate on a sufficiently broad scale due to high levels of market fragmentation, which makes it difficult to compete with the main US digital platforms.

Italy

The specific case of the Italian connected vehicles market is equally promising: according ot Statista, the forecast is for 12.7 million connected vehicles to be in circulation by 2023, increasing with a CAGR for the 2019-2023 period of 9.7%. By the end of the same period, connected vehicles in Italy will represent around 53% of the total vehicles in circulation for a market that will be worth more than a billion dollars.

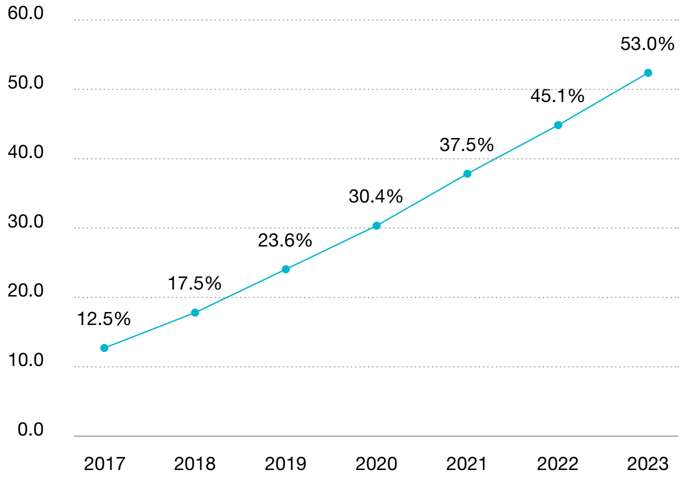
Stock of connected cars in the connected car market



Source: Statista

Penetration rate in the connected car market

in percent (Italy)



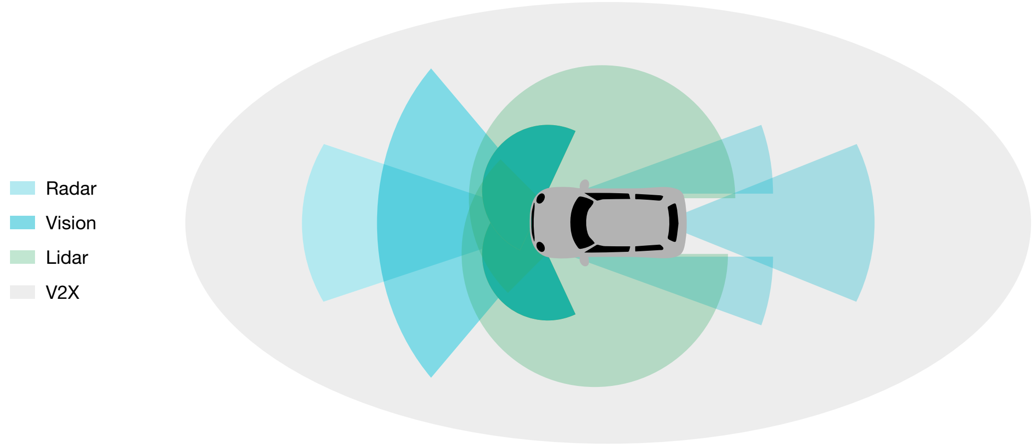
Source: Statista

Enabling Technologies

The development of new generation vehicles requires different applications in areas such as infotainment, telematics, assisted driving with high levels of reliability, safety and privacy. It follows that vehicles must be capable of communicating with other vehicles, but also with pedestrians, and roadside and network devices.

Connected vehicles have access to internet and are equipped with a variety of sensors (LiDAR, radar, sensors IoT) and video cameras, which enable communication with other vehicles, with road infrastructures (Road Side Units) and with other external objects; they are, moreover, interconnected through the same network infrastructure. Thanks to connectivity vehicles assume a proactive role, alerting drivers to potential collisions with oncoming vehicles, monitoring junctions, gathering information on the traffic in real time, sharing notifications of accidents and emergencies with a rapid response and paramedic services.

The technology in support of the so-called vehicle networks, named Vehicle-to-Everything (V2X), is “broadening the field of vision” of the vehicle. By using wireless signals from devices connected in proximity, such as other vehicles, infrastructure sensors or smartphones, V2X allows the vehicle to see beyond the “physical” limits of the on-board devices, offering the possibility to identify, detect and predict rapidly and accurately the actions of surrounding vehicles.



Vehicle-to-Everything (V2X) communication

V2X is a vehicle communication system that includes different types of communication:

Vehicle-to-Vehicle (V2V)
V2V technology permits vehicles and fleets to communicate together, improving traffic flows and reducing the collisions. It allows, for example, for safety notifications to be shared in the event of risks on the road or reports of vehicles in blind spots.

Vehicle-to-Infrastructure (V2I)
The vehicle can be connected to roadside units operating as network nodes. V2I permits vehicles to communicate with road infrastructure such as traffic lights and road signs. The system on board the car connects to infrastructure sensors on the road, commonly referred to as Road-Side Units (RSU), or to devices such as aerials, receivers and processors. V2I allows for better traffic management and provides drivers with additional road safety information.

Vehicle-to-Pedestrian (V2P)
The vehicle can be connected to pedestrians through smartphones or other personal connected devices (wearable), so as to know in real time the position of the individuals and to report to vehicles dangerous situations that could cause accidents involving pedestrians.

Vehicle-to-Device (V2D)
V2D systems of communication support data exchange between vehicles and other devices connected to internet, such as, for example, smartphones, remote controls used for keyless cars and others on board units (OBU).

Vehicle-to-Cloud (V2C)
The vehicle can be connected with the cloud to perform software updates *over-the-air* (OTA) and to download other information intended for the management of systems on board the vehicle.

Vehicle-to-Home (V2H)
A connected vehicle can be used also for the remote control of domestic smart applications (remote control of lights, of heating at home or of cooling systems, charging stations for electric vehicles, etc.).

Vehicle-to-Everything (V2X) is thus a system of communication of information between a vehicle and anything that can affect that vehicle and vice versa. It allows wireless data exchange between a vehicle and the surrounding environment, providing connected devices with real-time feedback on what is happening around the vehicles themselves.

This system of communication is based, on the one hand, on a WLAN network infrastructure and, on the other, on the cellphone network. The first specifications for V2X communication based on WLAN are from 2012 (IEEE 802.11p standard) and were born to support communication between vehicles (V2V) and between vehicle and infrastructure (V2I).

All the V2X systems depend on GPS technology for position, which is globally referred to as GNSS (Global Navigation Satellite Systems). GPS by itself is not, however, sufficient since it displays significant limitations linked to accuracy and reliability. It can suffer from various kinds of interference that can compromise the precision and power of the signal. For these reasons some companies are developing systems of communication for short-medium distances, determining the position of the vehicle through the sensors present in the roadside units.

In the area of V2X communication, it emerges that wireless and, in future, 5G, *advanced imaging*, virtual and augmented reality, GPS and sensor systems may be integrated to develop advanced solutions for vehicle communication.

Connectivity and alerts	Status data exchange linked to the vehicle via V2X communication (e.g. position, speed, direction of driving or special events such as a fault or a temporary damage to the vehicle) enables a set of information connected to notifications or alerts. These help users maintain a prudent approach to driving and awareness of the potential risks, not yet perceptible with the naked eye.	Examples are: • Alert for accidents in proximity to a junction • Alert for arrival of emergency vehicle • Alert for dangerous situation • Alert for stationary vehicle • Alert for traffic jams • Anti-collision system
Perception and Data Sharing	In addition to status data, road users using C-ITS can share data acquired from sensors and advanced environmental information. In this way, the other users present in the traffic are not only forewarned of the hazards that cannot yet be perceived, but it is also possible to protect also those not in direct communication with the systems (for example, pedestrians).	Examples are: • Alert for blind spots • Extended alert for accidents in proximity to a junction • Alert for vulnerable user (pedestrians, cyclists etc.) • Cooperative adaptive cruise control • Alert for roadworks • Priority for particular vehicles (e.g. ambulances)
Prediction and Cooperation	In addition to status data and data on sensors, cooperative road users can also provide data of intent, allowing them to interact in a smart way and to coordinate their own behaviour even in complex traffic situations. Predictivity is an important prerequisite to achieving the long-term goal of highly automated and autonomous driving.	Examples are: • Platooning (static or dynamic) • Booking of parking zones, halts for loading/unloading, etc. • Cooperative entry into traffic flow • Cooperative lane changing • Cooperative overtaking

Here above are displayed, according to the evolutionary roadmap provided by the European Commission under the umbrella of the C-ITS (Cooperative Intelligent Transport Systems), some of the applications that are and will be enabled by V2V and V2X communications.

↳ “V2X Technology”

V2X systems “boost” traditional car visual sensors: they provide information on the road hazards, on traffic jams and on blind spots, that is to say all the situations outside the vehicle’s field of vision.

Thanks to V2X, it is possible to achieve a higher level of safety, an essential feature for the implementation of autonomous driving and for increasing the efficiency in the whole transport ecosystem.

V2X communication also lays the foundations for the birth of the Smart City, since the points in the connected infrastructure provided with real-time traffic data can gather valuable information for the management of the city and, in some cases, the infrastructure itself can adapt dynamically to optimize the flow of traffic, using, for example, a regulation of the traffic lights based on the levels of road congestion.

Standards for connected cars

From a strictly technological point of view, the origin of connected cars can be traced back to 2007, with the birth of the US project known as WAVE- “Wireless Access in Vehicular Environments” that defined the modifications to the IEEE 802.11 standard (for wireless communication at the heart of Wi-Fi products) to support system requirements for vehicle transport, implementing the IEEE 802.11p version. This version of the standard was subsequently adopted in the ambit of the US project by the name of *DSRC- “Dedicated Short-Range Communications”* and also by the ETSI ITS technical committee for the European version known as ITS-G5.

Within V2X systems, DSRC/ITS-G5 was tested and trialled in the field for more than ten years, becoming to all effects a market standard. DSRC/ITS-G5, which being a de facto variant of Wi-Fi and providing unidirectional and bidirectional communications over short- and mid-range distances, is specifically designed for vehicle communication, which requires greater speeds and bandwidth than the Wi-Fi used for mass consumer electronic devices.

As the car becomes progressively more complex and more vehicles are connected to the internet, a certain number of automotive players, including BMW and Daimler, are opting for faster wireless communication systems with lower levels of latency, such as the cellular V2X (C-V2X), based on LTE technology, that therefore exploits the cellular network and differentiates itself from Wi-Fi-based V2X technology.

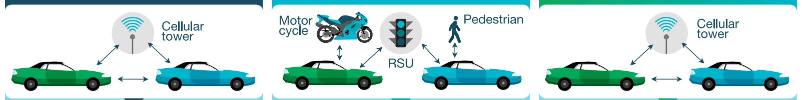
The use of cellular technology for connected cars is still in the standardization phase and requires several stages of development. 2017 saw the termination of Release-14 of the 3rd Generation Partnership Project (3GPP) that provides for applications of "basic safety" such as overtaking warnings, prevention of collisions and notifications based on the road signs. 2018 then saw Release-15 come out, providing for support for more complex uses such as "platooning" (dynamic convoy formation of a group of vehicles travelling with a minimum safety distance between them), the "extended sensor" (data collection by local or remote sensors, sharing of video material from other vehicles, for a common representation of the surrounding environment), '"advanced driving" (synchronization and coordination of routes and intended manoeuvres) and "remote driving". There follow more stringent performance requirements that can only in part be satisfied by a linear evolution of LTE systems and that more generally require a rethinking of radio and network architectures in light of 5G.

Although LTE technology currently harnesses V2V and V2I applications for connected cars, the large-scale adoption of C-V2X is then strongly based on the implementation of 5G.

V2X Communication Protocols

C-V2X is more promising than DSRC technology. Trials have been succesful and cellular companies will make most of this opportunity regardless of which technology is introduced first

V2X Market: V2X Communication Protocol, Global, 2019



	C-V2X	DSRC	Hybrid (C-V2X & DSRC)
WHAT?	Cellular based V2X solution, relies on network access in the 4G/LTE/5G spectrum to communicate with various entities	V2X (mainly V2V and V2I) applications, relying on IEEE 802.11p Wi-Fi communication, to interface with all the devices	Solutions and applications that rely on a mixed use of both C-V2X and DSRC communication
WHO?	OEMs: Audi, BMW Group, Ford, Geely, Honda, Lexus Mercedes Benz PSA Group Suppliers: Qualcomm, Quectel, Keysight Technologies, LG Innotek	OEMs: GM, JLR, Toyota, Volkswagen Suppliers: Qualcomm, Quectel,Keysight Technologies, LG Innotek	Technology providers such as Auto Talks, Qorvo etc. are some of the front runners to introduce modules. OEMs in this space are unknown
WHEN?	Ready for deployments in 2019-20. Push from regulatory bodies required for successful implementation	Gained much prominence after successful trials and will be deployed as early as 2019	As of 2019, Technology companies are already introducing hybrid chips and deployments will follow respective timelines

Source: Frost & Sullivan

It is not yet clear whether the best standard for connected cars may be DSRC/ITS-G5 or C-V2X, and in 2019 the question seems to be in a situation of stalemate in many parts of the world.

In December 2016, the US Department of Transportation proposed the imposition of the DSRC standard on all new vehicles. The Trump administration has not, however, followed up on the proposal and the debate is also open as regards radio frequencies for vehicle communications.

In Europe the question seems to be definitively closed following the choice made by the EU Council, which on 4th July 2019 rejected the Commission's proposal for the obligatory use, for connected cars, of frequencies linked to specific technologies analogous to Wi-Fi, the so-called ITS-G5, placing on the market and no longer on a delegated act of legislation the choice regarding the best technology to adopt, through the full freedom accorded to auto makers and suppliers of technologies to make use both of cellular technologies and Wi-Fi variants.
China has instead moved beyond the testing stage with C-V2X. With the guidance of the government and the allocation of frequencies, it will begin to distribute LTE-V2X in 2020 or 2021.

The connected mobility ecosystem and added-value services

The different levels of connectivity that characterize the automotive market and the gradual convergence of technologies for the mobility autonomous, electric and shared, are expanding the range of opportunities for sector players, as well as for new entries.

Car manufacturers are increasingly focused on the development of connected vehicles, but also of "smart" ones. The first objective of "in-vehicle" connectivity is certainly that of improving road safety and of reducing the number of victims caused by road traffic accidents. Most of these, in fact, are due to driver error and for this reason it is of vital importance to develop technologies designed to create "smart" vehicles with the aim of preventing collisions.

The US National Highway Traffic Safety Administration (NHTSA) has estimated that technologies for connected and "smart" vehicles could eliminate or reduce by up to 80% the gravity of accidents that do not involve drivers under the influence of alcohol or mechanical failures.

The US Department of Transportation and Frost & Sullivan have tried to estimate what the real impact of the diffusion of connected vehicles globally will be, concentrating precisely on safety, on journey efficiency and on user experience, linked both to added-value services enabled by connectivity, and to journey optimization in

specific conditions of heavy traffic and to the consequent reduction in atmospheric pollution. Connected mobility can in fact aid the reduction of road congestion - and consequently of greenhouse gas emissions - and improve users' journey experiences of journey, thus providing greater safety and comfort.

25% Accident reduction

The technologies and applications for connected cars can alert the driver in time in the event of situations of danger, guaranteeing appropriate reaction times and preventing many collisions.
In case of bad weather or poor visibility, the implementation of connected systems of traffic management, as well as of technologies for communication between vehicles in real time and between vehicles in movement and infrastructures can reduce road traffic accidents by 25%.

27% Travel time reduction

Connected vehicles can communicate in real time with the roadside infrastructures, in turn connected in the cloud with the operating centres for the control of the traffic. They thus have the possibility to manage critical traffic situations and optimize routes, reducing journey times by 23% for emergency vehicles (ambulances, fire service, law enforcement services) and by 27% for all others.

22% Fuel saving

Smart technologies for connected cars can alert users in case of road congestion or roadworks and help them in choosing alternative routes, as well as in selecting a speed appropriate to the situation.
An optimized use of traffic management systems and of lanes can reduce CO_2 emissions by 11% and provide a fuel saving of 22%.

Frost & Sullivan's market research has identified three macro-trends that are affecting the connected mobility ecosystem in 2019, on which it is expected that the role of new players will be consolidated:

- **Marketplace**: in 2019 around 60% of new premium-range vehicles placed on the market were equipped for purchases to be made directly on board the vehicle. By the end of 2020 this percentage is destined to rise to as much as 80% of new vehicles in the aforementioned range, thanks to partnerships between car manufacturers, producers of original parts and suppliers of platforms for online purchases. We mention, by

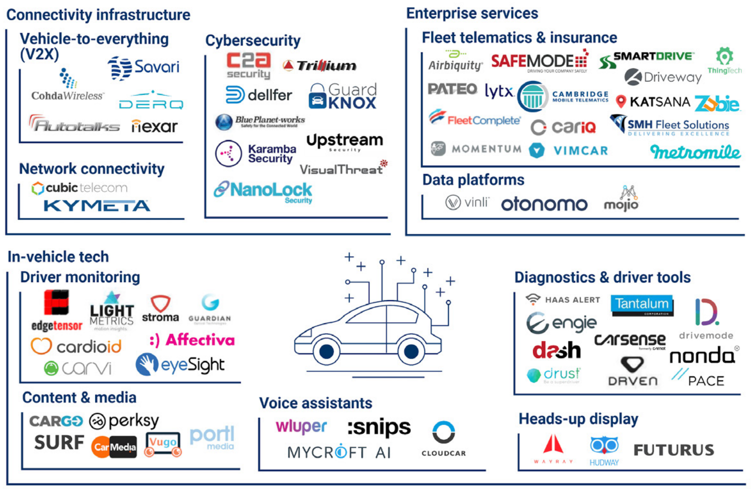
↳ "www.xevo.com"

way of example, the partnership between Chevrolet, Hyundai and Toyota with Xevo Market, the commercial services platform devised specifically for the automotive sector, which puts consumers in touch with their favourite brands through the touchscreens in their vehicles or via mobile apps personalized according to on the vehicle. This, as well as other solutions on the market, is also capable of capturing and analyzing customer data thanks to digital assistants and to the integration of artificial intelligence algorithms, in order to personalize the offering of products and services on the basis of individual passenger preferences. Integration of services for in-vehicle payment, that is to say the possibility to make payments directly from the cabin, is necessary.

- **Features On-Demand (FoD):** the second trend that involves the connected mobility ecosystem is represented by Features on Demand (FoD). In 2019 around 40% of new cars in the luxury segment include FoD, represented by packets of add-on services that the user can select on purchasing the car or can download OTA subsequently according to personal needs and preferences, this also with a view to personalizing the passenger experience and generating new revenue flows for producers of vehicles and OEM's.
- **Hands-On / Hands-Off**: the digital driving assistants that make use on the decoding and comprehension of natural language are becoming ever more integrated into vehicles and permit passengers to interact with the environment, imparting instructions by voice directly to the vehicle, fostering multimodal HMI (Human Machine Interaction) and improving the user experience. The integration of well-known digital assistants such as Amazon's Alexa or Google Assistant in numerous vehicles makes it possible to hone their features, adapting them ever more to market needs.
- At the same time it emerges that suppliers of technology are continuing to work on C-V2X connectivity, developing and incorporating into cars hybrid communication modules. In terms partnerships, the tie, that Frost&Sullivan defines as "digital business engagement", between car manufacturers and digital companies, in particular Big Tech businesses, is strengthening.
- The increasing digitalization that is transforming the sector, in fact, encourages the main players in the ecosystem to collaborate with tech companies to respond more agilely to customers' digital needs, allowing car manufacturers, at the same time, to develop internal competencies in management and data analysis. For this reason many car manufacturers are already acquiring, collaborating with, or investing in tech companies capable of sharing their own strategic vision.

CB Insights has mapped some of the innovative start-ups populating the automotive connectivity ecosystem and that are working to broaden the capacities and features in vehicles, concentrating on vertical aspects linked to connected mobility and in particular to technologies for innovative services on board the vehicle, to technologies and solutions in support of corporate mobility and of fleets and to connectivity of vehicles and infrastructures.

60+ companies driving innovation in connected car tech



Source: CBInsights

Adopting the classification displayed above, we may group and analyze the various types of high-value-added services on which both established players and sector start-ups are concentrating.

“In-Vehicle” services

As previously mentioned, the car is acquiring more and more important functions compared to those traditionally linked to the carriage of persons and objects from one place to another. User expectations revolve around the concept of “always on” and around the continuity of the media and of content accessible switching from one device to another, from the home or from the office to one’s own personal vehicle: it is being transformed into a “physical mobile space” at the heart of all daily activities. It follows that drivers’ purchasing choices are more and more influenced by the decisions adopted by car manufacturers in terms of technology and of added-value services.

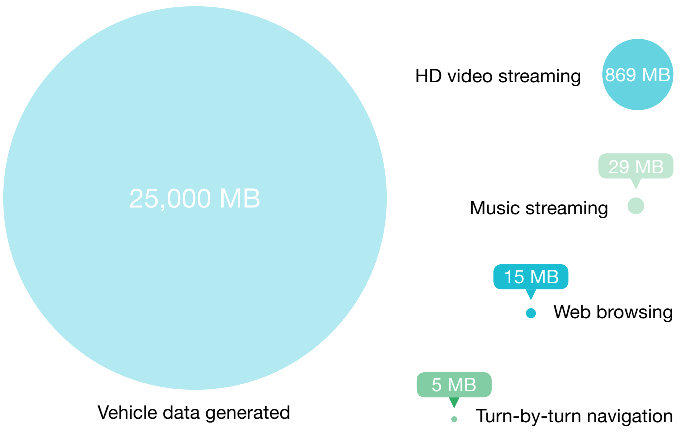
On the question of infotainment services it emerges that, for example, streaming subscriptions are replacing the classic enjoyment of music and other multimedia content through car radios or the on-board “embedded” computer in the dashboard, precisely because on-demand content streaming online is more personalized than passenger preferences. Furthermore, when the integration of virtual assistants becomes the prerogative of all private vehicles – and not only of top-of-the-range cars – presumably the services for mobile workers will increase and will become common, consequently transforming the car into a “*smart office*” where it will be possible to perform various activities while driving by exploiting voice control and commands.

Also services for safety and for maintenance and diagnostics are undergoing a significant transformation: connected vehicles and the IoT devices incorporated into them make it possible, in fact, to enable on-board-vehicle services linked to predictive maintenance and to the reporting and sending of notifications to users in real time, allowing, moreover, cars to interface with repairs services and marketplace platforms for the aftermarket.

At the root of “in-vehicle” services are the data generated by cars on the move, whether processed on board the vehicle or remotely. Modern cars are equipped with over 100 sensors that create a constant flow of data: position, performances, biometric signs and user behaviour behind the steering wheel can be monitored several times a second, for which reason the quantity of data generated by these sensors becomes substantial. As can be seen from the following graph, currently connected cars can generate up to 25 gigabytes of data per hour, the equivalent of 30 hours of high-definition video or more than a month of streamed music 24 hours a day. The data generated have enormous potential in terms of monetization and of the supply of added-value services to car owners.

Big Data on wheels

Data generated by connected cars compared to data usage of online activities (per hour)



Source: Statista

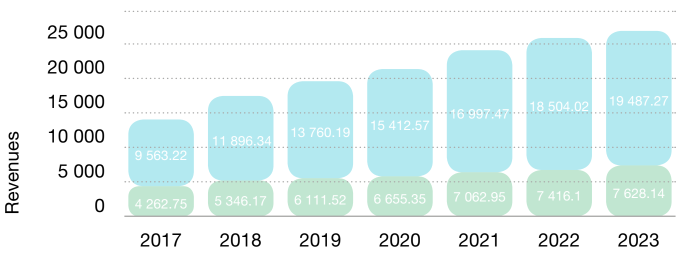
Information services and advanced telematics

> By “in-car entertainment” or “in-vehicle infotainment” is meant a combination of hardware and software within cars that is capable of providing audiovisual entertainment and information to passengers.

In-car entertainment has its roots in audio systems composed of the traditional radio and cassette or CD players, even if the most modern systems include systems to aid navigation, video and music players, USB and Bluetooth connectivity, on-board computer, internet and WiFi connectivity. The modern interfaces for the control of infotainment, once composed of simple knobs and dashboard displays, today present commands to the steering wheel, touchscreen panels and advanced voice controls.

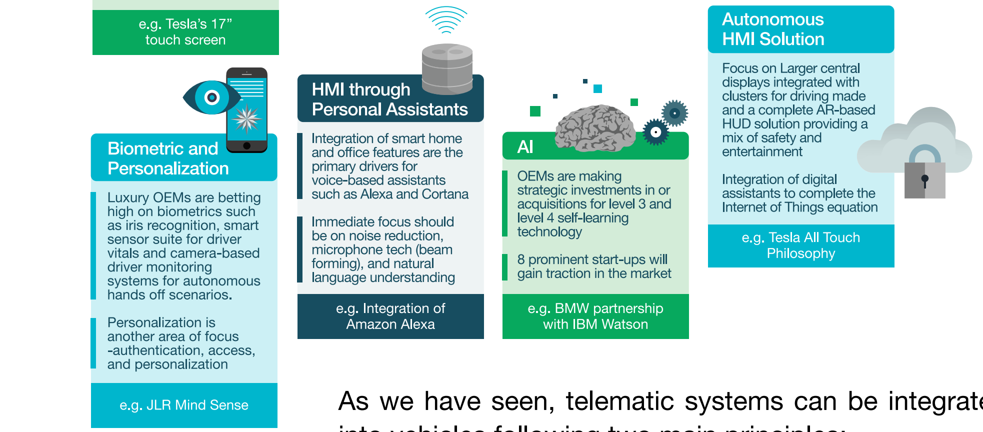
The greater evolution in this segment of services is due to the convergence of systems of infotainment and on-board telematics systems.

Revenues in the connected hardware segment worldwide from 2017 to 2023 by subsegments (in million U.S. dollars)



Source: Statista

In addition to the impulse given to the market by customer expectations, increasingly interested in internet access and to the enjoyment of multimedia content any time, any place, the enhancement of the systems and services of infotainment also derives from the need of producers to capitalize on new technological solutions to improve the on-board experience of both drivers, and passengers. These new solutions incorporate progress in the fields of artificial intelligence, of voice recognition and of *mixed reality*, technological areas that are profoundly enhancing and personalizing the *user experience* of passengers.



Source: Frost & Sullivan

As we have seen, telematic systems can be integrated into vehicles following two main principles:

- *Embedded system:* this provides for an integrated proprietary solution on board a vehicle. The interface offers access to a vast range of vehicle management functions and allows for the integration of several features through an internet/WiFi connection.

- *Tethered system:* this is a solution not incorporated into the vehicle, but in which the user's own smartphone interfaces with the on-board computer, via cable or wireless, in such a way that various features can be enabled.

Examples of *tethered* solutions include MirrorLink, Android Auto and Apple CarPlay. The main difference between the traditional MirrorLink systems and the corresponding Android and Apple systems is that, while the former is an opensource interface providing an actual replica of a smartphone "projected" onto the car's screen, it does not guarantee compatibility with all platforms and thus renders its use of limited effect, the latter two are proprietary systems also integrating more complex functions, such as the respective voice assistants Google Assistant and Siri, and ensure a superior optimization. Today most car manufacturers are opting for total compatibility with the Android Auto and Apple CarPlay systems, even if different producers are forming further partnerships with other big players in terms of voice assistance - for example Amazon Alexa -.

Real-time information for Traffic Management

Of all the trends recently developed relating to navigation services, RTTI – *Real Time Traffic Information* is currently one of the most common. The quality of navigation in general depends on the quantity and quality of the data available to calculate the route.
Most connected navigation systems are based on more than one data source, such as:

- GPS-navigation systems;
- Cellular networks;
- Fleet management devices;
- IoT roadside sensors.

The data collected are made anonymous, processed, updated continuously, sent to the connected navigation systems and used to optimize the route. The driver is informed in real time in the event of traffic jams, accidents or diversions and the system suggests alternative routes and avoids waiting times.

The main trends that, over the next few years, will concern the market of RTTI services are the use of artificial intelligence for predictive purposes in the traffic management, V2X communication, the growing investments in the Smart city and the spread of new models of business and of multimodal transport.

Particularly significant seem to be the consequences that the generation and exploitation of Big Data are having and will increasingly have in the future. One example can be found in INRIX, a supplier of real-time traffic information and connected driving services for vehicles and mobile devices. The company combines real-time data coming from the sensors of over 4 million vehicles equipped with GPS: its database conserves the records of traffic speeds and hundreds of other factors that affect it. Thanks to this great volume of data, INRIX is able to offer quality data with broad scope for personal navigation, cartography, telematics and other services based on location. INRIX's services are used by transport agencies, consultants, academic institutions that use its data to improve their operations, planning and performance assessment.

A further example in this area is represented by HERE, which supplies data for digital maps across more than 190 countries around the globe. In 2015 an alliance of German brands such as Audi, BMW and Mercedes-Benz, acquired the company for around 3 billion dollars. This acquisition ensured the independence of this OEM from the data of the main competitor in the field, Google. In its most recent products, HERE also uses V2V communication to provide additional information and to improve passenger safety. The data collected by on-board devices such as video cameras for road signs, rain sensors or braking systems, are anonymized and shared with other vehicles equipped with the same software.

↳ HERE map data

Focus – Startup ecosystem

Globally many start-ups are developing solutions in the areas of the Smart City and *traffic management* intended to reduce traffic and road congestion, exploiting the data produced by the connected vehicles and by the related smart infrastructures.

40+ startups transforming traffic management

Source: CBInsights

Adopting the classification proposed by CB Insights, it is possible to identify 6 clusters:

- Smart routing: Routing software and navigation platforms that gather traffic information in real time from a traffic management standpoint; one example of its application is route optimization on the basis of the individual journeys to be made.
- Connected infrastructures: Technologies for the monitoring of infrastructures, such as roads, traffic lights and lamp posts. These systems of sensors allow real-time monitoring of traffic activity. Some start-ups, like Valerann, are building both the sensor hardware for detection, and the software to analyze traffic information; others, such as WayCare, are concentrating primarily on data analysis from a predictive standpoint, acquiring and processing information from GPS, cellular network masts, mobile devices and video cameras already installed roadside.
- Connectivity of vehicles and tracking: Systems for connecting vehicles for real-time monitoring purposes. The data can be collected and used with the objective informing fleet owners and city administrators of slowdowns due to traffic, of weather conditions and of road traffic accidents. As regards technologies for V2X, start-ups like Savari, are developing sensors that make possible communication between vehicles and between vehicles and infrastructure.

- Mapping & planning: Companies like the Japanese Dynamic Map Platform – a firm deals with the research, development and marketing of high-precision 3D cartographic data for the support of self-driving vehicle systems and of safe driving -, are constructing highly-detailed maps of urban areas to help cities monitor the roads in real time. Others like Urban Footprint are constructing cartographic data that can help cities model future mobility from the perspective of "smart" territorial planning.
- Smart parking: As far as smart parking is concerned, innovative solutions are being developed to make parking simpler and more efficient, by exploiting open API's, as does Aipark, or platforms for the reservation of an individual car space before reaching the destination, among these, for example, is ParkWhiz.

Entertainment services

The diffusion of on-board entertainment services is one of the main effects of the digital transformation of the automotive sector. Some years ago now, especially in mid- and high-range vehicles, the traditional analogue dashboard was replaced by a screen that projects the information required by car users, and with which it is also possible to interact by means of voice commands. On-board car entertainment is a sector destined to grow above all through the diffusion of the *self-driving car* and the shift from a level of semi-autonomous driving to completely automatic driving.

Already today drivers can interact with infotainment systems without taking their hands off the steering wheel: they can, for example, listen to music, access their telephone contacts list, make telephone calls and send messages. Passengers, on the other hand, can use displays, for example, to see films during the journey. Besides concentrating on drivers, OEM's and car

MOOVIT

Moovit, formerly Tranzmate, is a transit data and analytics company that simplifies urban mobility all around the world, making getting around town via transit easier and more convenient. By combining information from public transit operators and authorities with live information from the user community, Moovit offers travelers a real-time picture, including the best route for the journey.

Total Funding
$131.5 mln

Last Round
Feb 2018 Series D
$50 mln

Country
Israel

moovitapp.com

manufacturers are also looking into new *on-demand* services to improve the experience of passengers.

To entertain users car manufacturers together with the big tech companies – such as Audi and Intel - are developing applications that offer captivating experiences directly inside the vehicle. At the CES in Las Vegas in January 2019, Audi presented Holoride, a new technology that integrates games, films and Virtual Reality applications with real-time data relating to vehicles to create an "augmented" experience for passengers.

↳ Audi at CES 2019 | Future in-car entertainment | holoride VR experience

As regards the streaming of content, start-ups such as Portl Media and Vugo are developing screens for the transmission of "in-vehicle" videos that generate advertising revenues in particular for ride-hailing companies like Uber and Lyft. Tesla, too, announced in July 2019 that it will offer Netflix and YouTube streaming in some of its vehicles.

At the moment, the biggest challenge for the players in the sector is to provide the driver with good on-board entertainment, combined, naturally, with drive safety. When the car becomes totally connected and autonomous, at the

URBANFOOTPRINT

UrbanFootprint maps existing conditions, builds and tests future scenarios, and analyzes land use impacts in terms of emissions, transportation, water use, energy use, walk accessibility, transit accessibility, risk and resilience, and more.

Total Funding
$9.56 mln

Last Round
May 2019 Conv. Note
$1 mln

Country
United States

urbanfootprint.com

WAYCARE TECHNOLOGIES

WayCare Technologies offers predictive insights for smart cities. The company's deep learning technologies provide municipalities with forward looking and actionable insights. Waycare has developed a SaaS-based transportation management platform that leverages a myriad of data sources from vehicles, weather, video cameras, and road sensors to help municipalities proactively manage their roads.

Total Funding
$10.07 mln

Last Round
Oct 2019 Series A
$7.25 mln

Country
Israel

waycaretech.com

PORTL MEDIA

Portl Media eliminates idle time by providing education and entertainment options to users through a network of strategically placed media and entertainment screens starting off in rideshare cars.

Total Funding
$0.12 mln

Last Round
Apr 2019 Incubator/ Accelerator

Country
Canada

portlmedia.com

driver's disposal will be all those features that generally he or she uses outside the car, but accessible and usable in the vehicle in movement through man-machine interfaces based on the comprehension of, and interaction in natural language.

Some start-ups have also been concentrating their attention on the entertainment of drivers in the interests of keeping them alert and focused on driving. Drivetime, backed by Amazon and Google, and which, as of September 2019, had raised $ 11 million, is developing interactive games for drivers based on voice applications.

↳ Drivetime nabs $11M from Makers Fund, Amazon and Google to build voice-based games for drivers

"In-vehicle" marketplace

Just like "in-vehicle" entertainment, marketplace access directly from the vehicle too is becoming more common, while the innovations linked to mobile payments facilitate in-car purchases. According to Frost & Sullivan, by 2020 80% of new vehicles in the premium bracket will have access to an "*in-vehicle*" marketplace. If it is true that the increased number of commuters has led to an increase in purchases made in mobility, in particular, by app and smartphone, it is equally predictable that, in the future, also on board private vehicles commercials and advertising will turn into purchases of products and services, above all in autonomous vehicles, and this makes such a market highly scalable.

New models of shared mobility, too, enable "in-car retail". With the growing diffusion of ride-sharing services and the potential increase in the shared robotaxis, indeed, the concept of the car as an alternative sale is taking hold. Ride-sharing vehicles understood as points of sale for end users are bound to increase as suppliers of mobility services seek ever more ways to increase customer loyalty and to improve the on-board vehicle experience. Given that the suppliers of ride-hailing services of such as Uber and Lyft compete on the prices of the services offered, the on-board- vehicle marketplace could represent new leverage with which to gain greater customer loyalty.

By way of example, the start-up Cargo has developed transparent boxes containing electronics items and snacks that the passengers travelling in the car can purchase during the ride via the app of the same name. The company has formed a partnership with Grab, the southeast Asian passenger transport company, and with Uber in mid-2018 for the distribution its boxes and to offer drivers a potential additional income for each ride. More recently, Uber and Cargo have launched an app for "in-vehicle" shopping that presents articles recommended directly by Uber, such as Glossier cosmetics, Nintendo Switch and Apple hardware. The app will also provide streaming of content in the car, showing films produced by Universal Studios.

CARGO SYSTEMS

Cargo is a data-driven general store for the ride-sharing economy. Cargo deploys POS tech in ride-share vehicles that enables on-the-go purchases.

Total Funding
$37.48 mln

Last Round
May 2019 Conv. Note
$5.45 mln

Country
United States

drivecargo.com/

General Motors has also developed its own on-board marketplace with "in-vehicle" payment features. Through the display it is possible to access the "Shop" section, within which internet traffic can be purchased for on-board use, as can also be bought discounted car accessories. The marketplace draws on the real-time data of the GPS for proximity marketing purposes. In the United States various fast food chains (Dunkin' Donuts, Starbucks, Wingstop) are present on the marketplace and allow for orders to be made through the on-board platform and collected at the restaurants; the TGI Fridays chain makes it possible to book a table as well. At Shell and ExxonMobil stations, instead, refuelling may take place, with Priceline hotel rooms can be booked, through Parkopedia parking can be reserved and paid for in various US cities.

GM In-Car Purchase App Marketplace

Worthy of note, too, is Volvo Cars' Concierge Service, an integral part of the Volvo On Call mobile platform, which allows Volvo owners to use an app to select concierge services available in the immediate neighbourhood and book them by smartphone. The requests are then submitted to one of the Volvo-approved service providers who will take care of refuelling the car, parking it and carrying out ordinary maintenance on it or any other service of assistance that might be requested by the vehicle owner. The app provides a one-time digital code containing specific information concerning the place and time and sends it to the authorized service provider. Once the service has been completed, the car doors lock and the digital code is deactivated.

More limited, but all Italian, is what Telepass offers customers signed up to its Telepass Pay service, with which it is possible to book a car or motorbike wash while the vehicle is parked: the operators arrive on the spot and perform the service directly on the roadside. The Telepass Pay car washing service is offered in partnership with the start-up Wash Out and is currently available in the city of Milan, but it is anticipated that this will be extended to other cities.

↳ "Amazon Key, now with in-car delivery"

Another interesting and innovative application enabled by connected cars is the possibility to use one's own vehicle as a hub for deliveries of purchases made online. The so-called in-car delivery has been launched by Amazon in partnership with GM and Volvo. The service, subject to vehicle registration on the Amazon portal, provides that the courier, by means of cloud access and the car's GPS, identifies the car and opens the boot directly in order to leave the packages therein.

Voice assistants and personal digital assistants

As we have seen, many of the added-value services devised, in particular, for the driver, to ensure driving safety, leverage technologies for the recognition of natural language (Natural Language Processing) and on voice commands. The advantages in terms of user experience, due to the integration of voice assistants allowing drivers to access information and services of various kinds without having to switch their attention from the road or without having to check their smartphones, have meant that car manufacturers have armed themselves with both proprietary and third-party solutions for their own connected vehicles.

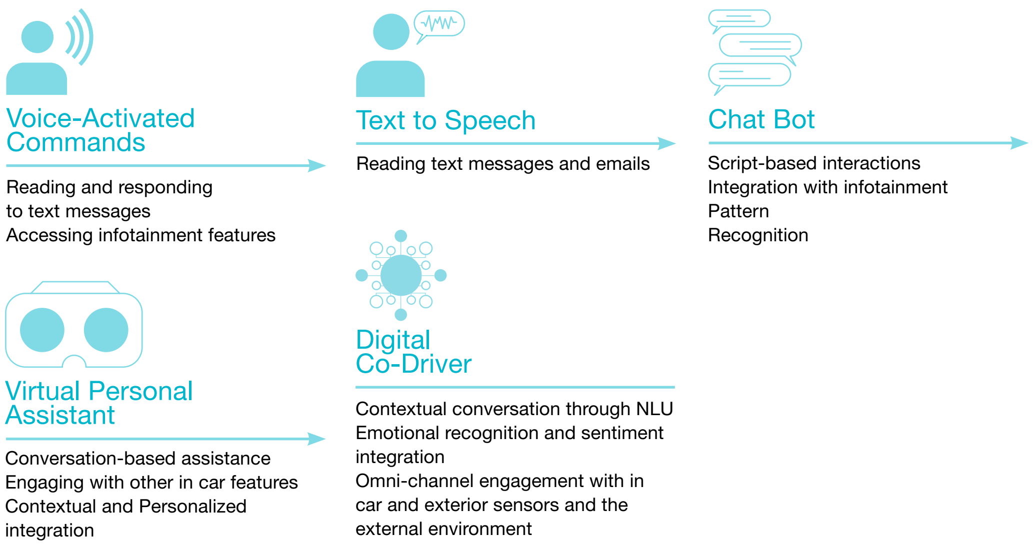
> "You want to keep your hands on the wheel and eyes on the road, so using your voice makes more sense." — Ned Curic, vice president of Amazon's Alexa Auto division

Voice technology goes beyond mere access to hands-free navigation: a personal virtual assistant is a software for voice recognition integrated into devices such as smartphones, personal computers or cars, equipped with a "human voice". It is devised to interact with the user through voice commands but is also capable of answering questions and carrying out tasks of greater or lesser complexity. The software "learns" thanks to the algorithms of machine learning and is "*always on*", irrespective of the device in use.

The most advanced on-board digital assistants can, for example, allow drivers to reproduce music, perform online searches, read and send text messages and, in the most cutting-edge versions, enable *in-vehicle* purchases or interface with other IoT devices, including applications for the *Smart Home* and *Smart Office*.

Global Connected Car Market Outlook

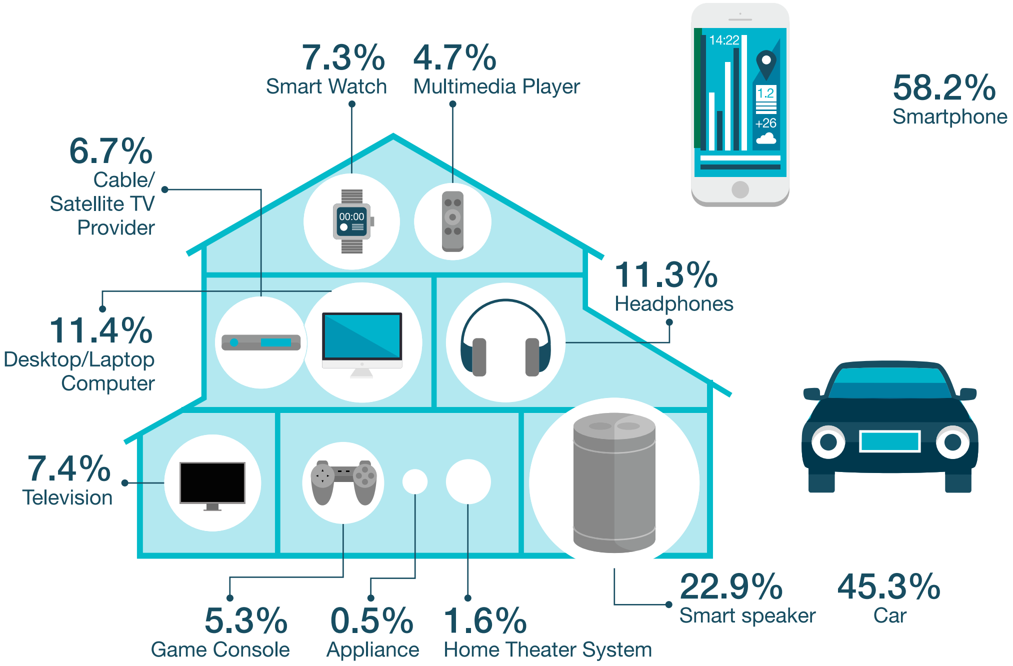
Source: Frost & Sullivan



A survey published by JD Power in April 2019 has found that most car owners (76%) would prefer to have the very same voice assistant in their vehicle as at home to the fact that potentially it would also be possible to interact directly from the car with the domotic devices in the smart house (smart speaker, smart lamps, etc.).

U.S. Adult Voice Assistant Use by Surface September 2018

Source: CBInsights



This suggests that Big Tech companies like Google, Apple and Amazon - that are integrating their own voice assistants into cars – could have a considerable competitive advantage compared with car manufacturers and start-ups attempting to create new proprietary assistants.

While Amazon's Alexa currently dominates the market of smart domestic speakers, the company must face up to the competition from Google and Apple when it comes to car systems. This is largely due to the fact that both Google and Apple are already present in numerous vehicles with their own operating systems, Android Auto and Apple CarPlay respectively. Having said this, Amazon is working with important car manufacturers like BMW, Toyota and Ford in order to integrate Alexa into their own systems of smart infotainment. The company has also recently launched Echo Auto, an aftermarket device that brings Alexa inside vehicles.

In China, too, tech companies are seeking to bring digital assistants inside cars. Alibaba announced in June 2019 that its voice assistant for connected cars, the Tmall Genie Auto, will be present in Audi, Renault and Honda vehicles. This suggests that Alibaba is looking to new markets for its voice assistant, in view also of the fall in smartphone sales in China and of competitive pressures in the field of smart speakers exerted by competitor Baidu, which, for its part, has developed a car version of its own conversation platform. Baidu's DuerOS platform is in fact already present in vehicles manufactured by Ford, Hyundai, Kia, and others.

Although the Big Tech companies have a series of competitive advantages, including operating compatibility and scalability, some car manufacturers are, in any case, developing the own voice assistants, based on the best understanding of the functioning of the vehicle itself, an aspect of particular importance for applications to aid the driver.

BMW presented its own digital assistant in September 2018, a few weeks after having announced that it would integrate Amazon's Alexa into its vehicles. In particular, the company has emphasized how the two voice technologies would complement one another rather than compete against one another, since BMW's proprietary assistant focuses on giving suggestions concerning driving and the vehicle, such as to switch on the headlights when it is dark or to provide information on car characteristics, while Alexa concentrates mostly on infotainment and on the passenger experience.

The car manufacturers developing their own voice assistants are turning to start-ups specialized in natural language processing. Daimler, Hyundai and Volkswagen have invested respectively in SoundHound, Saltlux and Mobvoi develop the own voice assistants.

Given the concerns regarding privacy in the world of smart speakers, various start-ups have also been working on "in-vehicle" voice assistants, specifically designed to ensure the privacy of users and user data, via the execution of local commands rather than via cloud. Companies working on this technology include Mycroft AI and Snips.

SNIPS

Snips offers a private-by-design voice platform and context-aware interface for connected devices, which analyzes habits to enable faster, more ubiquitous access to all services. The artificial intelligence-driven service will allow designers to embed voice assistant services in just about any device they make. Snips will work with customers to help them modify the platform so it suits their design needs.

Total Funding
$21.95 mln

Last Round
Ago 2018 Incubator/ Accelerator

Country
France

snips.ai

Although most motorists wish to have a voice assistant in their own vehicle, voice assistants remain, at this point in time, one of the most embryonic services for drivers, since the artificial intelligence used is not mature enough to manage most commands. While tech companies, auto makers and start-ups seek to improve the capacity for recognition of the commands of their in-vehicle voice assistants, a certain number of start-ups are looking towards conversational interfaces or chatbots that can perform functional tasks, such as closing car doors or opening the boot.

Lastly, other companies are seeking to develop specific features for car maintenance, such as detecting the need for an oil change and booking a service while on board the vehicle or functioning as a user's manual and maintenance book by answering the owner's questions about the car itself.

OEM	Digital assistant	Status
BMW	Amazon Alexa, Microsoft's Cortana, Google Assistant	Amazon Alexa – Launched (BMW connected App for Alexa), in all BMW vehicles by mid-2018, Microsoft's Cortana – demonstrated, Google assistant
Ford	Sygic Driving Assistant, Amazon Alexa	Launched in 2018
GM	IBM Watson, used with OnStar Go backend	Launched in 2017
Honda	HANA, proprietary assistant developed in partnership with Softbank	Concept demonstration
Hyundai	Amazon Alexa, Google Assistant	Google assistant – Launched in Genesis; Alexa – Launched in 2017 model year (MY) vehicles and select 2016 MY vehicles
Mercedes	Amazon Alexa, Google Assistant	Planned
Nissan	Microsoft's Cortana, Amazon Alexa	Cortana planned launch; Alexa - launched (MY 2017 and 2018 vehicles)
Toyota	Line's Clova, YUI, proprietary digital assistant technology	2018 for Clova, YUI concept demonstration

Human-machine interaction and "head-up" display

Also interaction between user and vehicle, the so-called HMI (Human-Machine interaction), on board the vehicle is undergoing a profound transformation.

Above all in top-bracket vehicles, advanced displays, touch interfaces, handwriting recognition, etc. are present and integrated. Start-ups and car manufacturers are, in fact, incorporating into the dashboard instruments for artificial vision and Augmented Reality (AR) to add a further level of security and personalization to the driving experience.

In particular, the "head-up displays" (HUD) are transparent displays positioned in the driver's field of vision that reproduce the information normally present on the dashboard, in such a way that the driver does not have to divert his gaze from the road.

Global Automotive Navigation System Market, Forecast to 2025

Source: Frost & Sullivan

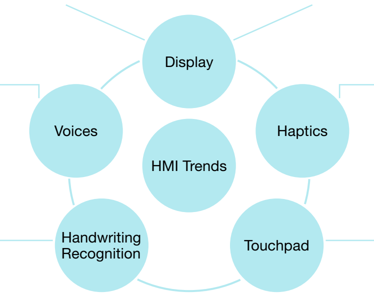
Instrument Cluster
- Increase in the integration of central display and instrument cluster with examples from Tesla and Mercedes vehicles.
- Visteon's 4K instrument cluster with driver monitoring technology.

Central display
- Average display sizes have increased. Top-end models now have 10.25 to 12.3 inch screens.
- Screen orientation preferences are changing across OEMs. Landscape mode still prevalent.

Head-up Display
- Windscreen type HUDs are popular among premium high-end segment vehicles.
- AR enabled HUDs developed by White Raven and WayRay aim to integrate location based services and autonomous driving modes.

- Handwriting recognition on the 2019 Audi A8 is screen based touch interface.
- Solutions from MyScript now apply AI and neural network algorithms for better handwriting recognition.

- Digital assistants with conversational AI abilities are being widely integrated.
- Voice-based biometrics will be used for authentication, personalization, control and payments.



- User interfaces will be optimized for autonomous driving and customization based on user profiles.
- Driver and occupant monitoring aims to reduce distractions.

- Use of touchpad will see a decline similar to the central controllers.
- Premium OEMs like Lexus still offer touchpads for user interface with the display

Some car manufacturers in the luxury segment already currently offer "head-up" displays but only two-dimensional ones, thus providing only a little depth-linked visual information, for example, in the event of imminent sharp bends. To make up for this limitation, car manufacturers and start-ups are seeking to improve the current "head-up" viewing technology so as to provide more complete information developed in 3D. The HUD can also become a support for immersive passenger entertainment, thanks to its holographic display that can project images and film.

More advanced displays with Augmented Reality Display functions may in future incorporate information from the road and present notifications to the driver, as well as navigation instructions.

The start-up WayRay, supported by Porsche and Hyundai, is leading the way technologically with its consumer product Navion, which offers an integrated HD video camera that maps the driving environment, by projecting step-by-step indications onto the dashboard and also providing alerts of danger, thanks to its "Turn-by-Turn navigation". The latter is a function found in some GPS navigation devices that presents the user with indications for a selected route selected in the form of voice or visual instructions. The application, moreover, makes it possible to interact with the display hands-free.

WAY RAY

WayRay is a provider of augmented reality car navigation solutions. The company builds heads-up displays for drivers, as well as fully augmented reality and virtual reality immersive systems intended for eventual use in self-driving cars.

Total Funding
$98.02 mln

Last Round
Sep 2018 Series C
$80 mln

Country
Switzerland

wayray.com

Car manufacturers and OEM's are also developing their own technologies to improve dashboard features. By way of example, Ford is working on "augmented" displays incorporated into the windscreen and personalized to the individual driver – with instructions for navigation and for driving support – and to the front-seat passenger, who can be offered entertainment services.

Jaguar Land Rover too is dealing with advanced viewing solutions, in particular by developing an immersive head-up display. In collaboration with the Center for Advanced Photonics and Electronics of the University of Cambridge, the company is also developing a technology that projects a close-up reflection of the road to allow drivers to react more naturally to hazards and to prompts from the systems.

Biometric authentication

Still in the area of "in-vehicle" services, OEM's and car manufacturers are exploring the use of the recognition of driver and passengers through biometrics, with the aim of improving security, on the one hand, and *passenger experience*, on the other.

Biometric authentication - which verifies the identity of an individual by using biological markers such as finger prints, face or iris – offers, for example, a powerful alternative to physical keys or their electronic substitutes for authorizing access to the vehicle. Biometric markers, in fact, are unique to every individual and are much more difficult to replicate if properly implemented.

In the field of safety, numerous start-ups and OEM's are drawing on biometric technology such as facial recognition and eye monitoring to prevent driver distraction and fatigue.

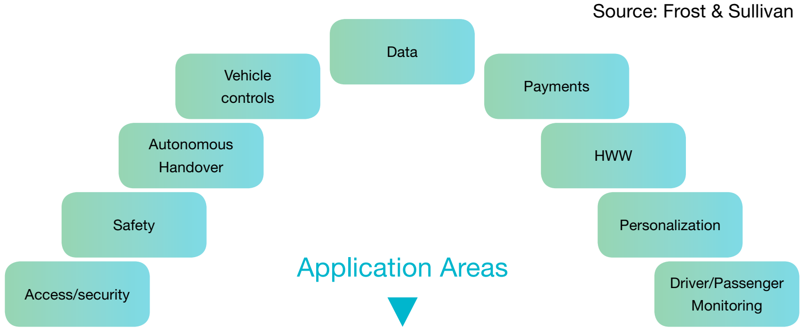
Auto makers are also seeking to use biometrics to improve the experience on board the vehicle. Vehicles based on biometric identification can in fact create and memorize different profiles for each driver and passenger in order to keep track of specific comfort settings. Once the driver and the passengers enter the vehicle, the latter proceeds to identify the former, automatically adjusting seats, mirrors and air conditioning according to previously-expressed preferences. Both Hyundai, and the Chinese producer BYTON are working on the implementation of this type of technology.

Biometrics can also be used to authorize "in-vehicle" payments, a service into which many car manufacturers are beginning to invest. Compared to the use of a credit card with a chip or a magnetic strip or to the keying-in of a password when making an on-board payment, authentication based on biometrics simplifies the purchasing process directly from the car.

In early 2019 Visa and SiriusXM expressed interest in working together to develop an authentication procedure based on voice recognition and on finger prints for payments made on board the vehicle. The two companies assert that such approaches based on biometrics are not only more secure, but that they improve user experience by facilitating the payment process.

Global Connected Car Market Outlook, 2019 By 2020

Source: Frost & Sullivan



Automotive-Biometrics

Automotive OEMs actively involved in developing and introducing biometrics technologies in cars

Highlights
• Voice recognition is the most widely implemented technology. Some uses-case include access/authentication, payments, vehicle controls e personalization.
• More companies such as Gestigon, Visteon and B-secure are coming out with biometric technologies related to driver monitoring systems.
• Synaptics' Natural ID fingerprint sensors can now be integrated into the infotainment screen for application such as vehicle controls and personalization.
• The recent launch of fingerprint technology for entry on Hyundai cars in China and Byton's concept applying biometric identification indicates more acceptance in Chinese market.

Global Connected Car Market Outlook, 2019 By 2020, Retail Platforms Like Marketplace to be Introduced by Major Automakers in the U.S and Premium Automakers are Considering Features On-demand as a Future Business Model

Services for passenger and vehicle safety and management of emergency situations

In addition to the natural functions of diagnostics and monitoring via location, connected vehicles have brought significant improvements in on-board safety standards, reducing the risk of accidents and assistance times. In this connection, a specific EU directive has established that from 31st March 2018 all new cars produced must be equipped with an automatic for emergency calls system (eCall), capable of alerting the emergency services immediately on the occurrence of road traffic accidents and of transmitting their position via GPS.

↳ "Type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service and amending Directive 2007/46/EC"

According to estimates produced by Bosch, this system will prevent around 260,000 road accident deaths per year globally, with a saving in economic terms of around 4.43 billion euro in material damage, which would benefit, above all, insurance companies and national health services.

In summary, safety solutions, enabled by vehicle connectivity, can be divided into two categories: the first is based on accident prevention, based on monitoring features enabled by the extensive use of sensors both internal and external to the vehicle, while the second is based on vehicle response to any accident, damage or theft occurring.

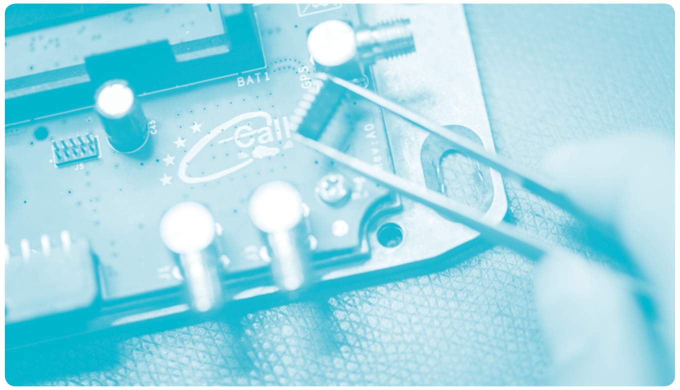
Technologies for emergency calls

As previously mentioned, since 31st March 2018 all new vehicles registered in the European Union – including light commercial vehicles - must be equipped with technology emergency call (eCall) technology via GPS – specifically making use of Galileo, the European Global Navigation Satellite System (GNSS). The eCall system can be used in vehicles across the European Union (the 28 EU member states, Iceland, Norway and Switzerland) and is capable of automatically making a free call to emergency number 112 if the vehicle should be involved in a serious road accident. Alternatively, the call can be made manually by means of a specific button.

When the service is activated, the vehicle connects to the closest emergency assistance centre, allowing passengers to communicate with the emergency services operator; simultaneously, it transmits a series of vehicle data, including the exact position of the vehicle, the time of the accident, the vehicle identification number and lane direction. This information is transmitted only in the event of a serious accident; in this way no sensitive data is shared and no vehicle tracking occurs in normal driving situations. The EU implementation target for the eCall service is to reduce emergency response times by 50% in rural areas and by 40% in urban areas.

According to the same community directive, the vehicle owner is entitled to use a third-party eCall system (TPS eCall), and these often incorporate complementary paid services (for example roadside assistance), in addition to the standard one based on call to 112 (Pan-European eCall).

The market analyses conducted by Technavio forecast that, globally, the segment of telematic services dedicated to eCalls for the automotive sector is destined to grow at CAGR of over 19% in the 2018-2022 period. Here below are some examples of market players positioned in the market segment of vehicle emergency calls.



Some players in the automotive ecosystem are working precisely in the area of vehicle emergency calls, for the development of new solutions and of new connected services. Thanks to EU funding, the Hungarian company Albacomp RI is developing a system of communication via on-board device suitable for retrofitting in used vehicles not equipped with eCall features. The data relating to the accident are transmitted via “tethered” connectivity.

The German multinational Infineon Technologies is one of the first companies to have explored “eSIM” features for direct incorporation into vehicles. In addition to eCall, Infineon’s eSIM supports many other functions that make driving more secure and efficient, such as updating of software over-the-air (OTA), V2I communications and advanced infotainment features.

Bosch has instead developed a Connectivity Control Unit (CCU), that is to say, a hardware unit capable of controlling vehicle communications towards the outside. The CCU monitors the airbag and seat belt pressure and, when an accident occurs, it automatically alerts the support centres. Apart from GPS data and basic vehicle data, the CCU transmits (thanks to its integration with the sensors) additional information such as the number of passengers in the vehicle

In the Italian context too, Marelli (ex Magneti Marelli)

has in its portfolio of products the so-called “Telematics Box”, an electronic control unit that incorporates a telephone module, a module for satellite vehicle location compatible with different satellite systems and an accelerometer on 3 axes to measure the parameters of acceleration and braking. The box is capable of supporting various functions of infotainment, safety and other services associated with smart mobility (fleet management, tracking, carpooling). The box is specifically devised for the support of eCall services and, thanks to Marelli's experience in the sector of telematics for safety, is designed in full compliance with sector standards.

Technologies for the monitoring of the driver and surrounding environment

Many suppliers of innovative technologies for the automotive sector and many car manufacturers have developed in the last decade various solutions for the prevention of the accidents. These often occur due to a dip in concentration behind the steering wheel, due to personal irresponsibility to a greater or lesser extent, or because of an unforeseeable event associated with the external environment.

The technologies linked to “*driver monitoring*” are the main solutions for the monitoring of the driver and of the inside of the car.

The first “*driver monitoring*” system was introduced by Toyota in 2006 on the last models of the Lexus and makes use of infrared sensors and video cameras to monitor driver concentration. If the system detects scarce attention to the road on the part of the driver and, at the same time, a situation of potential danger, it emits flashes and warning sounds inside the cabin. If the driver fails also to react to these stimuli, the system activates the brakes and stops the vehicle, avoiding collisions. Since 2008 Toyota’s “*driver monitoring*” system has also been capable of observing of the driver’s eyelids. In more recent years OEM’s and car manufacturers have concentrated their attention on systems for the detection of drowsiness, which is one of the main causes of often fatal accidents, using monitoring of driving style, the position of the vehicle within the lane, the monitoring through sensors and video cameras of the driver's face and eyes, measurement of physiological parameters and bio-signals.

In general, the systems for the monitoring of driver and environment include the use of computer vision, augmented reality, artificial intelligence and sensor systems to prevent or correct behaviours dangerous for the passengers and for other vehicles in circulation.

Among the innovative companies working in this market segment, Affectiva has developed an AI-based software for the recognition of human behaviours. This technology makes it possible to detect the physical and mental states of drivers and passengers. The AI algorithms measure in real time complex emotional and cognitive states thanks to biometric recognition, so as to alert the driver or passengers to the perceived risk.

AFFECTIVA

Affectiva is focused on emotion recognition technology. Affectiva brings emotional intelligence to the digital world by measuring and analyzing facial expressions of emotion. Its emotion-sensing and analytics software is built on an emotion AI science platform that uses deep learning and a global data repository of emotion data points. Affectiva is used by brands to gather insight and analytics in consumer emotional engagement. The company also provides developers the tools to add emotion-sensing and analytics to their own games, mobile apps, devices, applications and digital experiences.

Total Funding: $60.2 mln

Last Round
Jan 2019 Series E
$26 mln

Country
United States

affectiva.com

EyeSight Technologies, too, has been concentrating on the development of solutions employing artificial intelligence and computer vision to allow vehicles to analyze the environment inside the car. In particular the company has developed three separate solutions for vehicle applications: DriverSense is an advanced driver-monitoring system, CabinSense is a system for monitoring all passengers controlling the whole cabin and FleetSense is the solution for monitoring driver tiredness dedicated to logistics and to corporate fleets.

The British start-up B-Secur is, for its part, exploring the implementation of other devices for the monitoring of biometric parameters within the vehicle. In particular, it is studying a series of electrocardiogram (ECG) applications for driver monitoring via specific sensors in the steering wheel. The ECG is activated when the driver touches the steering wheel, and, thanks to its advanced functions, it is not only able to identify the person behind the wheel, but it can also assess with a good level of detail the driver's state of health: it is indeed capable of detecting high levels of stress, breathing patterns, signs of atrial fibrillation. The algorithms applied are also capable of detecting more serious events such as heart attacks or strokes, as well as the most common risks linked to tiredness.

Also car manufacturers such as Daimler, Ford and Honda are developing technologies for the heart monitoring to incorporate into vehicles. In particular, Ford is working on connecting data from *wearable* devices with connected cars, and on keeping under control vital signs such as breathing, heartbeat, blood-sugar levels and body temperature. Ford is also developing a method for measuring brain waves so as to determine driver watchfulness, a technology that, however, in its current state, requires the invasive presence of a specific helmet. Mercedes Daimler for its part is working on a similar system: the sensors, whether incorporated into the vehicle or wearable, measure the driver's vital signs together with additional data relating to the surrounding environment.

B-SECUR

B-Secur is a biometrics company that produces a wearable device, Heartkey, which derives insights about individuals and how they are feeling based on their unique heartbeat, using electocardiogram technology. Heartkey combines user identification with advanced physiological monitoring for health and wellness purposes, including medical grade heart rate, stress and fatigue monitoring, which can be applied to everyday situations such as driving a car, or for real-time health monitoring in the home.

Total Funding
$9.78 mln

Last Round
Mar 2019 Series B
$5.2 mln

Country
United Kingdom

b-secur.com

The World Health Organization has estimated that globally every year there are around 1.35 million deaths due to road traffic accidents. Over half of these victims are represented by vulnerable road users (VRU), including pedestrians, cyclists and motorcyclists, often not noticed by drivers of motor cars or obliged to make hazardous crossings. For this reason, car manufacturers and many tech companies have decided to develop sensors or V2P (Vehicle-to-Pedestrians) communication systems capable of perceiving the surrounding environment as a whole.

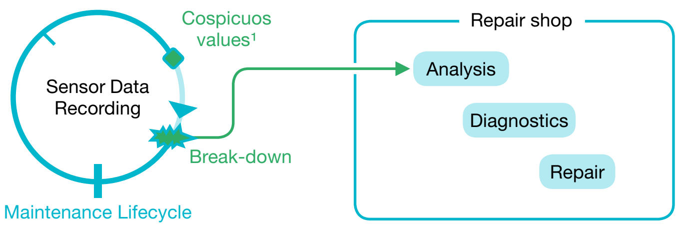
Among the players operating in this segment, mention may be made of the V2P and VRU solutions produced by Terranet, Savari and ZF. Terranet's VRU app uses GPS data from smartphones and vehicle devices to transmit the notifications of location and of collision risk in real time to vehicles, pedestrians, cyclists and motorcyclists. The X2Safe solution of the German ZF is instead a cloud solution that has the capacity to detect the pedestrians that are visible neither to the driver nor to the vehicle's perception sensors, to predict their behaviour and to provide a visual and acoustic warning to the driver to take action to give priority or to avoid the collision with the pedestrian. Lastly, Savari has developed a very similar application, thanks to which pedestrians and cyclists become active participants in vehicle communications making use of smartphone connectivity and being connected to other vehicles and infrastructures. In this way, Savari is able to alert the driver to a vehicle of to the presence of pedestrians approaching or that are crossing when the traffic lights or warning signs forbid them to do so.

↳ "X2Safe"

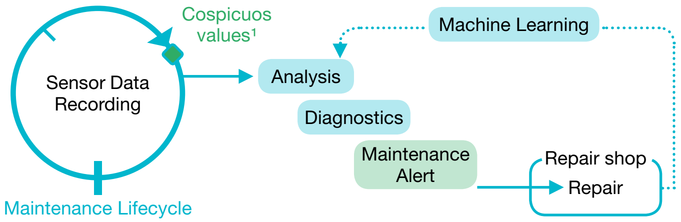
Maintenance and predicitive diagnostics

Source: Statista

Traditional Maintenance process



Predective Maintenance process



The sphere of services enabled by the vehicle connection and by the integration of sensor systems into "in-vehicle" components also covers the extremely important area of predictive maintenance and remote diagnostics.

Thanks to the capacities offered by machine learning

and real-time data analysis, the current diagnostic methods support the predictive maintenance of the vehicle, in future making it completely automated. Frost&Sullivan show how maintenance and diagnostics will evolve in a shift from current dealer or specialist mechanic diagnoses to the so-called *"self-healing"* vehicle.

Prognostics

Source: Frost & Sullivan

Also known as predictive maintenance, prognostics is considered a key driver for industry 4.0 and has potential for widespread application in the automotive industry. Except for a few OEMs (such as GM, BMW, Tesla), not many players are currently active in this space

Current scenario (Dealer diagnostics) → Future scenario (Self-healing cars)

Current scenario (Dealer diagnostics)

- In-vehicle operational data is collected to analyze potential causes of failure.
- Early warnings/notifications are sent to the user and the dealership.
- Repair/mantenance cycles are completed quickly

Contributing factors

- Driving style analysis
- Advanced on-board computers
- Artificial Intelligence
- Machine learning algorithms
- Cloud data + real-time analytics
- Crowdsourced data
- Telematics data
- Increased sensors usage
- Nano technology

Future scenario (Self-healing cars)

- Cars will be able to self repair in a certain scenarios.
- Dealer human intervention is partially or fully eliminated for minor issues.
- Automation of service stations will optimize part procurement and inventory.

Descriptive maintenance → Diagnostic maintenance → Predictive maintenance → Prescriptive maintenance

The evolution of analytics and maintenance that the auto industry will need to follow

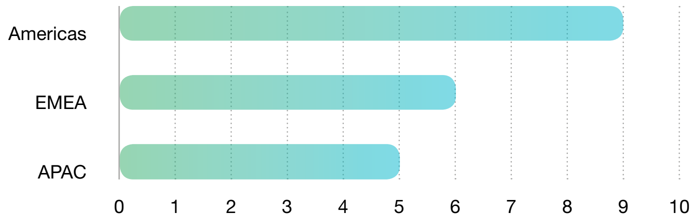
In practical terms, these make it possible to detect system faults or the risk that such may arise: the telematic device (TCU) sends the information to the user and in some cases directly to OEM's and to certified assistance centres.

The TCU also performs constant transmission of vehicle data, thanks to which the OEM's are capable of extracting important information for product improvement, by identifying systems errors and user experiences.

Projected global automotive remote diagnostics market in 2020, by key region

(in billion U.S. dollars)

Source: Statista



As can be seen from the previous graph, by 2020 remote diagnostics will be a market segment worth 20 billion dollars globally, driven primarily by private vehicles (74% of the market) followed by commercial vehicles.

For the private vehicles, but still more for commercial ones, remote diagnostics permits OEM's to build a direct relationship with the customer starting from services linked to aftermarket. This represents an opportunity for OEM's in perspective of acquisition of new market segments (assistance and aftermarket), but only if these will be capable of developing a business model matching the potential of technologies for connected vehicles.

One of the first car manufacturers to offer services of predictive maintenance, for private vehicles only, was, once more, in 2015, General Motors. Proactive Alerts is in fact the specific OnStar service that seeks to anticipate potential problems linked to the core components of the vehicle, reporting the risk to the owner via e-mail or text message. Initially, it only monitored the battery, starter and fuel pump, as key components for starting and keeping a vehicle moving, but, in the years since, the parameters monitored have grown in number thanks to the innovations in the world of sensor systems.

Hyundai has instead opted for a mobile application that is updated periodically. Among the many services to which vehicle owners can have access is also remote diagnostics. An app makes it possible to keep track of ordinary vehicle maintenance, to alert the user to the need for periodic vehicle maintenance with specific notifications, as well as for extraordinary maintenance, indicating, furthermore, the degree of urgency for the intervention. In addition, it is possible to perform a diagnostic test on the whole vehicle directly from the touchscreen, thanks also to which, when necessary, it is possible to transmit the diagnostics directly to the Hyundai dealership.

↳ "mbrace Remote Auto Diagnostic Tools Mercedes-Benz"

Another auto maker active in this sphere is Mercedes-Benz, which has integrated into its own vehicles (from 2016 on) a series of services and features available on the mbrace platform. All the services for the connected vehicle of mbrace are also accessible through the "Mercedes me app" application. These services include a diagnostics test, by means of which the dealership is capable of gathering remotely the data relating to the vehicle in order to determine the type of maintenance necessary. In order to offer efficient and effective services, Mercedes-Benz has decided to grant access to its own data directly to third-party suppliers. In this context, Daimler AG supports Mercedes with various functions of remote diagnostics. For example, since December 2018, on request for the customer, access to vehicle breakdown codes has been made available to third-party suppliers: Daimler is responsible for making available these error codes deriving from TCU's directly to providers of diagnostics and maintenance services.

Services for companies

In the area of logistics and corporate fleet management too, worker users and sector companies no longer merely expect to move from point A to point B, but to access advanced services of navigation, location and *fleet management*.

Connectivity guarantees access to and sharing of information relating to the position of individual vehicles in real time, by exploiting tracking systems and platforms for the sharing of company vehicles and using software and learning algorithms. These additional services ensure active support to the driver, on the one hand, and to companies in the logistics sector or in public transport, on the other.

Control of vehicle and location

GPS (Global Positioning System) was introduced by the United States Department of Defence in 1973 with the intention of overcoming the limits of the previous navigation systems. Full system operativity, following developments in computational techniques for satellite data analysis and integration, was achieved in the mid-1990's, while civilian use, and hence the natural development of applications for mobility, was enabled from 1999 onwards.

Modern systems of vehicle tracking and location, use mainly the GPS or the GLONASS, the Russian equivalent of GPS, or the parallel use of the two, thus guaranteeing even greater coverage.

Vehicle tracking systems are commonly used by logistics operators for functions of fleet management, from the monitoring of routes to the sending of information for the driver and for functions of safety both in terms of the vehicle, and of the driver.

Urban transport agencies have increasingly more recourse to technology for vehicle positioning, for a series of purposes including the monitoring of timetables and of any delays in buses in service, the automatic modification of on-board signs or for simple service announcements. No less importantly, the data collected along the route are analyzed in real time to compare the position of the vehicle and its timekeeping with the scheduled timetable, so as to signal to the driver the lateness or earliness accumulated at a given moment. The same data are often supplied via app to users, in such a way as to allow end users to monitor timetables and stops of interest on the routes.

Vehicle tracking systems are also used by private vehicles, but, with the exception of basic navigation functions, mainly in support of the monitoring and recovery of the vehicle in the event of theft. This feature, in fact, allows the authorities to trace the geolocation of the vehicle simply by following the signal emitted by the tracking systems.

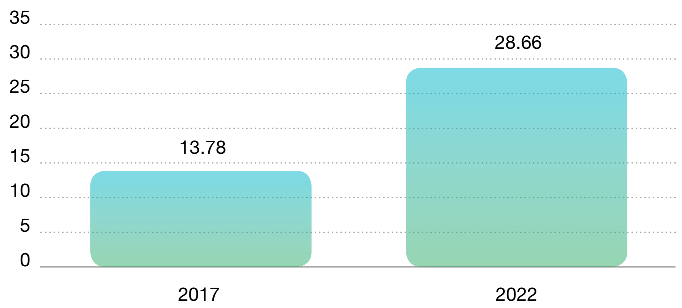
According to a Statista market survey, in Italy in 2018 around 70% of interviewees indicated "tracking systems and car blocking systems in case of theft" as the features of connected cars for which they would be prepared to pay more.

Fleet management

The graph below highlights the importance of the *fleet management* market in the five-year period underway. The elements to which is attributed this growth include the increasing importance of operating efficiency linked to logistics, the adoption of cloud computing for the monitoring, storage and processing of the data collected, the possibility to manage the fleet remotely and the significant drop in the price of connected hardware and in the costs linked to connectivity.

Global fleet management market size in 2017 and 2022

(in billion U.S. dollars)



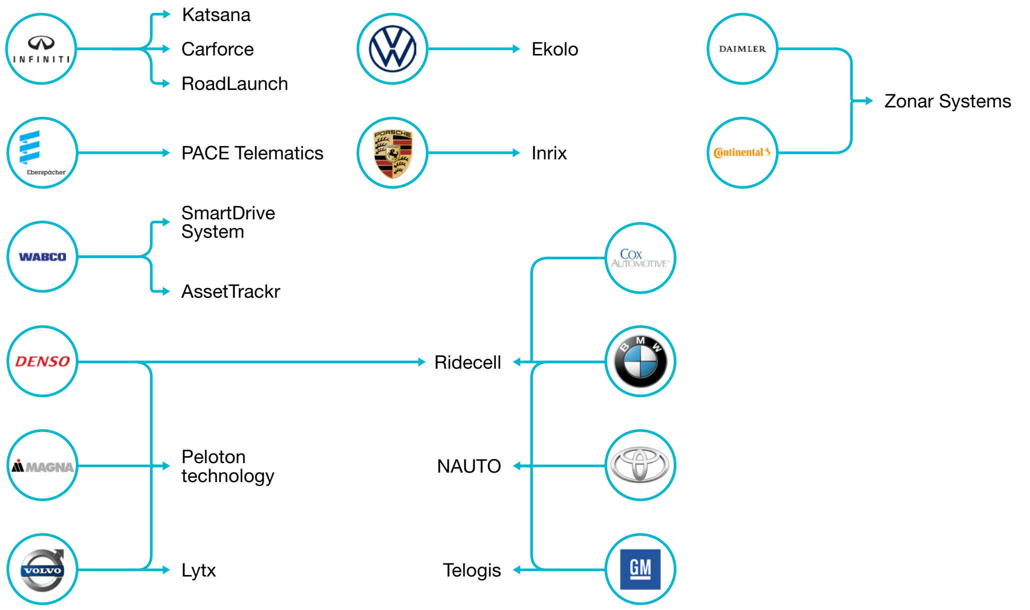
Source: Statista

The segment by far the most explored by new players in the market is that dedicated to Fleet Management Software (FMS), solutions that help companies and organizations to manage, organize and coordinate their own vehicles from a central data platform in real time.

The main players in the car market are keenly aware of the competitive advantage that they can gain by acquiring, integrating and supplying these services in their own vehicles already "as standard". For this reason, according to the findings of CB Insights, many of these players have decided to invest directly in start-ups and in companies active in the *fleet telematics* segment.

Auto incumbents investing in fleet telematics startups

2013-2018 YTD (10/10/2018)



Source: CBInsights

↳ "Volvo demos three-truck platooning system"

For example, Volvo has coinvested together with DENSO in Peloton Technology, a start-up specialized in telematic systems for the management of fleets of trucks, in order to be able to design and implement Peloton systems directly into its own heavy vehicles, on the basis of the innovative function of "truck platooning", that is to say the possibility of hooking up telematically two tow trucks to make them more efficient in their functions.

BMW, Cox Automotive and, again, DENSO have also invested in the Fleet Management Software of Ride-Cell, a start-up offering a platform for mobility management based on a cloud architecture. The platform was specifically designed to assist the companies active in car-sharing and in ride-sharing, and thus companies that find themselves having to manage entire fleets of shared vehicles.

Both Daimler and Continental have invested in Zonar Systems, an electronic fleet management system. In this case, as Daimler and Continental specialize in the production of connected hardware, semiconductors and telematic services, the acquisition of majority stakeholdings in a start-up specialized in FMS has the potential to make history in the evolution of solutions for the market of smart management of fleets of vehicles, based on the advantages linked to vertical integration of production and supply of devices for connected cars and services for the valorization of the data generated therefrom. The Zonar fleet management service is one of the most complete on the market and includes solutions for every segment of transport ranging from trucks for goods haulage to fleets of shared vehicles.

Many other start-ups and companies operate independently in this market segment. For example, KeepTruckin is specialized in fleet management solutions and includes features of compliance, tracking, vehicle and driver safety, consumption reporting, monitoring and remote diagnostics and many others. In detail, the function of vehicle tracking and location makes it possible to plan the route of a vehicle with extreme precision, as well as maintenance. Afterwards, vehicle- monitoring makes it possible to examine routes and performances, helping drivers to improve their activities.

ZONAR SYSTEMS

Zonar provides electronic fleet inspection, tracking, and operations solutions for public and private fleets. Zonar built the first Electronic Vehicle Inspection Report (EVIR) system revolutionizing how pre- and post-trip inspections, mandated by state and federal law, are conducted by commercial and private fleets. Zonar has grown into a comprehensive high-return telematics platform, providing an expansive set of solutions that remains simple to use.

Total Funding
$50 mln

Last Round
Apr 2016 Corporate Majority

Country
United States

zonarsystems.com

Teletrac Navman is another benchmark supplier of Software-as-a-Service for the management of mobile resources that monitors and manages more than 500,000 vehicles and mobile assets for over 40,000 companies around the world. Apart from the traditional functions of fleet management (safety, consumption efficiency, route optimization), Teletrac has thoroughly studied geo-fencing-based solutions, particularly useful for the monitoring of GPS positioning of mobile assets (such as building machinery, dredgers and cranes) within one or more predefined geographic perimeters.

The practice of geo-fencing is based on the geo-fence, that is to say a virtual geographic perimeter defined on the basis of the dynamic position of an object (understood as the space around a piece of machinery in movement) or on the basis of predefined boundaries (a building site, a district, etc.). This practice requires the presence of a device capable of recognizing the position of the vehicle or of the machinery that interacts with the perimeter. When the vehicle crosses the boundary, an alert is generated for the fleet manager.

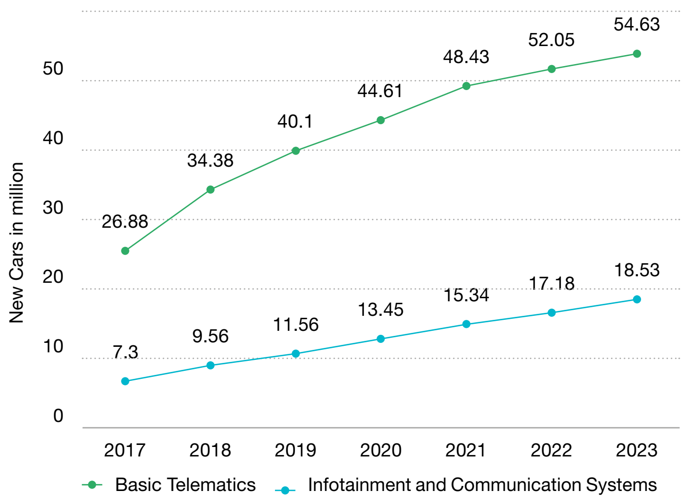
In the area of public transport fleet management, in the interests of optimizing user experiences, the suppliers of FMS have specialized in the development of modules for automatic vehicle location (AVL), modules for automatic passenger counting (APC) and interfaces and applications to interact with their own customers.

↳ “Traffilog solution for public transportation carriers”

The South African start-up Questek Telematics has developed an FMS specifically for public transport. The software makes it possible to monitor and determine the revenues and the so-called “dead mileage”, that is to say the distance covered by the bus without offering specific services (for example, journeys from the terminus to the depot). The platform also allows the behaviour of the driver and other detailed information on the vehicle (the length of the journey with relevant departure and arrival times and vehicle function parameters) to be monitored).

Services and hardware for connectivity

Estimated amount of new cars equipped with Connected Hardware worldwide from 2017 to 2023 by segment (in million)



Source: Statista

Connected car technologies include those capable of connecting vehicles to a network or external platform in such a way as to improve, as we have seen, the driving experience through advanced systems of infotainment, real-time diagnostics, smart navigation functions or systems for hazard detection and the prevention of the accidents. All these features require up-stream integration of hardware devices capable of capturing and communicating the information necessary to execute a command automated to a greater or lesser degree. Whether they are components for data transmission or for network communication, video cameras or sensors, or electronic control units, the hardware devices required by modern connected cars are numerous.

Components for data transmission

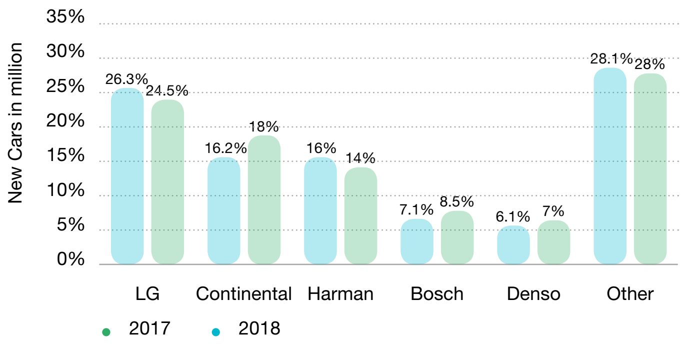
The main hardware device for connected vehicles is the Telematics Control Unit (TCU), the unit that houses all the components necessary to maintain the connection and vehicle tracking, and also the interface between the vehicle and external services. The TCU usually includes GPS, an external interface for mobile communications (GPRS, Wi-Fi, LTE, 5G), the microcontroller and a processor.

According to research by Counterpoint's automotive division, the global TCU market for the automotive sector is destined to grow to a CAGR of 14% between 2019 and 2025. Cumulatively by 2025, more than 430 million units will be produced, dedicated not only to private transport but also to light commercial vehicles, heavy commercial vehicles and buses, even though (according to data from 2016) around 76% of TCU's are destined to be installed in private vehicles.

The segment of the *connected hardware* is indispensable for the activation of many services, including eCall. The increasing adoption of integrated connectivity standards by car manufacturers, above all Japanese and German ones, together with an increase in the demand for connected vehicles in China and in the United States, will be the main driver of growth in the period in question.

As is clear from the graph, the TCU segment displays a high level of concentration, with five main players holding 72% of market share (calculated as a percentage of the total number of units shipped globally); among these the Korean LG is the market leader, possessing around a quarter of the market. It counts among its own main customers General Motors, which favours the penetration of its own TCU's into the two main markets for connected cars: United States and China.

Automotive telematics control unit shipment share worldwide in 2017 and 2018, by brand



Source: Statista

In this specific market segment one of the companies of reference is HARMAN. The multinational Samsung subsidiary specialized in the production of components for the connected vehicle offers TCU modules and telematic solutions for car manufacturers all around the world, supporting a series of functions ranging from emergency calls (eCall) to options for advanced connectivity, such as real-time traffic reports and remote booking of services. HARMAN telematic systems also offer the possibility to interface directly with the proprietary cloud data analysis platform, offering car manufacturers a platform of managed services managed capable of updating infotainment and other over-the-air (OTA) systems.

As regards communication standards, a marked decline is noticeable in TCU units for 2G/3G connections since 2018, as car manufacturers and telecoms operators from 2021 on will only adopt the recent 4G and 5G standards. In turn, the diffusion of 5G infrastructures, the fall in associated costs and the connection speed required by advanced services will lead to the gradual abandonment of 4G too.

Still in the area of hardware components for vehicle communication with the outside and data transmission, many companies are focusing on hardware solutions to ensure access and communication with the vehicle networks, in particular, the chip and devices necessary to allow V2X communications. The absence of a dominant model for vehicle networks has meant that V2X communications split into in two different standards, the DSRC and the C-V2X, which has made it difficult for car manufacturers and OEM's to adopt one standard or the other, or even, alternatively, a hybrid solution.

For this reason, start-ups like Autotalks have opted for the development of chip hardware to allow the vehicle to communicate with both standards, therefore choosing a hybrid solution. By equipping its own chip with C-V2X, over the original support of DSRC communications, Autotalks has developed one of the first dual-mode chipsets in the world.

Other players in the automotive sector have instead opted for the formation of joint ventures with companies specializing in the production of chips for vehicle networks. By way of example, in July 2019 Toyota announced its own joint venture with Denso, a Japanese producer of semiconductors, chips and electronic components for vehicles, with the aim of developing semiconductors and other hardware devices for future generations of connected cars. The company established – with a 51% stakeholding by Denso – will focus on the production of highly innovative semiconductors and on the development of components powered by these, including power modules for electric vehicles and sensors for the monitoring of self-driving cars.

Observing the European ecosystem of producers of hardware components, one example is STMicroelectronics (ST), a Franco-Italian multinational specialized in the production of semiconductors, which has studied a complete line of products for the automotive sector, in particular microcontrollers (MCU), so as to allow remote and secure updates, and fast connections to vehicle networks. The new line of chips can execute several applications simultaneously, making electronic architectures for vehicles more flexible and economical.

Sensors and applications for vehicle monitoring

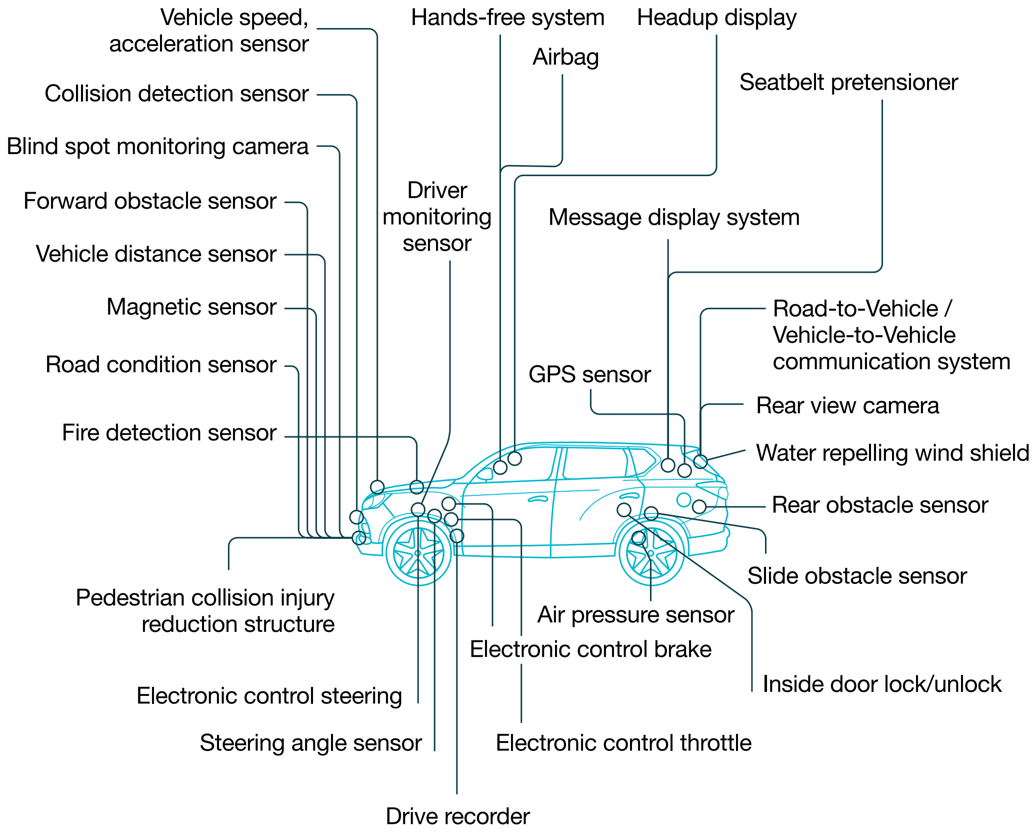
The potential of IoT and Industrial IoT devices has been highlighted and demonstrated in different areas of use, sectors and applications. Among the main advantages, particularly for connected devices in industry including car manufacturing is the possibility to monitor the "state of health" of machinery, production processes and, in general, the possibility to perform these actions systematically, by aggregating data in series of records in order to highlight preventively the risk of damage and the best moments for undertaking planned maintenance.

Many are the areas of use and types of integrated sensors in connected vehicles, ranging, for example, from camshaft applications for engine ignition and more efficient engine function, to sensors incorporated into the transmission or entirely dedicated to monitoring the speed of the vehicle or of the wheels, and from those for the monitoring and control of the engine to "smart" ones for passenger safety.

Modern sensors incorporated into vehicles are capable of measuring minute variations in sound, light, temperature, pressure and in movement. These variables constantly monitored are then communicated externally by data transmission modules, in such a way as to enable services of *predictive maintenance* in real time. The vehicle, in fact, receives from the *hub* dedicated to data analysis, alerts relating to a variety of mechanical and electronic problems linked to tyre pressure, the brakes, on-board electronics, lights, engine performance and much more.

Globally, the car sensor market, valued at 23 billion dollars in 2019, is growing at a CAGR of 6.71% and it is anticipated that it has the capacity to reach 36.5 billion dollars by 2022.

Vehicle internals: a swarm of sensors



↳ “Bosch MEMS sensors: Working principle of an accelerometer”

Among the players making up this ecosystem, in particular, in the field of electromagnetic sensors, Allegro Microsystems is the record holder in terms of market share, with over 11 billion integrated sensors since it began its activities in this sector. Allegro has developed a complete line of these sensors for the automotive sector, to guarantee, for example, engine or transmission efficiency.

With the gradual increase in the number of vehicle parameters monitored by sensors, it is becoming essential to be able to reduce to the minimum the size of the sensors themselves, so as to incorporate these into other systems without having to affect vehicle design significantly. For this reason Bosch has developed a broad range of MEMS (micro-electro-mechanical system) micro-sensors, today indispensable in vehicles and in electronic devices, for example, for the orientation of the vehicle, for the monitoring of sudden decelerations for the activation of airbags, for the acquisition of vehicle movement on its own horizontal and vertical axes or for adaptive suspension systems. These sensors have very high standards of performance since they control and communicate the state of the vehicle in situations in which passenger safety could be compromised. At a slightly lower standard of precision, are, instead, those MEMS dedicated to telematic systems, seat comfort and engine monitoring and control.

Another multinational active in the area of components for connected mobility is Continental. This German company, alongside its more traditional sensors, has developed a complete line of advanced and smart sensors for the control of functions linked to safety, to the stato and functioning of commercial vehicles and buses.

Other market players, in contrast, have focused on those sensors necessary to supply data to the Engine Management System, that is to say, the systems responsible for the control of the entire combustion process within the ICE. This is the case of Delphi Technologies, which offers a complete range of solutions for the detection and actioning of mechanical components to improve the emissions control, fuel economy and driveability.

Electronic control unit and CAN communication protocol

An electronic control unit (ECU) is a device responsible for the supervision, regulation and modification or variation of the functioning of electronic systems.

Every feature that depends on the car’s electronic systems, such as assisted braking system or ABS, the electronic configuration of fuel injection and many others, is generally controlled by an ECU. These units are often in charge of the control of a single system, while in other cases an ECU can be responsible for different interconnected systems.

In functional terms, an ECU is an electronic device into which is conveyed a variety of information deriving from sensors incorporated into the systems. These inputs are analyzed by the ECU and compared with the data memorized on board. On the basis of this comparison, the ECU decides what must occur for the correct functioning of the systems in question to be guaranteed.

To give a practical example, the electronic systems regulating fuel injection are controlled by an ECU. Some of the inputs “fed into” the ECU include temperature, engine speed and accelerator position.

Here below is a table summarizing the main ECU’s and their related tasks:

Engine control module	Transmission control module	Suspension control module	Body control module
The ECU is responsible for the assessment of the load of the engine and of its ignition, fuel supply, etc.	It controls the automatic transmission, based on how the vehicle changes gear and when. The ECU controls transmission sensor data.	Nicknamed the “drive control module”, this ECU controls adjustable suspensions according to vehicle set-up. It adjusts suspensions on the basis of road conditions and operates to maintain optimum ride height.	This unit is generally responsible for the control of access, for comfort and for the security of the car. Among the various components regulated are the doors, windows and heating and cooling systems.

The main market players operating in this segment of the sector are predominantly the same as are specialized in the production of semiconductors and other connected hardware components previously analyzed.

As regards the modes of communication and interconnection of the ECU’s incorporated into connected vehicles, this is based on the Controller Area Network (CAN) communication protocol, which ensures the connection between ECU, sensors and actuators. This robust and economical protocol was originally developed and launched by Bosch in 1986 and has since become one of the most important sector standards since it is essential for many applications.

In practical terms, the Controller Area Network (CAN bus) can be seen as the system that allows communication between all the components of the automobile, in a way similar to that through which the human nervous system is capable of controlling and allowing the various parts of the body to communicate.

The CAN bus protocol allows ECU’s to communicate without a complex system of dedicated cabling, which makes it possible to add different features via software applications, allowing the various ECU’s to communicate via a single CAN interface and reducing costs for parts.

↳ “CAN Bus Explained - A Simple Intro”

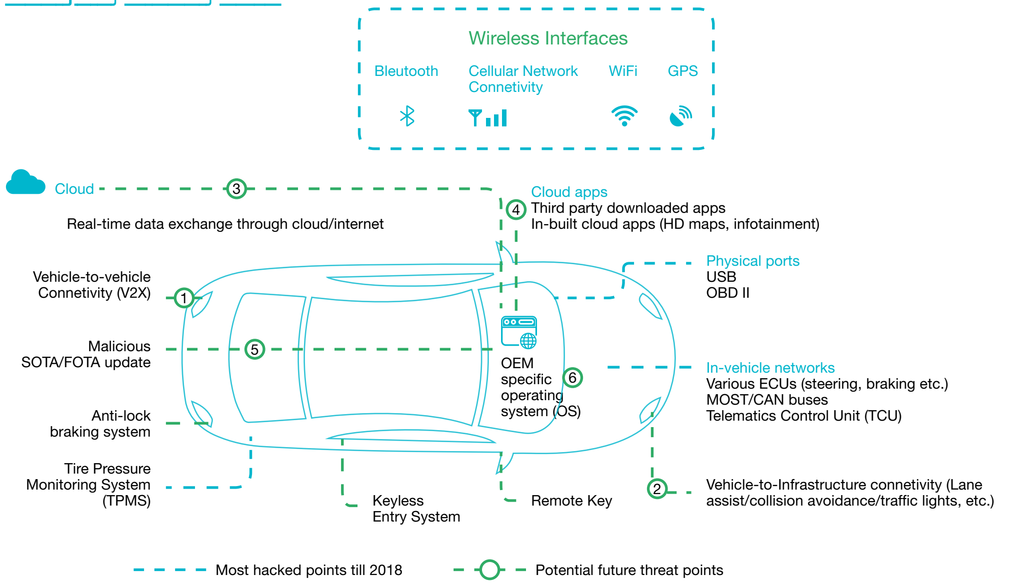
CAN bus communications, moreover, are not very susceptible to electrical disturbance and electromagnetic interference, which makes them ideal for vehicle applications. All these advantages have meant that the CAN protocol has been adopted serially in practically all vehicles, aircraft and boats.

Cybersecurity: the potential vulnerabilities of connected vehicles

The advent of connectivity and the integration of connected hardware capable of extrapolating data from vehicles and of software solutions for the control and monitoring of the functions of the various components has directly increased potential vulnerability to cyberattacks on the mobility ecosystem and on the vehicles themselves.

Automotive Cybersecurity Market: Threat Vector Analysis, Global, 2018

Source: Frost & Sullivan



As demonstrated by Frost & Sullivan, the points of potential hacker attack are continually increasing thanks to a corresponding increase in connectivity solutions. If, at present, the main targets for hackers are the systems on board vehicles, by 2025 the scenario is destined to change: the anticipated targets will predominantly be the cloud environments from which data and applications, V2X connections and *over-the-air* (OTA) channels for the updating of onboard software, are remotely managed.

Owing to the disparate nature of the aforementioned vulnerabilities, according to Frost & Sullivan, the cybersecurity infrastructure for connected vehicles (including autonomous vehicles), must be founded on three complementary pillars:

Software, Network & Threat Intelligence	Hardware Security	Cloud Security
As regards “software” vulnerabilities, there exist methods of cyberattack designed specifically for vehicles. The protection of onboard data must be elaborated in a secure framework within a reliable environment. In relation to network security in connected vehicles, it is necessary to tackle both those vulnerabilities relating to the internal network, and to the external one. The common protocols such as CAN, FlexRay and Automotive Ethernet should be adopted by the OEM and Tier-1 suppliers for the protection of the vehicle network. Upstram, Threat Intelligence for the automotive sector must be capable of establishing a standard procedure for the elements upon which the security of the entire vehicle depends.	The challenge linked to the security of the connected hardware resides in the profound impact on the chains of value, given the necessary increase in investments in this area. The key solutions for the protection of hardware are Secure Elements (microprocessors capable of archiving data and allowing applications to function securely), Hardware Security Modules (devices with computational capacities capable of protecting and managing digital authentication keys for harnessing cryptography) and the Trusted Platform Module (dedicated chip incorporated into an endpoint device in which the specific RSA cryptography keys of the host systems for hardware authentication).	The download of the updates firmware Over-The-Air (FOTA) and Software Over-The-Air (SOTA) in the vehicles is one of the main causes for concern for the players of the connected mobility ecosystem. The updates released by OEM's must be issued via authenticated and secure cloud channel, harnessing cryptography.

In order to meet the needs of the sector, many start-ups have opted for the specific development of cyber-security solutions for the connected vehicle. Start-ups such as Karamba Security have developed solutions to protect connected hardware. Carwall, Karamba's top-of-range product, in fact provides a safety solution that acts directly on the code of the vehicle’s ECU programme. This solution is capable of detecting and preventing all types of attacks on the car's systems, by blocking the vehicle's ECU and only permitting the execution of operations conforming to factory settings.

The Irdeto start-up has instead developed a cyber-security product by the name of Secure Environment and designed with the aim of forcing hackers to adopt extreme efforts to attempt to penetrate devices, thus rendering the attack unworthwhile. Briefly described, the solution protects the critical files and application data and prevents hackers from adding harmful code or from modifying executables and scripts.

Further exploring the global ecosystem of start-ups, the Californian VisualThreat for its part has developed a framework for IT security in connected vehicles, composed of a firewall, an OTA security system, an “umbrella policy” for the risks linked to cyberattacks and a threat intelligence service. Thanks to its holistic approach, VisualThreat is one of the market leaders in connected car security, as well as being a supplier of cyber-security solutions for multinationals such as TUV Germany, BYD, Baidu and many others.

The Argus suite - acquired by Continental in 2017 - is a further benchmark for the sector. Designed especially for the car industry, it offers complete, modular and multi-layer protection. A first layer of IT security is placed on the connected electronic control unit (ECU). The suite's second layer, focuses instead on protection in terms of the network, examining communications from and towards the connected vehicle and preventing attacks from spreading via the network itself. A further layer is dedicated to the protection of fleets of vehicles: monitoring attacks and the trends highlighted by the Big Data analysis, it acts directly on the cloud from which the fleet is managed remotely or integrates security features directly in the operating unit.

↳ “Argus Cyber Security”

Glossary Connected mobility

Term	Acronym	Definition
Automatic Passenger Counter	APC	A system that detects and counts the number of passengers on board of public transport vehicles.
Automatic Vehicle Location	AVL	A technology that makes it possible to automatically locate vehicles in different ways and for a wide variety of purposes. Also referred to as “telelocating” or “teledetection”.
Connectivity Control Unit	CCU	Telematic unit for vehicle connectivity connected to various systems therein, such as the electronic control unit (ECU) and the infotainment system. It controls vehicle-vehicle and vehicle-infrastructure communication.
Controller Area Network	CAN Bus	Communication protocol designed to allow microcontrollers and devices on board the vehicle to communicate together and with applications. It is the standard of reference in this area.
Dedicated short-range communications	DSRC	Dedicated “short-range communications” – that provide for a set of protocols and standards – these are short-range and medium-range wireless communication channels whether one-way or bidirectional and specifically designed for car use, corresponding to a set of protocols and standards.
eCall		European initiative that has the objective of providing rapid assistance to motorists involved in road traffic accidents, wherever they may find themselves within the European Union. The device is obligatory in every new automobile sold within the EU since 2018.
Electronic Control Unit	ECU	The “electronic control unit” is an embedded software control system, that is incorporated directly into the component (or subsystem) responsible for the supervision, regulation and modification or variation of the functioning of the electronic systems.
Embedded SIM	eSIM	The term eSIM is short for embedded SIM, that is a SIM integrated into a system. It is not an actual SIM Card but an integrated circuit board of SON-8 standard size directly soldered into a device, and consequently neither extractable nor replaceable.
Engine Management System	EMS	The “engine management system” is composed of a vast array of electronic and electric components such as sensors, relays, actuators and an engine control unit, that collaborate to provide the engine management system with parameters of data essential for govern effectively the various functions of the engine itself.

Term	Acronym	Definition
Features-on-Demand	FoDs	“Features- on-Demand” are packets of features that can be selected at the moment the vehicle is purchased or that can be added at any time.
Geo-fence		A geo-fence is a virtual perimeter associated with a geographic area of the real world. It can be generated dynamically, for example as an area within a range of a pre-established point, or else can be defined by a set of pre-established boundaries.
Head-up display	HUD	Common term in the world of videogames to indicate the information constantly visible during the game in on-screen captions. In this report, it refers to the introduction into vehicles of images projected onto the inner surface of the windscreen.
Human Machine Interaction	HMI	Human-machine interaction refers to the layer that separates a human being using a machine from the machine itself.
Micro Electro-Mechanical Systems	MEMS	Electromechanical microsystems are a set of devices of the size of a micrometre of various types (mechanical, electric and electronic) incorporated in highly miniaturized form into a single substrate of semiconductor material, for example, silicon, that combines the electric properties of the devices integrated into the semiconductor with opto-mechanical properties. These are "smart" systems combining electronic functions, fluid management functions, optical, biological, chemical and mechanical functions in a very small space, incorporating moreover sensor and actuator technology.
MicroController Unit	MCU	A microcontroller, in digital electronics, is an electronic device on a single electronic circuit chip.
Over-the-air	OTA	Data exchange technology allowing the updating of the software of a digital device via point-point communication and by means of a wireless network, typical of the devices that do not use a fixed data connection.
Telematic Control Unit	TCU	A telematic control unit is understood in the car industry as being a system incorporated on board a vehicle that controls vehicle tracking. It includes a GPS unit, a cellular communication unit for the sending of GIS data to a central server, a microprocessor or an embedded circuit board for data processing.
Turn-by-turn navigation		Turn-by-turn navigation is a function of some GPS navigation devices in which the indications for a route selected are continuously presented to the user in the form of voice or visual instructions. The system keeps the user updated on the best route by which to reach the destination and is often updated on the basis of changing factors such as traffic and road conditions.
Vehicle-to-everything	V2X	"Vehicle to everything" is a system of communication of information between a vehicle and anything that may affect the vehicle and vice versa.
Vulnerable Road Users	VRU	Vulnerable road users vulnerable (VRU) are defined in the ITS directive as "non-motorized road users, such as pedestrians and cyclists, and also motorcyclists and persons with disabilities or reduced mobility and orientation".

Autono-mous mobility

4

Autonomous Mobility

LEVELS OF AUTOMATION

1. LEVEL 0 – NO AUTOMATION
The vehicle has no capacities for automatic or autonomous driving

2. LEVEL 1 – DRIVER ASSISTANCE
An advanced system of driver assistance offers automatic functions limited to steering, braking or acceleration, but not simultaneously

3. LEVEL 2 – PARTIAL AUTOMATION
The vehicle is capable of steering, accelerating and braking automatically

4. LEVEL 3 – CONDITIONAL AUTOMATION
Level 3 vehicles have environmental detection capabilities and can make informed decisions

5. LEVEL 4 – HIGH AUTOMATION
Vehicles handle most activities, manoeuvres and driving functions, actually being able to steer, accelerate and brake on their own

6. LEVEL 5 – FULL AUTOMATION
The vehicle will be completely autonomous and will not require any human intervention

EUROPE

Generating profits for the European automotive industry of up to 620 billion euro by 2025, Level 4 (SAE) cars should represent a larger market share in terms of volume than Level 5

Level 4 and 5 (SAE) autonomous cars are expected to become a large worldwide market by 2030, with a total value of $ 60 billion

$60 Bn

GM
RENAULT NISSAN

General Motors, Ford, Honda and Toyota, Renault-Nissan had expected to launch level 4 or even 5 vehicles by 2020

Germany represented the largest market in 2018 with a share of over 20% held in terms of volume

20%

GERMANY

The German Teraki has developed an embedded client for smart signal and insurance data processing and, in particular, crash detection, predictive maintenance and autonomous driving, using edge data extraction and processing thanks to machine learning algorithms and artificial intelligence models

In the field of computer vision, VisLab, a spin-off of the University of Parma acquired by the American Ambarella in 2015, has, since its foundation, focused on all aspects related to self-driving vehicles

ITALY

Navya, a French company, is building and selling Level 4 shuttles in Europe and the United States

FRANCE

NEXT Future Transportation, a start-up from Padua, today in Silicon Valley, is developing a revolutionary smart transport system

next

UK

The British start-up Immense Simulations creates interactive virtual replicas of cities using data from mobile telephone operators and public transport databases

Google as early as 2009 had started its first tests of a driverless car. Google's project is by far the longest running

Google

USA

CALIFORNIA

July 2019
California received authorization from the California Public Utilities Commission to manage its robo-taxi fleet

$264,000,000

Pony.ai, founded in California in 2016, raised investments of $ 264 million from Chinese investors, with the aim of developing the first autonomous vehicle system ready for the Asian market

CANADA

The Canadian company LeddarTech, develops solutions for light detection and ranging, based on LED lighting systems for object relief and distance measurement applications

China has several companies working on autonomous driving systems. Beijing-based Momenta achieved unicorn status in October 2018, thanks to contributions from electric vehicle manufacturer NIO and Chinese tech giant Tencent

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The Chinese Horizon Robotics offers a data processing platform based on artificial intelligence that integrates algorithms, design processors, software and hardware

CHINA

Israeli Mobileye is developing autonomous vehicles, in particular for the Chinese market

ISRAEL

NIO will develop a version of self-driving electric vehicle that Mobileye will implement as a robo-taxi for the global market

Israeli Cognata has developed a 3D simulation platform that virtually recreates existing cities and superimposes artificial-intelligence-based traffic models to simulate real-world conditions

TAXI

The distance covered by autonomous delivery vehicles will reach 78 billion miles per year by 2040

Nuro has presented autonomous vehicles for local commerce. They are small, efficient and can be loaded by end users or merchants with groceries, packages, gifts or other goods for short distance carriage

Public transport

Self-driving buses are also expected to be seen widespread use to transport passengers over long distances

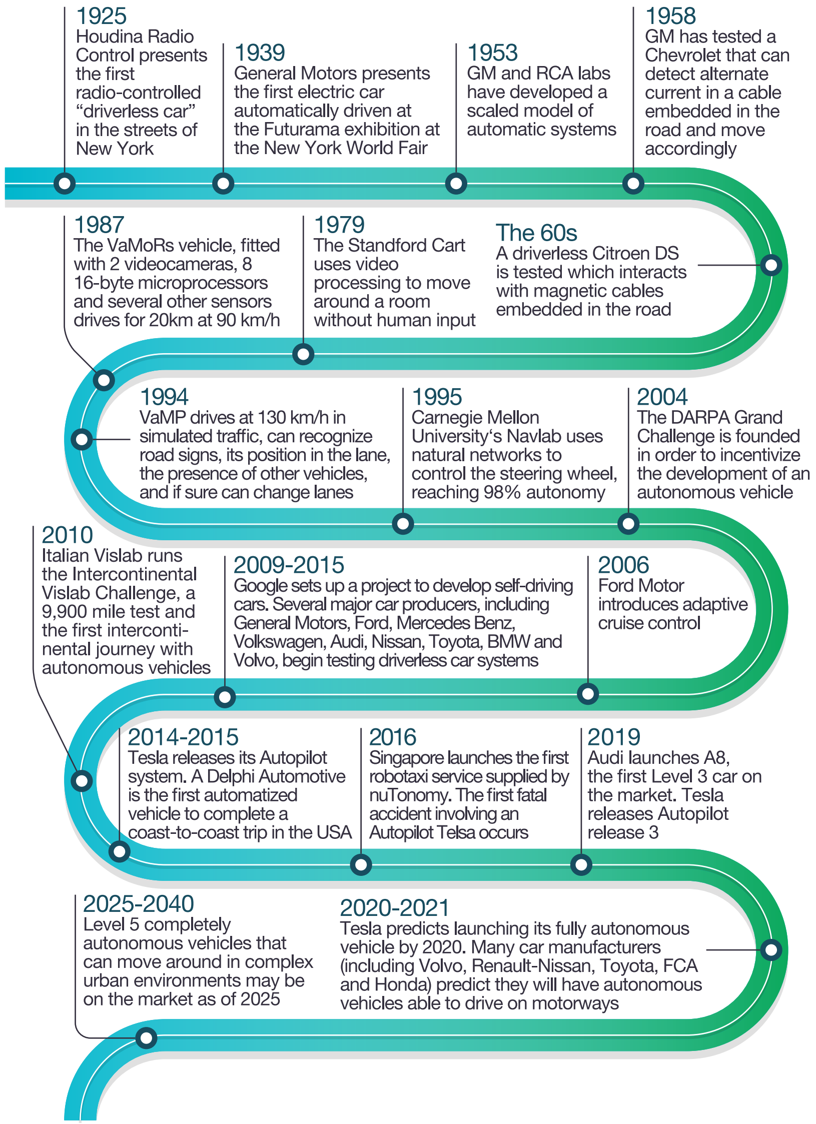
Introduction

Thanks to recent technological developments such as robotics, artificial intelligence and high-performance computers, “self-driving cars”, about which humankind has fantasized at length in films and books of the past, seem to be becoming a potential reality for the near future.

Through the use of complex technologies capable of replacing the driver in a growing number of activities, cars, in the past mechanical devices controlled by man, are assuming an ever greater degree of autonomy. The ultimate goal of these developments is identified by several names, including “autonomous vehicle” or “self-driving car”, “driverless car”, “connected and autonomous vehicle (CAV)”. Although the terms mentioned are often used interchangeably, frequently, however, reference is made to intermediate levels of autonomy, precisely because a completely autonomous vehicle is not yet available in reality. It is necessary, therefore, to make the due taxonomic distinctions, especially in relation to the different levels of “autonomy”.

The first experimentations of autonomous mobility begin in the 1920’s, with the first radio controlled vehicles defined “Phantom Cars” because of the very absence of a driver within. Subsequently, in 1939 General Motors presented some radio controlled vehicles powered by an electromagnetic field on the occasion of the “Futurama” exhibition, at the World’s Fair in New York.

Since then many prototypes of progressively more autonomous vehicles have been presented and tested, without, though, ever responding to the full definition of autonomous car by virtue of the contingent technological limitations.

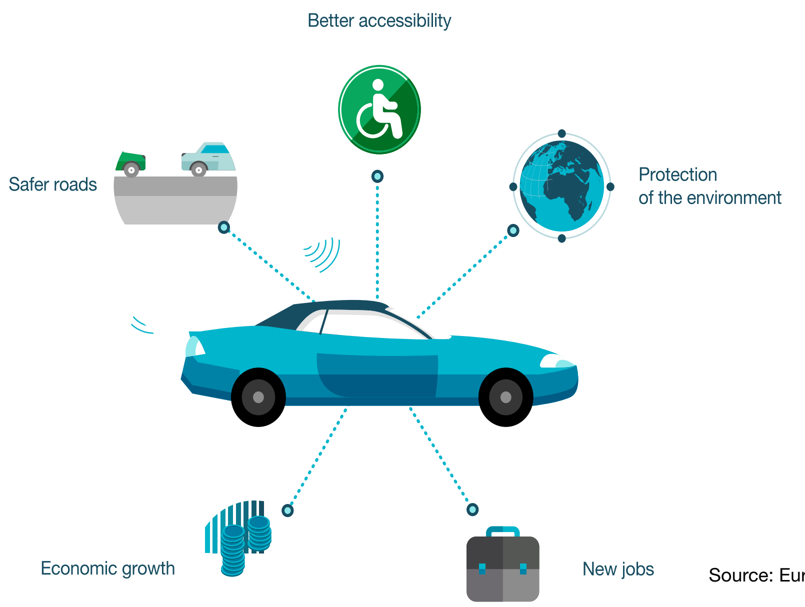


The technological innovations currently in progress, as well as those forecast for the near future, seem, however, to be able to converge to fully create the autonomous vehicle. Only in the later years of the second decade of the millennium, in fact, did technological progress permit self-driving vehicles to overcome some of the major engineering challenges: to gather information defining the surrounding environment, to process the information itself and to react to the environment and to circumstances. According to Frost & Sullivan forecasts, by 2030 one car in four sold worldwide will be “automatic” (of level 3 or higher, according to the SAE classification that will be examined in the next pages), for a total of 18 million vehicles.

"Automatic" cars resemble the vehicles that we drive today, with seats facing forwards, a steering wheel and controls on the dashboard and via pedals: as the level of autonomy gradually increases, these vehicles will assume control of driving and take the place of the driver in certain situations. Some elements of autonomy are already available. Automatic and adaptive speed control, speed adjustment to maintain a safe distance with the cars ahead, automated braking and other driving support systems are now available on many car models, no longer only in premium ranges. In the near future - according to some car manufacturers from 2021 - vehicles with driver assistance systems could take over driving in conditions of heavy traffic or on the motorway.

Truly self-driving cars, however, will presumably be very different means of transport from those that we know. A car, or, more generally, a driverless vehicle will have to be capable of navigating towards a destination, of avoiding obstacles and of parking without any human intervention. To this end, it will have to dispose of systems capable of detecting the surrounding environment, of processing visual data to determine how to avoid collisions, of steering and braking, as well as of location technologies to track position.

In really autonomous vehicles the steering wheel, together with other command systems devised for human drivers, are destined to disappear. Driving systems will be capable, in fact, of replacing them entirely by exploiting a complex system of sensors, radar, GPS and artificial intelligence algorithms. The central role of data collection, also and above all from external sources, makes the subject of connectivity particularly important as the level of automation increases. Data exchange between vehicles and infrastructure is indispensable in completely autonomous driving systems in guaranteeing safe and, at the same time, efficient mobility.



Source: European Commission

It is predicted that self-driving vehicles may radically change transport consumption models: the traditional business model places private ownership of a car at the core. The advent of the autonomous car might, in contrast, enable significantly more efficient models, linked to the sharing of fleets and of autonomous vehicles, whether for the transport of people, or of goods.

According to a Barclays analysis, reported by the weekly "*The Economist*", should the cost of self-driving vehicles become sustainable both for the ride-hailing companies and for other companies and should, at the same time, hurdles regarding safety and ethical and legal questions be overcome, total sales of vehicles could see a sharp contraction (of up to 40%) precisely because of the greater efficiency of the "autonomous shuttle" and of shared "robo-taxis", making private ownership of cars superfluous. Consequently, car manufacturers would find themselves faced with a sharply-contracting market concentrated in the premium segment. Many car manufacturers and OEM's are thus searching for new spaces in the market, directing their attention to the areas of logistics and goods delivery, with products such as self-driving trucks and autonomous cargo shuttles for last-mile delivery, or focusing on innovative, autonomous and modular electric vehicles for collective public transport.

For autonomous mobility to fully establish itself on the market, the technology of the systems on which it is based will have to tackle and overcome important challenges concerning the following issues:

- **Road Safety**: since driverless vehicles must share the road with non-automated vehicles, pedestrians and bicycles, adequate safety standards and the international harmonization of traffic codes are prerequisites.
- **Questions of liability**: since self-driving vehicles do not provide for the presence of a driver, the legal framework must evolve and clarify onto whom legal responsibility falls in the event of accidents – from the driver to the manufacturer?
- **Data processing and cybersecurity**: data protection laws, different according to specific geographic location, also apply to autonomous vehicles. Nevertheless, as yet no specific measures guaranteeing cybersecurity and protecting such vehicles from cyberattacks have been adopted.
- **Ethical questions**: how must autonomous vehicles be programmed to manage situations of conflict, in which in fractions of a second 'the lesser evil' must be chosen? What room is to be left to the self-learning of autonomous vehicles, with the possibility that two different vehicles, in the same critical situation, take opposing decisions based on their different past experiences?
- **Investments in infrastructures**: in order to make autonomous mobility widespread, huge investments are necessary in the research and development of safe vehicles, while significant investments are also necessary to create the necessary infrastructures.
- **Work and training**: the changes taking place that involve all the dimensions of future mobility, but above all autonomous mobility, will have a strong impact on multiple sectors, also in terms of jobs and the competencies necessary to make vehicles "smart". Training, as well as research and management of "talents", will be a winning asset for all those car manufacturers and OEM's that wish to remain competitive. Training, however, will not only concern workers, but also users, who will increasingly have to learn to interface with smart machines and raise their levels of acceptance.

Turning to the benefits of autonomous mobility, according to the European Commission driverless cars and trucks can contribute to the drastic reduction of the number of road accidents, improving safety. Recent studies demonstrate, in fact, that human error represents the cause of roughly 95% of all road accidents in the EU, and in 2017 alone are 25,300 people died on European roads. In addition to this important benefit, it is predicted that the new digital technologies will be able to contribute to reducing both traffic congestion and emissions of greenhouse gases, as well as atmospheric pollutants. Furthermore, autonomous mobility could improve accessibility and social inclusion, for example, by permitting the transport of persons unable to drive, such as elderly people or those with reduced mobility.

The 5 levels of autonomous mobility

The technology for connected and autonomous vehicles, although it is undergoing rapid development, is still very much in an experimental phase. This is particularly true for those technologies necessary for vehicles to become truly “driverless”.

An autonomous car is a vehicle capable of perceiving its environment and of functioning without human involvement. A human passenger is not expected to take control of the vehicle at any moment, nor is it necessary for a human passenger to be present in the vehicle. An autonomous car can do everything that an expert human driver can.

Technology	SAE level 0	SAE level 1	SAE level 2	SAE level 3	SAE level 4	SAE level 5
Adaptive Cruise Control		•	•	•	•	•
Parking Helper L1		•				
Active Lane Centering		•	•	•	•	•
Parking Helper L2			•	•	•	•
Traffic Jam Pilot L2			•	•	•	•
Traffic Jam Pilot				•	•	•
Automated Traffic System L3				•		
Automated Traffic System L4					•	
Parking Valet					•	•
Automated Traffic System L5						•

Level of Automation	
L0	**No Driving Automation** Driver controls the vehicle; vehicle provides assist features
L1	**Driving Automation Assistance** Either Steering or braking assistance; but not simultaneously
L2	**Partial Driving Automation** Steering and braking assistance together as support features only; humandriver can supervise
L3	**Conditional Driving Automation** Automation of full driving task with human fallback; driver to respond promptly when alerted
L4	**Conditional Driving Automation** Full automated in pre-determined conditions; human to drive when system not engaged
L5	**Full Driving Automation** Vehicle drives itself always unless the human intends to drive

Source: Frost & Sullivan

The Society of Automotive Engineers (SAE) defines 6 levels of driving automation that go from Level 0 (completely manual) to Level 5 (completely autonomous). Some vehicles with different levels of automation can only travel in certain environments or under certain circumstances and occasionally require human drivers.

Currently, thanks to driving assistance systems present in many cars, levels 1 and 2 are dominating the global market. Level 3 and 4 vehicles are, for the time being, in the testing phase and are expected to enter the market between 2020 and 2025, while completely automated vehicles (level 5) should arrive between 2025 and 2030. According to Frost & Sullivan, by 2025 sales of cars with driver assistance features (up to level 4) will exceed 40% of the worldwide market of new cars. This market will grow from the current 1.3 to 84 billion dollars.

Let us now look in detail at the characteristics of each level of automation:

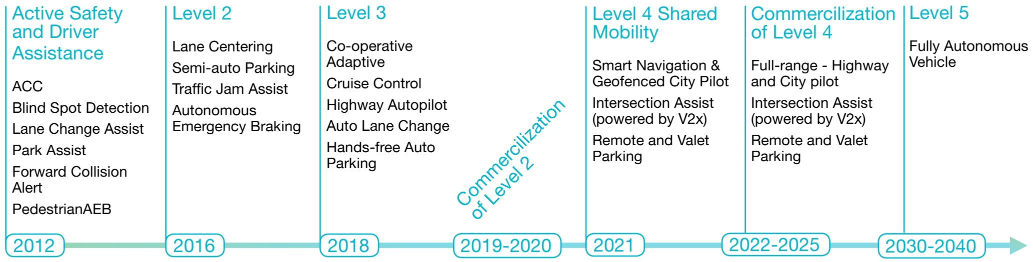
- **Level 0 - No automation**: The vehicle has no capacities for automatic or autonomous driving, it has only sensors to warn drivers in various potentially dangerous situations: by way of example, alerts in the event of a blind spot, automatic emergency braking and lane changing. The driver handles steering, braking, acceleration and all traffic situations. Most vehicles in circulation in 2020 are still at level 0.
- **Level 1 – Driver assistance**: An advanced system of driver assistance (ADAS) offers automatic functions limited to steering, braking or acceleration, but not simultaneously. The vehicle only has automated functions, for example, the systems of adaptive cruise control (ACC) to aid vehicles to detect their distance from vehicles in front of them and to regulate the speed accordingly, without using the pedals, while the driver deals with all other aspects of driving. An example of level 1 ADAS is the “adaptive” cruise control.
- **Level 2 – Partial automation**: The vehicle has more automated functions than those in level 1, being capable of steering, accelerating and braking automatically. The vehicles dispose of two or more advanced driver assistance systems

(ADAS), such as assistance systems in the event of a traffic jam, which offer better cruising speed control and lane assistance technology to avoid collision in conditions of heavy urban traffic. Examples of this type are Tesla Autopilot or the Mercedes' adaptive system Distronic Plus Include for cruise speed control, assistance for staying in lane and automatic emergency braking. At Level 2 the driver still handles the most advanced driving functions and manoeuvres such as lane changing, turns or responses to road signs.

- **Level 3 – Conditional automation**: The transition from level 2 to level 3 is substantial from the technological point of view, but negligible from the "human" point of view. Level 3 vehicles have environmental detection capabilities and can make informed decisions, since they can operate autonomously when certain operating conditions are met. Level 3 automation comprises a driver assistance system with an autopilot, but still requires human supervision. In fact, the driver must be ready to take hold of the steering wheel and intervene when advised. One such level 3 automatic system is, for example, Tesla's autopilot, with the function of remote autonomous parking. The first level 3 vehicle announced by Audi in 2017 and launched on the market in autumn 2019 is the Audi A8, equipped with Traffic Jam Pilot, which combines a LiDAR scanner with advanced sensor fusion and processing power (in addition to integrated redundancies in case of component failure).
- **Level 4 – High automation**: Vehicles handle most activities, manoeuvres and driving functions, actually being able to steer, accelerate and brake on their own; but in certain conditions, for example, in the event of bad weather, intervention is required of the driver. The latter is not expected to drive, but must sit in the driver's seat to take control when necessary. Vehicles with level 4 automation have a steering wheel and pedals on board to allow the human driver to take over driving. Until legislation and infrastructure evolve accordingly, level 4 vehicles will only be able to move in a limited area (geo-fencing), typically an urban environment in which maximum speeds reach an average of 30 miles per hour, which is why most of the existing level 4 vehicles are geared towards ride-sharing or collective public transport. By way of example, Ford intends to provide autonomous level 4 commercial vehicle fleets for ride-sharing by 2021. Toyota, too, expects level 4 vehicles to operate in specific areas in the next decade. However, according to BCG, level 4 vehicles could represent roughly 10% of global sales only in 2035.
- **Level 5 – Full automation**: The vehicle will be completely autonomous and will not require any human intervention, to the extent of not requiring the presence of the driver within the vehicle itself. At level 5 the vehicle will be capable of driving in all conditions and will have advanced autonomous features for driving anywhere. The final phase of automation will require an on-board "smart" system with redundant processing systems.

Autonomous Shuttle Market: Feature Roadmap, Global, 2012-2040

Source: Frost & Sullivan



With the advancing shift from vehicles driven by human drivers to driverless vehicles, dependency on technology increases: the emergence of "smart", reliable and safe control systems is a key aspect for driving the adoption of completely autonomous vehicles.

The characteristics of ADAS systems for levels 4 and 5, as we will see, are not only applied to traditional vehicles for the transport of passengers or goods, but also underlie new types of vehicles for collective or personal transport, for the transport of people with special needs or for the autonomous delivery of goods.

The autonomous mobility market

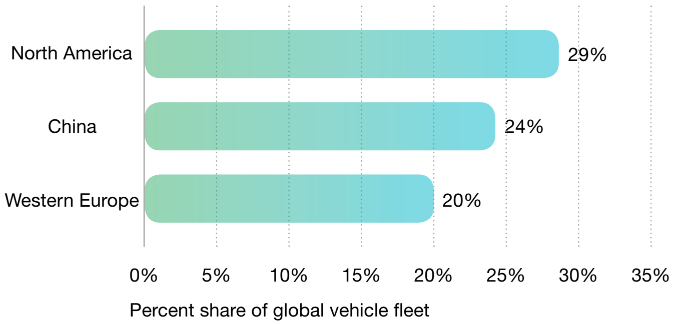
Worldwide

The technology of self-driving vehicles is still in the development and testing phase but represents nonetheless an emerging global market.

Frost & Sullivan hypothesizes that one car in 4 sold (for a total of 18 million cars) worldwide will be automated (level 3 or higher) by 2030, with level 4 leading the growth in the private car market.

In terms of total sales China is expected to hold the record, with 14.5 million autonomous vehicles to be sold in 2040, while in terms of market penetration the North American continent will lead the way, with almost 30% of the vehicles in circulation.

Projected share of self-driving vehicles in the global vehicle fleet in 2035, by region



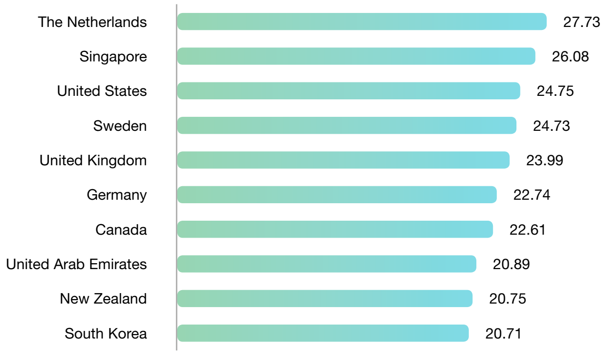
Source: Statista

Today, driverless vehicles are becoming a reality and many autonomous vehicles of different kinds travel thousands of kilometres on public roads in different countries. As an example, Daimler has obtained a license to test its self-driving cars in China on the public roads of Beijing, while in the United States around 50 companies are testing autonomous vehicles in California. In Italy, the city of Turin has also obtained ministerial authorization to test self-driving vehicle on a circuit of public roads in the city. As technology gradually becomes more widespread, which countries are best prepared to exploit it? Although Europe is not attracting the same attention as the United States, a KPMG study published by Statista found that, globally, the Netherlands is actually the nation with the highest level of "predisposition" to autonomous vehicles. The study assessed countries on 26 variables over 4 pillars: policy and legislation, technology and innovation, infrastructure and consumer acceptance.

Singapore is second in this ranking and has made progress by introducing an amendment to the Road Traffic Act of 2017 that has allowed self-driving cars to be tested on Singaporean roads. The United States is also towards the top of the ranking: this is not surprising given its significant efforts in research and development and its ambitious testing programme. More than 160 companies that develop technology for autonomous vehicles - including Tesla – are located in the USA (and in particular in Silicon Valley), the highest number of any country.

The Countries best prepared for autonomous vehicles

Index scores on level of preparedness for driverless cars in 2018 (30= best prepared)*



*Scores based on four pillars: policy e legislation, technology & innovation, infrastructure and consumer acceptance

Source: Statista

Level 4 and 5 (SAE) autonomous cars are expected to become a large worldwide market by 2030, with a total value of $ 60 billion.

In the field of "collective" autonomous mobility, according to research conducted by PwC and published by Statista, Level 4 (SAE) "people mover" vehicles will operate in restricted urban areas, called "geo-fenced" areas, and at less than 50 km/h already by 2021. The same analysis also highlights that only after 2029 will there be an expansion on the roads of level 4 and 5 (SAE) highly automated vehicles.

As regards the market for components capable of enabling autonomous driving, some examples of technological components that we will examine hereafter include driver assistance systems, radar, ultrasonic sensors, LiDAR. Overall, the automated driving technology market will be worth $ 270 billion in 2030 with a CAGR of 13%. The global automotive radar market, in particular, stood at $ 1.2 billion in 2015 and is expected to grow significantly by 2021.

Europe

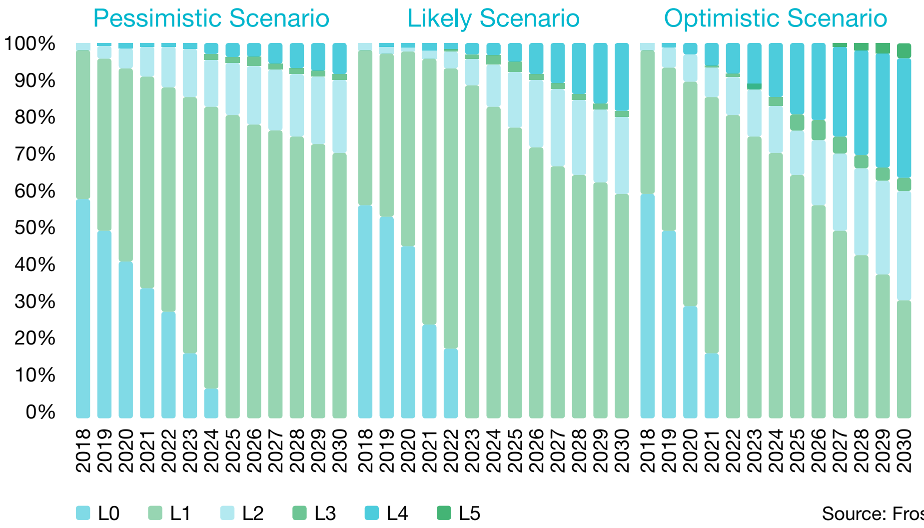
According to the forecasts of the European Commission, in the next few years the self-driving vehicles market will grow exponentially, creating new jobs and generating profits for the European automotive industry of up to 620 billion euro by 2025.

In general, the support of public institutions for the development and testing of autonomous cars, the evolution of connected vehicle technology and the need for efficient and safe driving are the main factors driving growth in the European market.

The growth of completely autonomous cars in Europe is apparently mainly led by the adoption of Level 4 and 5 (SAE) autonomous cars within sharing mobility services. According to ResearchAndMarkets.com estimates, the European autonomous mobility market, which is supposed to reach a value of $ 191.6 billion by 2030, is subdivided into semi-autonomous cars and completely autonomous cars. In terms of sales volume, during the 2023-2030 period, the entire market share will be held by semi-autonomous cars. The share of full autonomous vehicles, on the other hand, is expected to grow more rapidly during the period under consideration with the launch of these cars expected, as early as 2023, according to this analysis. Level 4 (SAE) cars should represent a larger market share in terms of volume than Level 5.

With regard to the various forecasts and estimates made by analysts, it should be highlighted that these are very frequently revised, since underlying developments in this market there are a number of variables to be considered: consumer perception, development of physical infrastructures for connectivity, the need to establish technological standards common to different countries, regulation, clarity regarding liability and reliability, improvements in technological safety, questions linked to privacy, reduction of the costs of research and development activities, as well as possible developments in the sharing mobility market and in models of Mobility-as-a-Service.

Autonomous Driving Market: Forecasting scenarios, global, 2018-2030



Source: Frost & Sullivan

Key: Vehicle sales for the above three scenarios have been considered as same
Note: All figures are rounded. The base year is 2018.

In general it is anticipated that in Europe autonomous cars used for commercial purposes will dominate the market, when compared to private ones. This would be due to the deployment of completely autonomous vehicles in sharing services and to the introduction of robo-taxis.

Germany represented the largest market in 2018 with a share of over 20% held in terms of volume. This is due to the presence of the main car manufacturers, which are launching new models with advanced automation levels (take, for example, the Volkswagen Group or BMW). To these can be added other OEM's very active in the panorama of technologies and components for self-driving vehicles, such as Bosch and Continental AG.

Italy

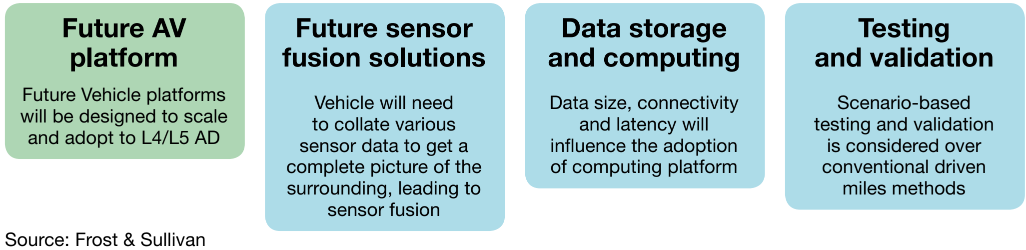
Italy still brings up the rear in Europe: for the moment specific data concerning the domestic market are few, even if some initiatives are starting.

Italy has particularly intensified its involvement in research projects within European consortiums on the question of autonomous driving and smart roads, despite the fact that its leadership is limited to a few projects.

Recently, the Ministry of Infrastructure and Transport, which in June 2018 set up the "Technical Observatory for the Support of Smart Roads and connected and automatically-driven vehicles", approved the Smart Road Decree authorizing the testing of driverless vehicles. In 2019, the first tests were started in Piedmont and Emilia Romagna. With regard to the initiatives and partnerships undertaken by car manufacturers, the FCA group is collaborating in the United States with Waymo, the company dedicated to autonomous driving created by Google, with which it has entered into an agreement for the supply of 62 thousand Chrysler Pacifica minivans for the creation of an autonomous fleet. FCA also signed an agreement in 2019 with the US start-up Aurora that produces software and hardware for autonomous driving, in order to launch a fleet of driverless commercial vehicles overseas.

Enabling technologies

Autonomous Vehicle (AV) Market: Technology Trends for AV, Global, 2018

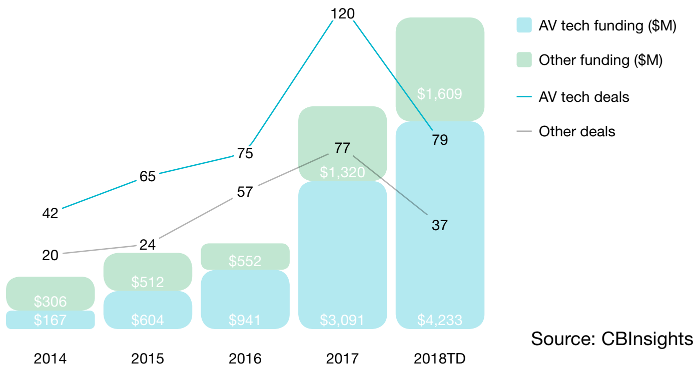


Source: Frost & Sullivan

With the evolution of the sector of the so-called advanced driver assistance systems (ADAS), the attention of manufacturers of hardware components and software solutions for cars has shifted to the development of platforms for Level 4 and 5 (SAE) self-driving vehicles and to the necessary computational platforms. However, a "virtual" testing and validation system proves fundamental, and which thanks to the available technologies is capable of discovering and correcting any problems related to self-driving vehicles, in a test environment that is safe but still connected to the "real world".

Funding to AV tech outpaces rest of auto tech

Deals and dollars to AV and other auto tech startups, 2014-2018TD (9/20/2018)

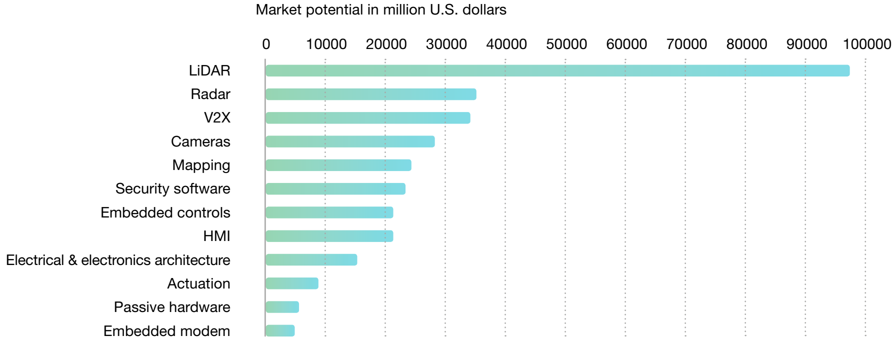


Source: CBInsights

Since 2016, investments in innovative companies working on semi-autonomous and autonomous driving technologies have outperformed all the other segments of technologies linked to the automotive sector. Since early 2018, according to CB Insights, the biggest rounds of automotive start-up financing have involved companies from the autonomous mobility ecosystem. These investments are dedicated to enabling components and technologies such as sensors, video cameras, 3D mapping, radar and LiDAR.

Source: Statista

Global autonomous vehicle component market potential for automotive suppliers in 2050



Autonomous car components: global market potential by segment 2050

Here below we will take a closer look at the numerous technologies that make self-driving vehicles possible, subdividing them into clusters. The first concerns genuinely autonomous vehicles, in many cases designed and built ad hoc to respond to specific requirements, or the software platforms that enable driverless "driving". The second includes all sensors allowing vehicles to "perceive" the surrounding environment. The third, instead, regards technologies for location and connectivity, allowing autonomous vehicles to communicate with other vehicles or with road infrastructures, always being aware of their exact position, and to support the development of reliable and safe autonomous solutions. The last cluster concerns technologies for the collection of external information, its processing and computational capacity.

Sensors for "perception"

According to Maximize Market's analysis, the advanced driver assistance systems (ADAS) market was valued at

26.2 billion dollars in 2017 and is expected to increase at a CAGR of 14.6% in the 2017-2026 period. The growing concerns around road safety, combined with a regulatory push towards the installation of these systems determine growth in the sector. Various governments around the world have, in fact, made the installation of ADAS on newly-manufactured vehicles compulsory, with the aim of improving road safety.

Underlying autonomous vehicles are assisted driving technologies that define Levels 1 and 2 (SAE) of automation. Among these we can indicate:

- Adaptive cruise control
- Automatic control of the high beam
- Autonomous parking assistant
- Blind spot detection
- Driver monitoring
- Frontal collision warning
- Front lighting
- Autonomous emergency braking
- Night vision
- Head Up Display
- Lane departure warning
- Parking assistant
- Surround View system (360 ° view)
- Recognition of traffic signs
- Tyre pressure monitoring system

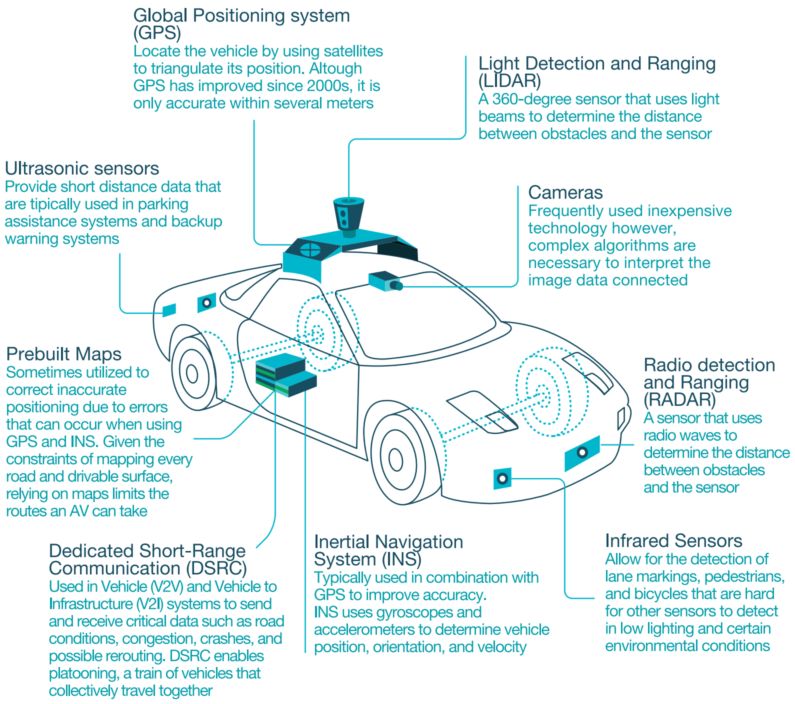
Each ADAS system is based on a specific type of sensor, capable of managing in the best way possible the particular road situation. These systems first appeared in premium segment vehicles and then began to spread to other classes of vehicles too.

↳ "Advanced Driver Assistance Systems"

In modern Level 1 and 2 (SAE) vehicles, these technologies and sensors are used jointly, since each offers a level of autonomy that helps make the whole system more reliable and robust. For example, Tesla's driverless technology, known as "Autopilot" uses eight cameras to provide 360-degree visibility, while twelve ultrasonic sensors and a front radar analyze the vehicle's surroundings and identify potential hazards.

The autonomous driving of Level 4 and 5 (SAE) requires, however, a change of paradigm: the perception of the surrounding environment must, in fact, be extremely precise and this is why the cars, going forwards, will contain many more on-board sensors. Autonomous vehicles must be able to recognize road signs, but also other cars, bicycles and pedestrians. They must also sense the distance and speed of an approaching object to be able to react accordingly.

AV systems are generally based on video cameras and other sensors such as radar and Light Detection and Ranging (LiDAR), each of which offers its own set of advantages and limitations. The data collected by these sensors are combined through a technology called "sensor fusion" to create an accurate representation of the environment surrounding the car.



Source: Center for Sustainable Systems, University of Michigan. 2019. "Autonomous Vehicles Factsheet." Pub. No. CSS16-18.

RADAR (Radio Detection And Ranging) Sensors

Radar transmits pulsed radio or electromagnetic waves. Once these waves have struck an object, they return to the sensor, providing information on the speed and position of the object. In a similar way to video cameras, the waves surround the car so that it can see into each corner. Radar technology is also useful for long distances, albeit not very precise. It is also not able to distinguish different types of objects, which is why it is combined with video cameras. In contrast, radar sensors perform better than cameras in situations of poor visibility, such as night driving or when the video camera is covered.

It is also necessary to consider the degree of technological development: radar has been used since the early 1900s, it is, therefore, inexpensive and technologically advanced.

The main shortcoming of radar is its low resolution, which does not allow objects to be identified, especially if static. However, new generations of sensors called 4D Radars are appearing on the market, with a high resolution, capable of identifying objects up to 300 metres away and also of defining their dimensions in terms of height and width. Lastly, the identification of the colours of objects in the environment surrounding the vehicle can be obtained by combining radar with the use of video cameras.

LiDAR (Laser Imaging Detection And Ranging) systems

> LiDAR is the acronym for "Laser Imaging Detection and Ranging". Similar to radar emitting radio waves that "reflect" the objects struck, a LiDAR emits infrared laser light beams with the aim of measuring the distance between the vehicle and objects on the road.

LiDAR systems for autonomous vehicles are relatively new, with the first player, Velodyne, showing this technology's potential in 2005 at the first DARPA Grand Challenge. LiDAR technology is rapidly evolving, with the aim that of making the sensor cheap and compact, and it is one of the essential components for the diffusion of autonomous vehicles. According to experts, its diffusion and the evolution of hardware and software components will be key to achieving autonomous Level 5 (SAE) driving. These sensors are actually able, unlike others, to have a 3D view of what is happening around the vehicle.

A LiDAR system calculates the time it takes for light to strike an object and reflect on the scanner. The distance is then calculated using the speed of light.

LiDAR systems can generate approximately 1,000,000 pulses / lasers per second. Each of these measurements, or returns, can then be processed in a high resolution 3D visualization known as a “point cloud”. In this way, the LiDAR sensor processes the surrounding environment and is effective even in difficult situations such as heavy traffic.

Like radar, LiDAR works equally well in conditions of poor light or when cameras are covered. However, unlike radar, it provides shape and depth to surrounding objects (other vehicles, pedestrians, bicycles, crossroads, traffic lights, etc.), as well as to the topography of the road.

As Frost & Sullivan point out, the current LiDAR sensors meet L2 and L3 autonomy standards. They are capable of detecting objects with up to 10% reflectivity, but are subject to weather conditions, they work only below certain speeds and are very delicate (they are small mobile components). Their current costs are also too high (a question of some 75,000 dollars) which does not allow their diffusion on private cars.

The most recent developments of this technology for autonomous vehicles have led to the frequency modulated continuous wave LiDAR (FMCW), in which the frequency of the light beam emitted varies continuously and the distance travelled by the return beam before the rebound is measured by the difference in frequency between the outgoing and incoming beams. Thanks to the FMCW LiDAR it is possible to measure the speed of the object present in the surrounding environment, as well as the distance.

The LiDAR technologies described so far are mechanical and require mobile components and generous dimensions (we are therefore talking about the well-known “spheres” that can be identified on top of the roof of Waymo cars) and which may therefore require frequent maintenance and particularly onerous calibration.

In order to contain size and make the vibrations irrelevant, solid state LiDAR sensors are being developed, entirely built on a silicon chip, which makes production cheaper. On the other hand, they have a reduced visual range, which will no longer be 360 °, and will therefore require the installation of multiple sensors on the same car.

Video cameras and computer vision

Recognition of images is essential for a true understanding of the environment. Unlike the previous sensors described, video cameras are capable of identifying colours and characters; however, the recognition of images from video cameras is not effective when it comes to measuring the depth and distance of an object or in particular light or weather conditions, such as at dusk or in the pouring rain.

↳ “Automotive camera technology and computer vision algorithms”

Image recognition can be subdivided into two large categories: machine vision and computer vision. The first is simpler, based on the identification of the particular characteristics of an object (edges, angles, etc.), it allows you to detect movement, and use stereo vision to estimate the distance through the extraction of 3D information from digital images. By looking for particular characteristics, it is possible to identify objects such as pedestrians, cars, lane signs and road edges.

Computer vision involves a much more complex process. It uses algorithms based on artificial intelligence and machine learning techniques and is useful in identifying and understanding road signs, in particular in the case of temporary signs for work in progress or diversions, which cannot be entered into a database.

Sensor fusion

> “Sensor fusion” is the combining of data from different sensors in such a way that the resulting information displays less uncertainty than would be possible if these sources were used individually. In this way it is possible to obtain a result that is far better than what would be obtained from a sensor taken individually.

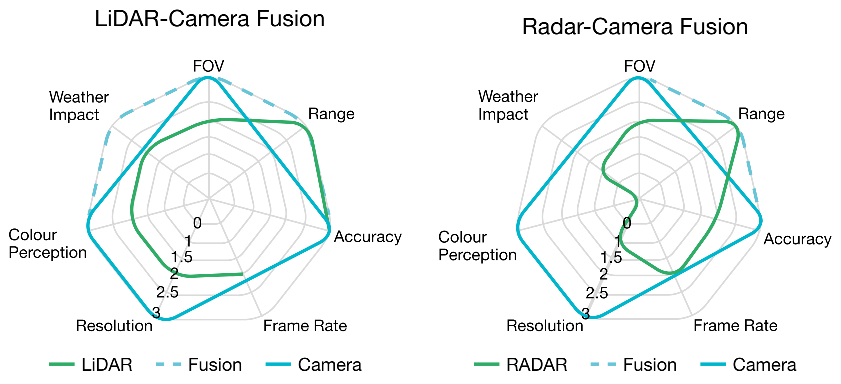
Since each type of sensor has specific advantages and limitations, the car and transport industry is embracing the use of multiple types of sensors simultaneously: these complement each other with unique strengths, ultimately reducing the effects of any limits that might be present. A greater use of sensors will further reduce costs, leading to a greater number of vehicles having them installed.

↳ “Raw data fusion for safer autonomous driving”

A sophisticated sensor fusion platform requires high-level performances from processors and algorithms to synthesize data from multiple sources. Some of the ADAS systems enabled by sensor fusion are lane-keeping assist, highway assist (which combines adaptive cruise control, lane centering to control speed, acceleration and braking) and blind spot detection.

Sensor Data Fusion Strategy: Sensor Fusion Performance Capabilities, NA and EU, 2019-2025

Source: Frost & Sullivan



LiDAR-Camera fusion increases short-range and reduces impact from weather.

Radar-Camera fusion increases color perception, while keeping sensor costs low.

Although the self-driving vehicle sensor par excellence seems to be considered by most of the players in the sector, including, for example, Waymo, the LiDAR system, Tesla and other companies (for example, AutoX) have opted for solutions that exclude the use of LiDAR sensors.

Despite the expected growth of LiDAR systems and a very great deal of dedicated development, Elon Musk declared in April 2019 that “LiDAR is madness” on the road to completely autonomous vehicles. Actually, the eccentric billionaire described the technology as “expensive” and “unnecessary”, adding that “anyone who relies on LiDAR is doomed.” Tesla embraces the idea that, with the aid of eight strategically positioned, inexpensive video cameras, a front radar and ultrasonic sensors and thanks to the data collected over the millions of kilometres travelled, artificial intelligence systems based on neural networks will learn to make driving decisions just as humans do.

Musk’s version of the completely self-driving vehicle, though, seems not to meet current sector standards. And Tesla’s “Autopilot” system, a semi-automated system that in any case requires the driver’s attention, has been linked to a number of fatal accidents.

The great majority of car manufacturers do not seem to share Musk’s opinions of LiDAR and are working on the development of ADAS incorporating LiDAR as a critical part of a safe system in which system failures are not permitted. Although it will take decades for regulations, infrastructures and other sensors to evolve to the point of adapting to completely autonomous vehicles, many car manufacturers have set 2021 as the market launch date for their own driverless vehicles.

Location and connectivity

Autonomous vehicles must know their exact location, both to make real-time decisions and to plan their route.

Many rely on the GPS signal, but this can achieve a maximum accuracy of 1-2 metres, with an error rate that is too significant to guarantee driving in complete autonomy and safety.

Driverless vehicle developers rely on a range of location and on-board connectivity technologies, including vehicle-to-vehicle communication and infrastructure technologies, simulation software, high-resolution maps, which reduce the error rate to less than 1 metre.

A big step forwards for autonomous driving technology is vehicle-to-everything communication (V2X), that is, the possibility for the vehicle to transmit and receive information from other vehicles and from the various IoT devices present in the infrastructure. This protocol, its origins, its possible future developments have been examined in detail in the chapter dedicated to connected mobility, precisely because the V2X is considered to be one of the major enablers of the connected car first of all, and then to the autonomous car.

Invisible-to-Visible VR

Nissan has taken the concept of V2X and 5G network integration one step further with its Invisible-to-Visible (I2V) concept. It is a Virtual Reality-based system that integrates information from V2X's and vehicle sensors to create an unobstructed 360-degree view of the environment surrounding the driver.

Integration between the physical environment - that is, the car and the real elements that surround it - and a cloud ecosystem create an unprecedented driver and passenger experience. The car, through its external and internal sensors (part of Nissan's Omni-Sensing system that also includes the ADAS of the ProPILOT semi-autonomous driving system), transmits information to the cloud, cross-referencing it with data from the network.

↳ "HD live map for autonomous cars"

This means that the car is able to visualize the immediately surrounding area and at the same time predict the scene that will appear in front of the driver (for example by showing elements hidden by a building or by a bend). The integration between virtual and real occurs through avatars that are displayed inside the car, ensuring a more engaging *user experience*.

HD mapping

In addition to depending on technologies for "perception", autonomous vehicles must know their precise position on the road in order to evaluate situations and calculate the dimensions of the physical elements present on the road (lanes, position of traffic lights and intersections, pedestrian crossings, etc.). Location-based services, in their simplest form, allow vehicles to position themselves with millimetric precision on a map and to provide additional information helpful for planning routes and for the positioning of autonomous vehicles on the road.

The data generated may concern, for example, the availability of kerbside parking spaces sidewalk or in car parks or of real-time traffic information. These services, based on highly accurate geolocation – defined as *HD mapping* - allow vehicles to understand the surrounding environment, to interpret the setting and any hazardous situations and to act according to the data received.

High Definition (HD) maps are similar to mobile navigation platforms like Google Maps, but are considerably more detailed. They are designed to provide autonomous and semi-autonomous vehicles with a three-dimensional representation of their surroundings.

HD maps contain measurements down to the centimetre together with information on lane width, pavement height, speed limits and exact positions of traffic lights and stop signs.

HD maps are generated from initial data from the road infrastructure, generally collected by vehicles equipped with sensors that travel on public roads.
The sensor suite of a self-driving vehicle generally contains LiDAR technology which, as seen, generates three-dimensional representations of the road, as well as other reference points such as buildings. These visual elements are then divided up and the permanent features on the road such as crossroads, pavements, posts, traffic lights, are classified and memorized.

Since the autonomous vehicle already knows the permanent road features, the use of HD maps allows its perception system to focus more on moving objects such as pedestrians, vehicles and roadworks, and on unexpected situations.

In-vehicle video cameras and aerial and satellite imagery can provide additional visual details, although image-based content updating is heavier. This has prompted a number of companies to take advantage of the crowdsourcing of images from smartphones and fleets already in circulation.

Simulation and "traffic modelling"

Training autonomous vehicles is a complex and costly activity. Given the infinite number of possible scenarios and situations that a vehicle could encounter on the road, experts believe that autonomous vehicles need billions of kilometres of testing for their safety to be approved.

↳ “NVIDIA automotive simulation”

Existing fleets would take dozens and sometimes hundreds of years to cover these distances and it is not easy nor safe to replicate the different scenarios in real environments.

To speed up the training process for autonomous driving systems, from level 3 (SAE) up, autonomous vehicle manufacturers use virtual simulations or reproductions of roads, intersections, etc. with the aim of effectively teaching autonomous vehicles to react correctly in certain scenarios, such as dangerous road conditions, situations of darkness or of blinding light, as well as in the event of a sudden crossing by a pedestrian or another vehicle.

Simulation and traffic modelling are indispensable particularly in the management of the urban environment in all its complexity. When compared to air and rail traffic, urban traffic in particular has numerous co-existing elements and the presence of pedestrians and cyclists, who can exhibit unpredictable behaviour.

In parallel with the development of simulation environments, and very useful for the validation of autonomous driving systems, there are also the government initiatives allowing companies that develop technology for autonomous driving to carry out tests on public roads in controlled environments in order to be able to guarantee maximum safety.

Data storage and processing

In a cloud-based processing system, the term edge computing means the possibility of processing data and information coming, for example, from sensors scattered "on the edges of the network", where the data themselves are produced.

Edge computing is based on the fact that for some “critical” applications the processing of the data collected must take place at the extreme limit of a network infrastructure and not in a centralized way at the data centre. The goal is to bring intelligence and calculation closer to action, minimizing latency and allowing an immediacy of analysis.

With the advent of the Internet of Things (IoT) and the exponential growth of connected devices, edge computing takes on a central role.

As regards autonomous mobility, these vehicles have video cameras, numerous LiDAR sensors, radar and so forth. Many self-driving car manufacturers have predicted that sensor data will flow into their proprietary cloud allowing them to collect billions of driving-related data to be used to train autonomous systems and to improve vehicle performance through machine learning.

Considering the huge volume of data produced by self-driving vehicles’ sensors - according to Intel, it is 40 Tb of data per day for each self-driving vehicle - and the time required to pass information onto the network it is evident that a large part of the processing must take place on the edge. The time required for data transmission is in fact enormous, given that the car is in motion and that decisions must be made rapidly to control the car.

Edge computing requires localized computational processing and memory capacities to be capable of ensuring that self-driving cars and AI-based systems are able to perform the tasks necessary.

The choice between cloud and edge computing is not to be understood as being mutually exclusive.

A well-designed self-driving car will be capable of blending local processing and cloud processing according to needs, delegating to cloud processing those tasks less “time sensitive”.

EDGE Computing		CLOUD Computing
Allows rapid processing of critical and time-sensitive data	Data processing and latency	Data processing in the Cloud requires a great deal of time due to dependencies
Optimization of the data downloading big blocks of unrelated data during the processing of critical data within the vehicle	Dimension and storage of data	Centralized storage and treatment and of large quantities of data for the decision-making process
Reduced dependency on network connectivity	Connectivity	Depends on network connectivity with real-time access to global data
Discrete system with application at the level of the vehicle and limited scalability	Integration and scalability	Large scalable platform to integrate multiple applications and services
Limited security levels, without real-time updates	Security	Greater safety in the Cloud infrastructure

The ecosystem of autonomous mobility: players, competition and partnerships

Digital-led disruption in the world of transport will have unprecedented consequences for all players in the ecosystem of connected and, above all, autonomous mobility, linked to new models of mobility, safety and environmental sustainability, as well as to increasingly advanced consumer and business demand. We are witnessing a market repositioning for all stakeholders, from the traditional automotive industry to insurance, to telematic service providers, public bodies, technology companies and start-ups, who must pursue a diversification of innovative services and revenues.

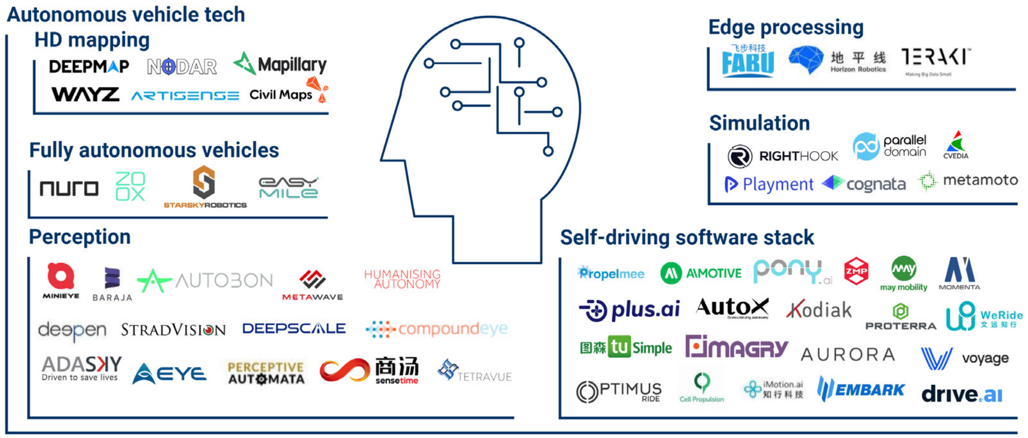
Marking the beginning of a new era for the automotive and transport sectors, competitors from the past are joining forces and working together on highly strategic projects. By way of example, in July 2019 the two automotive giants Ford and Volkswagen announced that they would expand their global alliance to electric and self-driving vehicles in the United States and Europe. The partnership was just one of many recent announcements in the sphere of autonomous vehicles, with OEM's rushing to catch up with "new entries", such as Google's Waymo or Uber, which have been working on advanced systems and software platforms for years for autonomous vehicles and are today the top players in this competition.

Meanwhile, the global automotive industry is continuing to invest billions of dollars in start-ups working on specific aspects of research and technology that enable self-driving vehicles, with an urgent need to find “talents” with the right skills. According to research conducted by the Boston Consulting Group and the Michigan Mobility Institute, the U.S. auto industry alone will require approximately 45,000 mobility engineers and 70,000 skilled workers to test and launch autonomous vehicles over the next decade. What is certain is that the advent of autonomous mobility will have a powerful impact on all current business models: the centrality of vehicle ownership, car insurance, financing and management of company fleets and public transport.

From level 3 to level 5 – What automakers, OEM’s, tech companies and start-ups are doing

As we have seen, the car and transport market in its current state is concentrated in levels 1 and 2 of the SAE scale. In 2019 most vehicles on the market, both in the premium segment and among the subcompact models, integrate varying levels of advanced driver assistance systems, such as adaptive cruise control, lane keeping, emergency braking. However, the road to full autonomy is still long. Despite the fact that the technology is not yet ready to be integrated into vehicles and placed on the market, car manufacturers, OEM’s, tech companies and start-ups are working to make it safe, reliable and available in a short time.

In order to understand the extent of the phenomenon and to understand the boundaries between vehicle manufacturers, traditional car suppliers and technology companies, we have adopted the classification proposed by CB Insights to subdivide into six clusters the players moving in the ecosystem of self-driving vehicles.



Source: CBInsights

The first group of ecosystem players are focused on software platforms and full-stack “smart” systems capable of ensuring vehicle autonomy.

Other companies are working on the design and development of real vehicles, understood not only as cars or other means of transport as we have known them to date, but also modular and autonomous vehicles for private, public and logistics transport.

A third group of companies is working on sensors and, more generally, on the analysis and understanding of the surrounding environment, such as radar systems, LiDAR, ultrasound, video cameras.

Then there are companies that deal with data analysis and simulation, while a fifth group develops maps and services based on location.

Finally, the last cluster includes companies dealing with edge computing, i.e. software and / or hardware solutions to meet the high processing requirements.

To these main clusters that we will examine in detail in the following pages must be added those companies that develop mobile and web applications and the companies that work on mobility infrastructures and provide software or physical infrastructures for the testing of autonomous vehicles.

A further group is represented by companies that deal with connectivity, and in particular with connected cars and with the V2X communication that ensures communication between devices, vehicles and the surrounding environment. These further groupings are covered extensively in other chapters in this report.

Self-driving software stack

The companies in this category build the entire autonomous driving system, offering a package that includes artificial vision and sensor fusion software, as well as hardware for self-driving vehicles. These companies work both on advanced driver assistance systems (ADAS) to improve certain driver skills and on complete solutions. Within the ecosystem, this cluster is the most densely populated: the start-ups and OEM's that are part of it generally collaborate with car manufacturers and big tech companies to implement their own technology and integrate it into vehicles.

The strong push towards autonomous and assisted driving and, consequently, for the development of advanced software systems, started with so-called Big Tech, Google above all, which as early as 2009 had started its first tests of a driverless car. Google's project is by far the longest running. Google initially used the Firefly or "Pod Car", which is a completely driverless car used as a platform for the development of technology. In December 2016, Waymo, an internal company within Alphabet, was set up specifically to develop driverless cars.

Google, followed by Waymo, began to develop their hardware and sensors internally in 2011, when nothing else existed on the market that could provide the functions that would guarantee vehicles with level 4 systems (SAE). The sensor suite for autonomous driving is composed of LiDAR, video cameras and radar, as well as microphones for detecting sounds (e.g. sirens), with each integrating with the others like the five senses of a person.

Waymo publicly revealed its customized self-driving hardware in February 2017, planning to sell an integrated hardware and software package. The years of development have allowed Waymo to gain a leading position in this ecosystem. In fact, the Waymo fleet officially reached 4 million miles of self-driving on public roads in the United States in November 2017. The company reported that the vehicles travelled 2.5 billion additional miles in simulations, facing more than 25,000 "problematic scenarios" and 20,000 different individual tests on the track.

In the second quarter of 2018 Waymo announced the purchase of 62,000 new Chrysler Pacifica minivans, which are equipped with all Google hardware including sensors, video cameras and LiDAR, increasing the size of its self-driving fleet approximately 100-fold. In December 2018 Waymo launched Waymo One, its self-driving commercial taxi service, in Phoenix, Arizona. In the testing phase, the vehicles have a driver on board to ensure safety. In July 2019 it received authorization from the California Public Utilities Commission to manage its robo-taxi fleet. In general, Waymo, in the race for autonomous driving, appears to have a clear edge over its competitors and, in particular, over traditional car manufacturers.

Among the top players working on full-stack software systems for autonomous vehicles, one of the most active, and one that can perhaps be placed second after Waymo in terms of the development of its platform, is General Motors, which in 2016 acquired Cruise Automation, a company specializing in autonomous driving. Cruise vehicles use machine learning techniques, cloud-based systems and IoT sensors to collect data on the surrounding environment and make smart decisions.

Safe in the knowledge that it has raised billions of dollars in investments, Cruise boasts a significant number of vehicles on the road (around 180 in October 2019), but the commercial launch of a fully autonomous ride-hailing service was postponed from 2019 to the following year so that further tests could be carried out.

Cruise Automation

By Dllu - Own work, CC BY-SA 4.0

"Our goal is to get there as soon as possible. We want that moment to come as quickly as we can. But everything that we do right now is going to be gated by safety. And that's why we're increasing our testing and validation mileage just to get to that point as rapidly as possible."
Dan Ammann, CEO di GM Cruise Automation

Another company that has taken a leading role in the technological and market competition for the development of advanced software systems for level 4 and 5 autonomous vehicles is Argo AI. The start-up is an artificial intelligence company that is developing machine learning software for L4 autonomous vehicles and that collaborates with the major car manufacturers - in particular Volkswagen and Ford - to provide a completely integrated autonomous driving system, which can be produced on a large scale for safe and reliable distribution in shared mobility and goods delivery services. It differs from competitors because it is not interested in the vehicle or in the provision of a service, but it focuses exclusively on a technological solution based on a combination of LiDAR sensors, radar and video cameras.

Looking beyond the U.S. ecosystem, the start-up Pony.ai, founded in California in 2016, raised investments of $ 264 million from Chinese investors, with the aim of developing the first autonomous vehicle system ready for the Asian market. In April 2019, the company announced its PonyPilot test project, the first ride-hailing service for China. In June 2019, the company also received permission to test robo-taxis in California.

China also has several companies working on autonomous driving systems. Beijing-based Momenta achieved unicorn status in October 2018, thanks to contributions from electric vehicle manufacturer NIO and chinese tech giant Tencent. Momenta collaborated with the Suzhou local government to implement a large-scale test fleet and build smart transport systems in the city.

In some cases, companies in this cluster are adapting existing vehicles with solutions that enable autonomous driving. Drive.ai, for example, is using its own autonomous system to create retrofit kits. The Californian start-up, founded in 2015 in the Stanford artificial intelligence laboratory and valued at $ 200 million in the last round of investments, transforms traditional vehicles into self-driving vehicles. It was acquired by Apple in June 2019.

Even within this cluster, some companies have specialized in full-stack platforms for specific vehicle segments, such as the trucking sector, with the aim of automating trucks and allowing them to cover long distances autonomously or semi-autonomously. By way of example, Starsky Robotics created a complete autonomous driving system for trucks and offers a hybrid solution; its technology combines autonomous driving with that of a remote human operator: the truck operates in autonomous mode on long stretches on the highway (for example in Florida), while the human operator can intervene in difficult situations.

Staying in the trucking sector, TuSimple, which originates in China but has a research and development laboratory in San Diego, is developing technology for level 4 (SAE) driverless trucks. The company envisages putting a fleet of autonomous trucks into circulation within 5 years. In May 2019, TUSimple launched a two-week

PONY.AI

Pony.ai aims to build reliable autonomous driving solutions. Pony.ai's fully self-developed software algorithms and infrastructure enable vehicles to perceive its surroundings, predict what others will do, and maneuver itself accordingly.

Total Funding
$264 mln

Last Round
Apr 2019 Corporate Minority $50 mln

Country
United States

pony.ai

STARSKY ROBOTICS

Starsky Robotics creates autonomous driving technology for long haul trucks on open highways.

Total Funding
$20.25 mln

Last Round
Mar 2018 Series A $16.5 mln

Country
United States

starsky.io

pilot programme with the American Postal Service (USPS) to test the feasibility of using autonomous trucks to transport mail across state borders. The trucks made five round trips of 2,100 miles each between the USPS distribution centres in Phoenix and Dallas, with a driver on board to guarantee safety.

Fully autonomous vehicles

Over the years, the major car manufacturers have announced the launch of their own fully autonomous vehicles, providing projections often distant from reality, not achieving the target that they had set themselves. General Motors, Ford, Honda and Toyota, Renault-Nissan had expected to launch level 4 or even 5 vehicles by 2020: they all backed down, imagining that they would launch new vehicles and autonomous vehicle fleets no earlier than 2021. Even Elon Musk with Tesla initially announced the introduction of completely autonomous cars by 2017, only to put back the date to the end of 2020.
Outside the United States, the Chinese electric car company Nio is collaborating with the Israeli Mobileye - Tesla's historic partner until the tragic accident of 2016, later acquired by Intel - in the development of autonomous vehicles, in particular, for the Chinese market. Nio will also develop a version of self-driving electric vehicle that Mobileye will implement as a robo-taxi for the global market.

ZOOX

Zoox is a robotics company pioneering autonomous mobility. The company is developing a fully autonomous electric vehicle and the supporting ecosystem required to bring the technology to market at scale. Through cutting-edge research, engineering, and design efforts across hardware, software, and user experience, Zoox aims to provide the next generation of mobility-as-a-service in urban environments.

Total Funding
$990 mln

Last Round
Oct 2019 Convertible Note $200 mln

Country
United States

zoox.com

Zoox is one of the start-ups globally considered to be the most innovative, with its vehicle prototypes differing substantially from a traditional car: they do not have a steering wheel or a dashboard and the interior contains two seats positioned one in front of the other.

Its vehicles are not yet legally authorized to travel on public roads, as a result Zoox is provisionally testing its technology in collaboration with Toyota. The company expects to implement its autonomous vehicles in a robo-taxi service by 2020.

The cluster dedicated to full autonomous vehicles also includes new autonomous vehicles for special purposes, ranging from autonomous buses for passenger transport in restricted or geo-fenced areas (such as residential areas, university campuses, airports, industrial areas, etc.), to pods for last-mile deliveries, to street-cleaning vehicles and transport for people with reduced mobility.

Optimus Ride, for example, has developed a fully autonomous fleet of electric vehicles within restricted geographical areas, such as residential communities, airports and academic campuses. This approach allows Optimus Ride to exploit its product in collaboration with service operators within areas in which the circulation of autonomous vehicles is allowed, avoiding the regulatory complexity of distributing their vehicles on public roads. In August 2019, the start-up launched an experimental service for the 10,000 people who work inside the Brooklyn Navy Yard industrial park in New York. Optimus Ride uses 6 autonomous shuttles that transport workers free of charge along a route of about a mile, travelling at 15 km/h and with the assistance of two human operators.

OPTIMUS RIDE

Optimus Ride develops self-driving technologies to enable safe, sustainable, and equitable mobility solutions. It is designing a fully autonomous (level 4) system for electric vehicle fleets.

Total Funding
$74.83 mln

Last Round
Apr 2019 Series B
$50 mln

Country
United States

optimusride.com

In the field of special purpose vehicles, the Chinese Idriverplus, for its part, has created a purely electric unmanned vehicle for street cleaning, called Viggo. During the cleaning process, the vehicle can automatically trace the routes avoiding obstacles and monitoring information in real time. As of mid-2019, it had more than 100 units in operation at universities, factories, parks and city streets with deployments in Beijing, Tianjin, Shanghai and other Chinese provinces and cities. The company is also developing two different solutions for autonomous driving, in particular for the delivery of goods. It is a level 4 (SAE) vehicle and with ADAS technology for automatic parking and highway monitoring. During the test, Idriverplus driverless vehicles covered more than 400 thousand kilometres.

↳ "PIX Self driving Chassis"

An interesting case in the production of fully autonomous vehicles is PIX Moving, a Chinese-US start-up based in Silicon Valley, founded in March 2019, which offers a universal chassis for autonomous vehicles printed in 3D, in addition to the software for the automation and creation of customized L4 vehicles for new commercial applications. The company has more than 30 patents to its name and applies generative design to the creation of its innovative vehicles. Its goal is to create new models for sustainable mobility and for the smart city. One chassis application is in fact the creation of housing modules that can be moved and "mounted" on 4-wheeled vehicles, in support of new mobility models for the Smart City.

Another example of an autonomous shuttle is Olli (in 2019 in its 2.0 version), developed by US company Local Motors, and devised for university campuses, hospitals and military bases. Olli, which does not exceed 25 miles per hour, has a level 4 (SAE) autonomous driving system that harnesses IBM Watson and Amazon AI. It differs from the competition in the high degree of customization of the modules and the user interface - it is possible, for example, to integrate virtual and augmented reality applications, or to provide specific internal configurations, for example for transporting hospital patients. Local Motors produces its vehicles in 3D as part of partnerships with research laboratories and micro-factories in a co-designing arrangement, ensuring the development of new prototypes in a matter of weeks.

Perception

Companies that fall into this category are developing technologies to support real-time identification and "understanding" of the environment and context surrounding the vehicle.

In many cases the solutions include hardware and software to allow data gathering and analysis. This cluster includes, for example, companies that develop computer vision software for the processing of data acquired by on-board sensors such as cameras, LiDAR and radar, but also those that produce the hardware for data acquisition.

Navtech Radar, for example, offers radar technologies for self-driving vehicles and industrial automation. Navtech Radar's sensors provide high-resolution images in all weather, lighting and environmental conditions, overcoming some of the fundamental limitations of laser solutions and cameras. They are in fact designed to withstand vibrations, extreme temperatures and environments, ensuring reliability for use in mission-critical automation applications or situations where safety must be guaranteed, such as in the case of autonomous driving.

As concerns companies working on LiDAR technology, Velodyne LiDAR produces solutions for light detection and remote scanners for identifying objects. The company evolved after founder David Hall developed the HDL-64 solid-state hybrid LiDAR sensor in 2005. Since then, Velodyne LiDAR has become the principal developer, manufacturer and supplier of 3D real-time perception systems used in a variety of commercial applications, including autonomous vehicles, vehicle safety systems, 3D cartography, and is collaborating with many automakers and OEM's worldwide (Volvo, Ford, Mercedes-Benz, Baidu, SAIC, to name but a few), providing them with technological solutions for perception.

VELODYNE

Velodyne LiDAR supplies solid-state hybrid LiDAR sensor technology used in a variety of commercial applications including advanced automotive safety systems, autonomous driving, 3D mobile mapping, 3D aerial mapping and security.

Total Funding
$175 mln

Last Round
Oct 2019 Corporate Majority

Country
United States

velodynelidar.com

The Chinese market can boast RoboSense, founded in 2014 and which today has 200 employees for research and development activities alone, recognized in 2019 as the best perception solution worldwide at the AutoSens event, in particular, for its safety features. RoboSense's sensor fusion technology, in fact, integrates excellent qualities both in the hardware field, thanks to its proprietary LiDAR sensors, and in the software and perception algorithms. In addition to a research and development centre in the Nanshan district of Shenzhen, China, the company has research and development centres in Beijing and Silicon Valley and can boast cooperation agreements with major education and research centres around the world including MIT, HKUST, Tsinghua and HIT.

INNOVIZ TECHNOLOGIES

Innoviz Technologies manufactures high-performance, solid-state LiDAR sensors and perception software that enable the mass-production of autonomous vehicles. InnovizPro is a solid-state LiDAR that offers value for automotive and other application. InnovizOne is an automotive-grade LiDAR sensor that provides superior 3D sensing for Level 3-Level 5 autonomous driving.

Total Funding
$252 mln

Last Round
Jun 2019 Series C
$38 mln

Country
Israel

innoviz.tech

Among well-established companies, LeddarTech has also seen its skills and partnerships grow globally in recent years. The Canadian company, founded in 2007, develops solutions for light detection and ranging, based on LED lighting systems for object relief and distance measurement applications. LeddarTech products are used to improve traffic flows, for the development of automatic parking solutions, for the detection of blind spots, for assistance in lane changing and in assisting the driver in some dangerous situations.

Among the best perception solutions, recognized in 2019 by AutoSens, we must also mention InnovizOne of Innoviz Technologies, an Israeli company founded in 2016, which in a few years has established itself as a leader among producers of solid-state and high-performance LiDAR sensors for the automotive industry. The company currently offers the InnovizPro solution on the market, but is also working on the innovative InnovizOne solution, which is going to be tested during 2020 and launched on the market the following year: it is a LiDAR sensor designed for autonomous vehicles from level 3 to 5 (SAE).

Some innovative start-ups are also working on vertical aspects related to perception. Among these, DeepScale uses deep neural networks (DNN) to improve recognition skills. In fact, the company develops software to support the perception system of vehicles. The software is designed for integration into an open platform, where a wide range of sensors and processors can be used. In January 2019, the company launched a perception software product, Carver, which uses deep neural networks to perform object detection, the identification of lanes and areas within which it is possible to drive. For this purpose, Carver uses three neural networks operating in parallel. In October 2019, the Californian company was acquired by Tesla.

Lastly, in the field of computer vision, VisLab, a spin-off of the University of Parma acquired by the American Ambarella in 2015, has, since its foundation, focused on all aspects related to self-driving vehicles: machine learning algorithms, deep neural networks (DNN), stereovision and sensor fusion. Like Tesla, VisLab has decided to use only sensors and video cameras, without resorting to LiDAR technology, but rather using an additional “stereo” feature, capable of receiving two images and processing them simultaneously, so as to allow the three-dimensional measurement of distances, rather than merely an estimate thereof. VisLab was the first autonomous driving solutions producer to be authorized by the Ministry of Transport to carry out road tests in our country. Despite its acquisition by American giant Ambarella in 2015, VisLab has decided to keep its laboratories and skills in Italy.

HD mapping

Operators working on autonomous mobility use maps to support autonomous vehicles’ decision-making processes and answer the questions: “Where am I?”, “What is around me?” and “What is the next action I need to take?” In order to answer it is essential to refer to the so-called high-definition living maps, since these allow vehicles to know the appearance of the road and know what is present in each square centimetre examined.

CARMERA

Carmera provides real-time HD maps and navigation-critical data to autonomous vehicles, as well as 3D scene reconstruction and site analytics data for professionals in architecture, construction, real estate and other built environment segments.

Total Funding
$26.4 mln

Last Round
Aug 2018 Series B
$20 mln

Country
United States

carmera.com

Many ecosystem players are working to create truly innovative solutions, that is “living” maps that “regenerate” and continuously update to support autonomous driving and the planning of short and long-range journeys. Some of the main automotive companies that we have already seen within other clusters of the autonomous mobility ecosystem, such as TomTom, NVIDIA, Cruise, also develop and offer HD map solutions. These solutions are not only devised for autonomous driving, but they are used in a wide range of ADAS applications, such as Predictive Powertrain Control, Highway Pilot and Adaptive Cruise Control.

Among the start-ups working in this specific segment, CARMERA is one that provides an HD mapping and real-time navigation-critical data management suite for autonomous vehicles. It uses LiDAR sensors for real-time data collection and builds HD maps in crowdsourcing using a “data-as-a-service” model, thus based on data from its customers’ vehicles and from its partner companies’ goods delivery fleets.

The American DeepMap, founded in 2016, has instead developed software for the creation of maps that it plans to license out to car manufacturers and tech companies focused on autonomous driving. DeepMap offers real-time location services, up to a centimetre in accuracy, for various types of roads and traffic conditions.

Simulation

Some innovative companies are developing simulation software to help car manufacturers and component suppliers speed up the development of autonomous driving.

These companies offer data analysis, annotation and image grouping, but also advanced simulation tools for car manufacturers and OEM’s intending to train their systems. These must in fact provide an accuracy and reliability greater than 99.9%, therefore companies that provide accurate simulation data and annotations are crucial to the autonomous mobility ecosystem.

Among the big tech companies working in this field and collaborating with many car manufacturers, NVIDIA has developed a complete platform for photorealistic simulation, called NVIDIA DRIVE Constellation, which is a data centre solution integrating powerful GPU's and NVIDIA's data processing hardware system. The advanced visualization software simulates the inputs of video cameras, radar and LiDAR. This scalable system is capable of generating billions of kilometres of test scenarios for autonomous vehicles, to test hardware and software in real time before the distribution of a new vehicle.

The multinational MSC Software, a global leader in the supply of software and simulation services for multiple sectors ranging from construction to aerospace, from automotive to manufacturing, also operates in the field of simulation for autonomous driving. In particular, the Virtual Test Drive allows users to create, configure, and view complete virtual environments, in which vehicle models can be assessed and validated in all possible operating conditions.

Since simulation is not an essential skill for most automotive companies, in many cases start-ups are taking advantage of advanced software skills to develop platforms for the virtual reproduction of physical environments. Among the most interesting globally, we may mention the Israeli Cognata, which has developed a 3D simulation platform and which offers car manufacturers and OEM’s a variety of autonomous driving test scenarios. The platform virtually recreates existing cities and superimposes artificial-intelligence-based traffic models to simulate real-world conditions, as well as taking advantage of data from vehicle sensors. It has formed its own partnership with NVIDIA, to develop a series of traffic scenarios and models based on simulation, and with Audi to accelerate the development of the software for the German company’s driverless car.

COGNATA

Cognata provides an automotive simulation platform that combines artificial intelligence, deep learning, and computer vision to provide a realistic virtual environment that accurately simulates real-world test driving, allowing for realistic results.

Total Funding
$23.5 mln

Last Round
Oct 2018 Series B
$18.5 mln

Country
Israel

cognata.com

In Europe, the British start-up Immense Simulations creates interactive virtual replicas of cities using data from mobile telephone operators and public transport databases. The simulations show where and how pedestrians and vehicles move within an urban space. It also provides decision support tools for public decision makers and e-mobility providers. The company has formed partnerships with Ford, Jaguar Land Rover and Bosch to support them in developing autonomous vehicles.

Edge processing

As vehicles gradually progress in the scale of their autonomy, the processing requirements necessary for autonomous navigation increase significantly. As autonomous vehicles require a minimal latency, edge computing pro-

TERAKI

Teraki provides embedded, pre-processing software for sensor data in the automotive industry. When embedded in automotive electronic systems, the software enables hardware to process the vast amount of data generated by in-vehicle sensors and control units (ECUs, MCUs, TCUs) to improve vehicle safety and autonomy at lower operational costs.

Total Funding
$16.38 mln

Last Round
Dec 2019 Series A
$11 mln

Country
Germany

teraki.com

cessing capabilities are becoming increasingly important.
For example, Tesla cars have powerful on-board computers that allow the processing of almost real-time data collected by the vehicle's tens of peripheral sensors; this provides the vehicle with the opportunity to make timely and autonomous decisions.

The German Teraki has developed an embedded client for smart signal and insurance data processing and, in particular, crash detection, predictive maintenance and autonomous driving, using edge data extraction and processing thanks to machine learning algorithms and artificial intelligence models.

The Chinese Horizon Robotics, supported by Intel, offers a data processing platform based on artificial intelligence that integrates algorithms, design processors, software and hardware, with the aim of transforming each device into a smart entity and of providing solutions for high-performance cloud computing, parallel computing, computer vision, face recognition and voice recognition.

Partnership and acquisitions

The panorama of autonomous mobility is dotted with companies, established to a greater or lesser degree, working on specific and vertical aspects to enable vehicle autonomy. However, large car manufacturers, big tech companies and mobility service providers are also operating in this ecosystem, facing new challenges not only related to technology per se, but also to business models and the deployment of autonomous vehicles on a large scale.

According to several analysts, the efforts and investments in research and development activities that have been concentrated in the last decade are not sufficient to win this "race", because to develop the technology necessary to demonstrate autonomous driving in controlled areas and for a limited number of vehicles is not the same as to develop large-scale fleets, with sustainable business models and regulations applicable to a broad market. To carve out a central role in this context, many car manufacturers and tech companies are forming alliances with each other or with other companies, with the aim, on the one hand, to enhance their technological competencies, on the other, to "specialize" in particular market segments - for example, in autonomous shuttles for public transport, or in vehicles for urban circulation or in trucks for long-distance routes.

Firstmile, a venture capital fund specializing in the automotive sector, has analyzed the existing partnerships between the players in the automotive ecosystem, highlighting some interesting trends.

First of all, a new group of OEM's focused on software for the next generation of self-driving vehicles is to be observed. While historically the automotive sector has seen hardware component producers emerge in the race for innovation, today we can highlight how crucial software has become and how rapidly the number of automotive industry players with purely technological skills has grown. Given the time and money needed to develop, build and train autonomous vehicles, many automakers are increasingly relying on companies working on full-stack platforms, trying to collaborate with them rather than to compete.

Waymo, for example, has formed several partnerships with major automakers such as Renault-Nissan, Jaguar Land Rover and FCA. The agreement with Renault-Nissan, particularly, concerns all aspects relating to autonomous mobility services for the transport of people and the delivery of goods in France and Japan. The goal is to work jointly on the assessment of opportunities in target markets, but also on the commercial, legal and regulatory issues related to mobility services.

Aurora, a start-up that develops software for autonomous driving, has also entered into partnership agreements with Hyundai, Byton and FCA, after the failure of its partnership with Volkswagen, while Honda collaborates with GM Cruise for the development of a fully autonomous vehicle.

One of the most important partnerships that characterized 2019 is that between the German companies BMW and Daimler, on the one hand, for the establishment of a new player in shared mobility and multimodal transport (in this operation they invested more than a billion euros), on the other to jointly develop technologies for level 4 (SAE) systems by 2024. On the one hand, BMW can boast existing partnerships with some of the tech giants such as Microsoft, Tencent and IBM, on the other, the partnership between Daimler, Bosch and NVIDIA to develop level 4 and 5 autonomous driving, starting from the automated valet parking is worthy of note.

A few days after the agreement between BMW and Daimler, Ford and Volkswagen also formed an alliance to step up the pace together towards autonomous driving and electric mobility, forming a partnership with the startup Argo AI: thanks to the collaboration with Ford and the Volkswagen Group, Argo AI's autonomous driving system is the first to have commercial diffusion plans in Europe and the United States. Volkswagen and Ford will independently incorporate the Argo AI system into vehicles specially developed for the movement of goods and people, on the basis of their respective industrial plans.

Among the current trends in the autonomous mobility ecosystem, it is also now apparent that the size of technological challenges creates new alliances even between large car manufacturers and OEM's, on the one hand, and technology companies, on the other, while some tech giants have also started collaborations - take Microsoft, NVIDIA and IBM, for example.

There are also partnerships involving some providers of shared mobility and ride-hailing services, such as Uber and Lyft in the United States and Yandex.Taxi in Russia. In fact, these companies offer car manufacturers with which they collaborate access to a substantial user base, as well as a profound knowledge of the market and of the consumers themselves, also because it is imagined that at least in an initial phase, self-driving cars will be used above all for commercial robo-taxi services, rather than being sold to individual consumers.

Only a few companies choose to develop technology internally.

Tesla, for example, is avoiding partnerships, as it firmly believes that the in-house development of skills and technologies can provide a competitive advantage, while Apple, after having heavily scaled down its Project Titan for the development of its self-driving car, has instead focused on the acquisition of Drive.ai to make the most of the startup's skills and talents in developing an autonomous proprietary system.

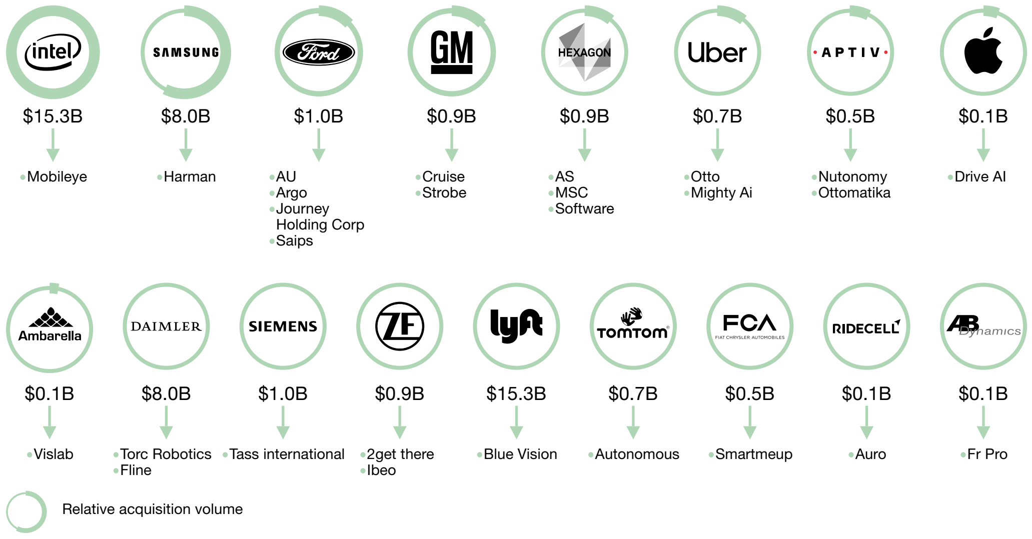
Finally, the emergence of new players in the United States and Asia is plain to see, while Europe seems to be losing ground. In 2018 Toyota set up a joint venture with Softbank, called MONET Technologies, which in mid-2019 joined (with smaller shares) Honda, Mazda, Suzuki, Subaru, Daihatsu and Isuzu Motors. The goal of the newly formed company is to launch an on-demand ride-hailing service for Japan starting in 2020.

The Chinese Baidu, a staunch supporter of the collaborative approach to the development of self-driving vehicles, also launched the Apollo project in 2017, an open source software platform designed to encourage cooperation in the automotive sector and to accelerate the development of autonomous vehicles. Under this project, Baidu has created a network of 130 partners, ranging from competing car manufacturers (such as Daimler, BMW or Volvo) to large OEM's, right up to tech companies specialized in HD mapping, perception, in route planning as well as in safety aspects.

In terms of acquisitions, in the last few years, car manufacturers, traditional OEM's, Big Tech companies and the main mobility service providers have invested in innovative start-ups or established companies that develop software, putting sometimes significant sums onto the table. From this point of view, Intel's acquisition of Mobileye in 2017 is considered by many as a turning point in the autonomous driving sector, as it has shown traditional automotive OEMs that the market was no longer based exclusively on physical components for vehicles, but rather that the developers of advanced autonomous driving systems find themselves at the centre of the competitive landscape.

Source: Firstmile

Notable Autonomous Driving Acquisition

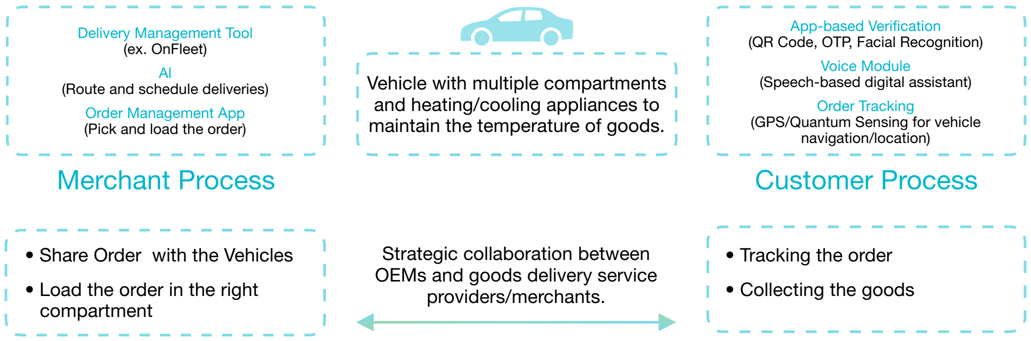


Autonomous commercial fleets

Considering the risks linked to passenger safety, many pilot projects and innovative companies have decided to focus their efforts on “autonomous delivery”, that is, the automation of vehicles for logistical uses and for so-called “last mile” deliveries. The latter, in fact, represents a challenge for e-commerce and for companies in all sectors: more and more operators are turning to autonomous solutions for “driverless” delivery.

According to KPMG, the distance covered by autonomous delivery vehicles will reach 78 billion miles per year by 2040, as e-commerce companies try to satisfy consumer expectations for same-day, if not even next hour, deliveries.

Moreover, the spread of new services and related business models for the construction and deployment, maintenance, cleaning and charging of autonomous land or air vehicles is expected, as are also the creation of loading / unloading areas for autonomous deliveries and small depots to house robotic vehicles. The use of autonomous vehicles for e-commerce and logistics requires efficient processes both on the part of the merchant / distributor and on the part of the customer / consumer.



Source: Frost & Sullivan

Some recent collaborations between car manufacturers and OEM's, on the one hand, and retail giants on the other, have involved, for example, Ford and Domino's Pizza, Toyota and Pizza Hut, Waymo and Walmart. Renault, too, in 2018 presented a new concept of electric and autonomous modular vehicle, called EZ-PRO, which uses robotic pods in a convoy, led by a leader pod with a human driver, able to support the handling of goods and the delivery of fragile items. In addition to reducing the cost of deliveries and allowing users to collect the goods ordered directly from the pods, this "platoon" solution is also designed to reduce congestion in urban areas.

Among the start-ups working in this area, Nuro has presented autonomous vehicles for local commerce. Nuro vehicles are small, efficient and can be loaded by end users or merchants with groceries, packages, gifts or other goods for short distance carriage. In 2019 Nuro formed a partnership with Domino’s Pizza and another with Kroger. In addition to having applied for a patent for smaller robots that can climb steps and cross lawns in the final stage of delivery, the company is integrating V2X technology into its vehicles to enable wireless communication with other connected devices and with other surrounding vehicles.

The Udelv start-up, founded in San Francisco in 2016, has also launched its own version of an autonomous delivery van called Newton, which uses Baidu’s Apollo

NURO

Nuro is developing autonomous vehicles for local commerce. They are designing a vehicle with a focus on last-mile delivery of goods. Nuro’s vehicles aim to be small, efficient, and can be packed for users or merchants to load with groceries, packages, gifts, or other goods for transport over short distances.

Total Funding
$1.032 Bln

Last Round
Feb 2019 Series B
$940 mln

Country
United States

nuro.ai

3.5 platform for self-driving vehicles. Unlike Nuro, which produces its own delivery vehicles, Udelv equips traditional vans by providing full-stack software for driverless vehicles. In the United States the start-up has formed partnerships with, amongst others, Walmart, Farmstead and HEB. As of the end of 2019 Udelv's autonomous fleet is capable of serving the areas of San Francisco Bay, Houston and Phoenix.

Lastly, some car manufacturers presented autonomous vehicle prototypes that appear more like robots than traditional vehicles. In 2019 Continental presented its delivery "dog", a four-legged robot capable of climbing stairs and climbing over objects to deliver parcels.

Autonomous shuttles and buses for public transport

Considering the uncertainty about the future of private mobility and of the traditional car, some car manufacturers are investing in "multi-purpose" self-driving vehicle prototypes, in some cases for the delivery of goods, as we have seen, in others for the collective mobility of passengers in the sphere of public transport and of "on request" ride-hailing services.

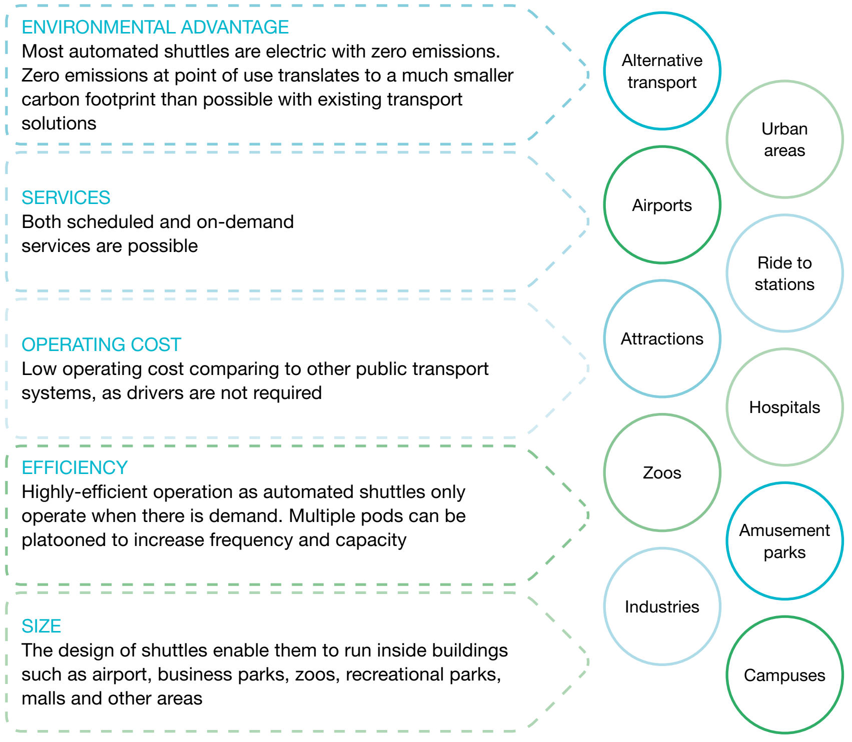
> "Autonomous shuttles" are compact vehicles designed to for facilitate daily journeys to public places and to eliminate the problems of connectivity encountered by commuters during the "first" and "last mile" of transit.

Fleets of self-driving vehicles are destined to revolutionize collective mobility in urban and suburban areas. By depriving the vehicles of a driver, "on-demand" transport and shared mobility services are bound to become cheaper for consumers.

Self-driving buses are also expected to be see widespread use to transport passengers over long distances. Autonomous shuttles or driverless buses can, in fact, serve even the most remote locations, now ignored by public transport, allowing people to move to peripheral areas without forgoing the conveniences of city life. Either way, whether they are used for short distances or for long ones, they can include fixed routes and stops or provide "dynamic" routes and stops based on the requests of the passengers themselves.

Potential Application Areas of Autonomous Shuttles

Source: Frost & Sullivan



Among the car manufacturers working on the development of "multi-purpose" solutions, in 2018 Toyota presented its e-Palettes, defined as battery-powered electric vehicles with low-speed automated level 4 (SAE) systems (up to 20 km/h), developed specifically for "Autonomous Mobility as a Service" applications for car sharing or for transport services within accommodation facilities, hospitals, commercial and industrial areas. In 2020, on the occasion of the Tokyo Olympics, Toyota will provide up to 20 shuttles in a version with an ad hoc design for the autonomous transport of Olympic and Paralympic athletes, aimed at facilitating movement within the Olympic villages even for people. with reduced mobility.

↳ "Toyota e-Palette "Tokyo 2020 Version" Autonomous Vehicle"

Among the companies operating in the autonomous mobility ecosystem, particularly in the autonomous shuttles for public transport segment, one of the main global manufacturers is Navya, a French company founded in 2015 that is already building and selling Level 4 shuttles in Europe and the United States. Navya's cabins are fully electric and can reach a top speed of 25 km/h.

Navya's autonomous shuttles are capable of carrying 15 passengers and are already in experimental use in many cities in 25 different countries around the world. In May 2019, for example, a new line was opened in Oslo that uses Navya's Arma shuttles: although the service is completely autonomous, in the pilot phase it provides for the presence of a human operator on board to assist passengers and to ensure driver intervention in case of need. Since November 2019, thanks to EU funding under the Interreg "Mentor" project, which seeks to develop and promote mobility not linked to the use of private vehicles in the Alpine range, Merano is also home to the testing of Navya autonomous electric shuttles.

EasyMile, for its part, launched, in 2015, the first model of EZ10 capable of transporting up to 15 passengers, initially tested in a commercial area in California and in a park in Singapore. Between the launch and 2019, the company states that it has already produced 230 driverless vehicles, which have carried over 380 thousand passengers over 600 thousand km. In 2019 EasyMile launched a new upgraded version of the shuttle, more comfortable and safer for passengers, and by 2020 it anticipates that it will also implement its own fleet and test the vehicles in areas of mixed traffic, that is to say not only in geofenced areas.

EasyMile also equipped some vehicles with an automated ramp, to allow disabled passengers to get on board without further aid, and installed wheelchair anchor points, conforming with the American with Disabilities Act. As part of the BusBot pilot project, in Coffs Harbor, Australia, Easymile has been making its autonomous vehicles available to the community of elderly people; these vehicles can be booked through the app, can carry multiple passengers at a time and do not provide for predetermined routes and stops. In fact, EasyMile uses artificial intelligence to determine the most efficient route based on picking-up and dropping-off requests in real time. The goal of the BusBot project is to assess the benefits of autonomous transport, as well as to contribute to an improvement in the quality of life and mobility of the area's elderly population.

NAVYA

NAVYA is a French company specializing in developing smart and sustainable solutions. NAVYA develops driverless, automated electric vehicles that are independent of all infrastructure. The vehicle is equipped with a multitude of sensors and an embedded system that enables it to interact with its surroundings.

Total Funding
$37.78 mln

Last Round
Jul 2018 IPO
$44.02 mln

Country
France

navya.tech/en

From this very varied panorama of applications, there emerges an indication of how decisive a role modular design will play in the future of mobility.

Among the car manufacturers that are working on the design of new concept cars designed for the transport of people or, with a change in configuration, for the delivery of goods, we can, for example, cite the Mercedes Vision URBANETIC, which as a ride-sharing vehicle can accommodate up to twelve passengers, while in cargo mode it can carry up to ten pallets of goods. The modules can be switched automatically or manually in a matter of minutes. The concept car analyzes in real time the demand for, and supply of transport in a specific area, with routes planned flexibly and efficiently on the basis of real transport needs.

Italy too is in the forefront in the competition for autonomous and modular mobility, thanks to the idea of a startup from Padua: NEXT Future Transportation, today in Silicon Valley, is, in fact, developing a revolutionary smart transport system, based on modular electric self-driving vehicles. The project involves the construction of four-wheeled pods, designed for on-demand collective transport, which couple together and uncouple during the journey, by using an automated docking mechanism called docking in motion, according to passenger requests and destinations. Once docked, the modules in the chain form, to all intents and purposes, a single vehicle, very similar to a bus or a tram. NEXT is also applying the same mechanism to the delivery of goods. This public transport solution received great plaudits both at an Italian level and internationally back in 2018: two NEXT modules prototype were "adopted" by the City Council of Padua, with the aim

↳ "EasyMile EZ10 Shared Autonomous Shuttle, the most deployed driverless shuttle in the world" of testing them on the road. After raising capital in San Francisco in 2016, the Padua start-up is also working on a pilot project in Dubai for the introduction of innovative solutions for urban public transport.

As for public transport over long distances and connections between cities, many bus manufacturers have been testing autonomous bus fleets, with the aim of launching the first standard-sized bus models by 2021-2022, despite the fact that a regulatory framework has not yet been defined.

Volvo Buses was one of the first manufacturers to work on an electric and driverless concept bus: the autonomous bus, equipped with sensors and navigation controls managed by a complete system of artificial intelligence, was presented in Singapore in March 2019, a result of the co-operation between Volvo and the Nanyang Technological University (NTU). Another demonstration was organized in November 2019 in a depot on the outskirts of Göteborg, in Sweden: the vehicle successfully manoeuvred between the car park and various work stations, including the car wash, maintenance and electric charging, before parking in the correct position, all performed with passengers on board but with no human intervention.

In the Italian context, at the end of June 2019 Iveco Bus signed a partnership with the aforementioned EasyMile. While Iveco Bus is equipping its prototype with electronic components and sensors for self-driving vehicles, for the pilot project EasyMile is making available its own technology and experience in the integration of platforms, and implementation and management of a fleet of autonomous vehicles.

Focus – Torino City Lab

According to statements made in 2019, the city of Turin is an Italian candidate to become a pioneer in the experimentation of innovative solutions for mobility. In the ambit of the Torino City Lab initiative, the Piedmontese capital is, in fact, together with Parma, a testing ground for companies and research teams wishing to test the autonomous driving performance of private and public transport vehicles in real conditions and in urban traffic.

Turin displays all the technical requirements indicated in the "Smart Road" decree for the experimentation of solutions for autonomous mobility, such as the presence of fibre optics and traffic detection systems, infrastructures equipped with sensors at intersections and traffic lights, coils under the asphalt that ensure the detection of the passing of cars, thus disposing of a real-time picture of the traffic.

↳ "Torino Smart Road"

Thanks to its own technological infrastructures, in March 2019, during the Turin Smart Road project, the city obtained positive feedback from the Ministry of Infrastructure and Transport for the experimentation of autonomous vehicles on public roads. With the collaboration of partner companies and city institutions, an authorized urban circuit of 35 kilometres in length on which to perform the testing of technologies and connected and autonomous vehicles has been created. Since the autumn of 2019, the Piedmontese capital has launched further pilot projects for the testing of autonomous shuttles and autonomous vans on public roads.

Furthermore, DORALab, an area for the testing of drones for services of public interest, has been created, with the aim of incentivizing the experimentation of services enabled by remotely-piloted aircraft and the development of the aerospace sector.

Autonomous mobility: opportunities and challenges

According to Frost & Sullivan, autonomous mobility raises questions about the impact that this will have on fundamental questions such as road safety, privacy, polluting emissions, the optimization of traffic flows and urban spaces. It also introduces matters regarding the social acceptability of innovation.

Why do we need Fully Autonomous Vehicles?
How will it impact our Daily Travel Experience?

90% — INCREASED SAFETY
In the long term, self-driving vehicles will be capable of analyzing the surroundings and predicting future events. Increased awareness of surroundings will reduce accidents due to driver distractions by 90% in the long term

60% — REDUCED FUEL EMISSION
Fully autonomous vehicles are programmed and capable of identifying road blocks and traffic jams. For the fuel-efficient automotive industry, self-driven vehicles can reduce fuels emissions by 60%

27% — REDUCED TRAVEL TIME
According to Frost & Sullivan research, self-driving vehicles can reduce the travel time by 27% through advanced alerts. It can help commuters to have increased productivity time of up to one hour for commuters

15% — PARKING SPACE OPTIMIZATION
Parking vehicles in confined spaces is a major cause of discomfort for vehicle owner in metropolitan cities. Autonomous vehicles are programmed to park themselves accurately and can save up to 15% of parking space

Source: Frost & Sullivan

In general, analysts are putting forward their projections, relating, yes, to level 4 autonomy, but above all to level 5. There are many factors - not only related to technology, which, in fact, is faster than the market and governments - that are decisive in speeding up or slowing down certain innovations: safety, liability, vehicle cost, regulatory aspects, consumer acceptance.

	Benefits	Costs/Problems
Internal (user Impacts)	• Reduced drivers' stress and increased productivity. Motorists can rest, play and work while travelling. • Mobility for non-drivers. More independent mobility for non-drivers can reduce motorists' chauffeuring burdens and transit subsidy needs. • Reduced paid driver costs. Reduces costs for taxis services and commercial transport drivers.	• Increased vehicle costs. Requires additional vehicle equipment, services and fees. • Additional user risks. Additional crashes caused by system failures, platooning, higher traffic speeds, additional risk-taking, and increased total vehicle travel. • Reduced security and privacy. May be vulnerable to information abuse (hacking), and features such as location tracking and data sharing may reduce privacy.
External (Impacts on others)	• Increased safety. May reduce crash risks and insurance costs. May reduce high-risk driving. • Increased road capacity and reduced costs. More efficient vehicle traffic may reduce congestion and roadway costs. • Reduced parking costs. Reduces demand for parking at destinations. • Reduced energy consumption and pollution. May increase fuel efficiency and reduce emissions. • Supports vehicle sharing. Could facilitate carsharing and ridesharing, reducing total vehicle ownership and travel, and associated costs.	• Additional risks. May increase risks to other road users and may be used for criminal activities. • Increased traffic problems. Increased vehicle travel may increase congestion, pollution and sprawl-related costs. • Social equity concerns. May reduce affordable mobility options including walking, bicycling and transit services. • Reduced employment. Jobs for drivers may decline. Increased infrastructure costs. • May require higher roadway design and maintenance standards. • Reduced support for other solutions. Optimistic predictions of autonomous driving may discourage other transport improvements and management strategies.

Source: Victoria Transport Policy Institute

Consumer acceptance

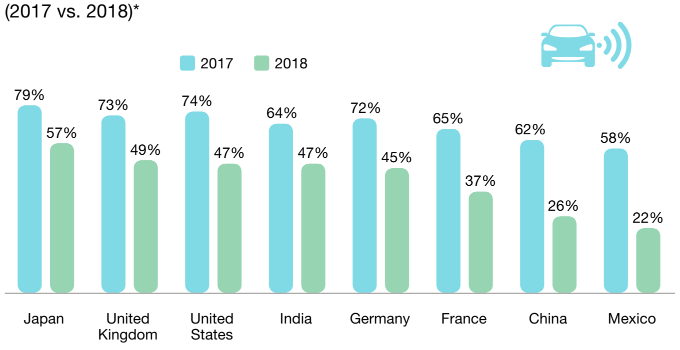
Despite the optimism of many industrial players, consumer acceptance remains an open question, influenced by the efforts and costs required to change driving habits, learning, concerns regarding safety and the price of a technology that still remains too high.

Many customers still appreciate traditional driving and do not wish to yield any control over the vehicle per se. An Accenture survey published by Statista based on data from 2017 shows that approximately 61% of young people between the ages of 18 and 34 are eager to use autonomous vehicles, a percentage that drops to 37% for the over-55's. In fact, the cultural driving model varies not only with the different generations, but also from region to region, as demonstrated by the dominance of automatic transmissions in the United States, as opposed to Europe where motorists still prefer manual driving today.

According to a survey carried out by Deloitte and published by Statista, in 2018 the percentage of consumers who believed that the fully autonomous car (L4 and L5) was not safe fell compared to the previous year. According to Capgemini, by 2029 driverless vehicles will be the preferred mode of transport for the majority of users.

People are warming up to self driving cars

Percentage of consumers who think fully self-driving vehicles will not be safe (2017 vs. 2018)*



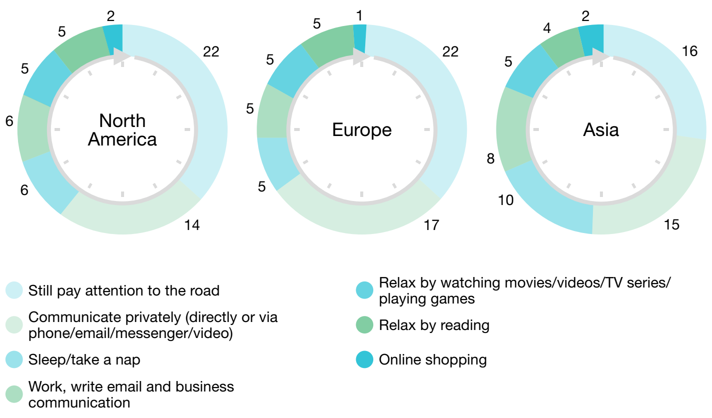
Source: Statista

*22,000 consumers in 17 countries were surveyed on issues relating to the automotive industry.

According to a 2019 Capgemini survey, drivers under the age of 36 would be prepared to pay a premium of 15% for the purchase of a driverless car. Considering all age ranges, on average, consumers would be prepared to spend 11.5% above and beyond their current budget for the purchase of a self-driving vehicle, while roughly a quarter of interviewees declared that they would refuse to pay a higher price.

Autonomous cars: how would you spend your time?

What would you do with your driving time if you didn't have to actively drive? (in minutes)*



*Time spent on activities/actions over a sixty minute period.
n=130,000 car owners in nine countries. Conducted April/May 2017.

Source: Statista

Road safety and cybersecurity

In the area of autonomous mobility, important challenges related to user privacy, road safety and the reliability of autonomous driving software are emerging, as cars will be increasingly connected to traffic management centres and large-scale internet. For companies in the automotive sector and tech companies to continue investing in autonomous mobility and for self-driving vehicles to spread among consumers, clear legislation and a legal framework capable of supporting vehicle safety and data protection are prerequisites. If in this initial phase, consumers are owners of their data - relating in particular to their movements, the payment of mobility services, etc. - access and exploitation of the same remain, for the time being, unregulated.

↳ "Driverless Cars: A New Challenge to Cybersecurity"

On the road safety front, as we have had the opportunity to examine in the chapter dedicated to connected mobility, there are numerous critical points on board a connected and autonomous vehicle: autonomous driving brings with it not only personal risks due to cyber attacks, but also risks for things and third parties. Think, for example, of a cyber attack capable of suddenly and dangerously causing the car to turn while driving.

As described in the analysis conducted by the Victoria Transport Policy Institute (2019), the technologies associated with self-driving vehicles can introduce new types of risks.

By “disengagement” is meant the disabling of autonomous mode when a failure in the autonomous technology is detected or when the safe functioning of the vehicle requires the test driver to disable autonomous mode and take immediate manual control of the vehicle itself.

The data relating to disengagement from eight companies that tested autonomous vehicles in 2017 made it possible to identify some of the most common problems: entry into traffic even with insufficient space, braking not sufficient to stop the vehicle, difficulty in identifying vehicles approaching from oncoming lanes, problems keeping the GPS signal stable, software crash, failure to recognize roadwork warning cones, uncertainty in the face of unexpected behaviour from other drivers. These and other hardware and software issues, if not properly managed, introduce new road safety risks and can potentially cause accidents, generating a net impact on road safety lower than the 90% reductions declared by the staunchest supporters of autonomous mobility.

Liability and ethics

Despite governments’ efforts to regulate and harmonize standards, there are concerns not only in terms of the safety of autonomous cars, but also in terms of actual liability in the event of an accident.

Indeed, the issue that causes argument is that of civil and criminal liability in the event of an accident. Who is liable? The driver, the vehicle manufacturer, the software provider, the network infrastructure operator or the road infrastructure operator? To date there is no unambiguous position and situations are evaluated on an individual basis. In the case of an accident involving an Uber autonomous vehicle, for example, the company was exonerated because it was ascertained that the victim would have been run over even if the car was not a self-driving one since the person crossed in a completely dark area with no pedestrian crossing stripes.

However, it must be borne in mind that artificial intelligence algorithms based on machine learning, therefore on self-learning, could misinterpret a road situation, thus causing an accident. In such a case, who is responsible for the accident? In fact, it may not be attributable to the software manufacturer: a specific algorithmic evolution may not be foreseen when writing the computer code, but consequent to the inferences of the software itself.

What is certain is that each country is following its own path in legislative terms, even if there do seem to be two main approaches: the first is the European one where liability generally falls onto the driver or owner of the vehicle, the other is the American one in which responsibility is directly attributed to the manufacturer.

In Europe, only three countries have so far adopted legislation on the matter: Germany, Italy and Great Britain. But there are also several countries in which the experimentation of self-driving vehicles has been activated, this however takes place under a waiver.

In Italy, under the Smart Road decree, thus in the testing phase, liability always falls on the driver.

The adoption of a clear and shared ethical code will be crucial. In this relation, Boston's MIT has developed a “Moral Machine”, an on-line platform that allows anybody who so wishes to describe how they would like a car's “electronic brain” to be programmed and how it should behave in extreme driving situations.

While Jeffrey Miller, associate professor of engineering at the University of Southern California, asserts that “the true moral question to which the manufacturers must respond when they are programming self-driving cars is not about who lives and who dies”. There are before that other problems such as, for example, “whether it is opportune to break the law in order to maintain safety”, whether to drive at a speed appropriate for the traffic even in the event of emergency or to run a red traffic light. Situations that often happen to flesh and blood motorists.

In Europe the first country to adopt an ethical code was Germany, which, in 2017, decided to establish twenty ethical principles to mark the boundaries beyond which programmers must never venture when writing the software for the cars and robots of the future.

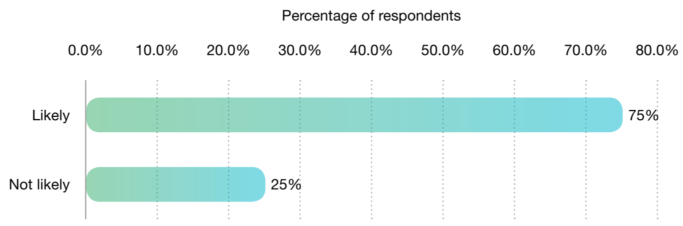
Accessibility and inclusion

While the overall benefits for society are difficult to estimate, the transformational potential of autonomous vehicles for some specific categories of users can also be understood in terms of the communities that these technologies might support. Automated and, in future, autonomous vehicles may in fact offer new mobility opportunities to millions of people.

A Ruderman Family Foundation study suggests that, in America alone, automated vehicles could create new job opportunities for approximately 2 million disabled people.

Not only will disabled people be able to gain independence, but all disadvantaged groups such as, for example, the elderly or people in difficult conditions or those who live in rural areas will be able to benefit from the advent of autonomous mobility. Thanks to autonomous shuttles it will be possible, for example, to provide efficient public transport services and, looking forwards, also low costs for users. At level 5 autonomy, which means that a car's computer will handle any driving situation, even a mental disability may not be an obstacle to the use of a private vehicle on a public road. The benefits for physical disabilities are clearer and more delineated, with even autonomy levels below 5 potentially allowing anyone to "drive".

Percentual of U.S. adults who expect that driverless vehicles would help the elderly and disabled to be more independent, as of may 2017



Source: Statista

Focus – Autonomous mobility and possible developments

When autonomous mobility reaches maturity, it will have a significant influence not only on daily activities and on user habits, but also on the traditional business models and on the services offered by different contiguous sectors.

The list that follows contains a series of questions to be pondered for scenarios that may, in some cases, be disruptive.

- **Insurance**: If, on the one hand, autonomous mobility should guarantee greater safety on the road, on the other, it might reduce the number of cars sold (due to new models of sharing) with a resultant reduction in the number of policies. For this reason, many companies are looking to new models of insurance, linked to the real usage time of the vehicle, to the distances covered and to driving behaviours.
- **Maintenance and spare parts**: As cars become safer, more electric and connected, the whole spare parts and maintenance sector will undergo a significant transformation. Given the great dependency of vehicles on software components, the latter will enable "predictive maintenance", thus obviating the need for more costly interventions and guaranteeing greater transparency.
- **Truck and taxi drivers**: Driverless vehicles and the diffusion of new models of shared mobility could reduce the demand for "driving professionals", since many logistics firms might orient themselves towards the management of autonomous

fleets in an “as-a-service” approach. Human beings will definitely still be necessary to manage these systems, but the sector is destined to change, with a smaller number of professional drivers, at the same time, much more specialized and with the IT skills required to handle emergencies.

- **Airlines**: If the cost of journeys by self-driving car should drop, many people might choose to make long and longish journeys by car, instead of having to face the numerous problems that air transport often entails. Entertainment services enabled by on-board connectivity may make the car journey more pleasant, while level 5 self-driving vehicles will make possible long journeys with a user experience similar to that of the train or of the aeroplane.
- **Ride-hailing**: The principal mobility service providers, such as Uber and Lyft, are investing resources and money in the development of autonomous vehicles to be employed within ride-hailing services, where savings due to the reduced number of drivers necessary, will make it possible for the providers themselves to assume vehicle and fleet management costs, today borne by the drivers themselves. Compared to many other players, these providers already have at their disposal a vast database (maps, navigation, most-requested journeys) onto which to draw and which to use in the interests of data monetization.
- **Car parks, garages and real estate**: The need for long-stay car parks may be considerably reduced, since the fleets of driverless cars will move around continuously in line with user requests. In the USA alone, according to McKinsey, thanks to self-driving cars 61 billion square metres of space dedicated to parking could be “saved”, and thus allocated for other purposes. In general, the whole real estate sector could change with the advent of self-driving vehicles, subject to a large-scale review of the allocation of urban space.
- **Media and entertainment**: If it is true that the average American drives for 46 minutes each day and, thanks to autonomous mobility, they could have more time to devote to news and entertainment, which could have significant effects on the media and advertising industries.
- **Shops and retail**: The diffusion of autonomous vehicles for deliveries of goods will mean that the location of shops will be less and less important. Deliveries could be made regardless of distance, with autonomous vehicles dealing with the goods bought remotely or previously ordered.
- **Healthcare**: It is estimated that the advent of autonomous mobility may have an impact on the health service equivalent to $500 billion per annum, in the United States alone. Besides reducing the number of accidents, autonomous fleets could also function as diagnostic control points allowing passengers to receive simple healthcare services, such as the checking of blood pressure or heart rate.

Glossary Autonomous mobility

Term	Acronym	Definition
Autonomous shuttle		Autonomous driverless shuttles that handle public transport services in specific urban areas.
Connected and Autonomous Vehicle	CAV	Connected and autonomous vehicles.
Crowdsourcing		Requests for ideas, suggestions, opinions, addressed to Internet users by a company or by an individual for the realization of a project or for the solution to a problem.
Frequency-Modulated Continuous-Wave	FMCW	FMCW is a special type of radar sensor that irradiates continuous transmission power as a simple continuous-wave radar (CW-Radar).
Full-stack		In IT, a stack of solutions or a software stack is a set of subsystems or software components necessary to create a complete platform in such a way that additional software supporting the applications is not necessary.
Invisible-to-Visible	I2V	A system based on Virtual Reality integrating V2X with the vehicle's on-board sensors to permit vision not allowed by the human eye.
Light Detection and Ranging	LiDAR	Remote sensing technique that makes it possible to determine the distance of an object or surface using a laser pulse; the distance is then calculated by using the speed of light.
Radio Detection And Ranging	Radar	A system that uses electromagnetic waves belonging to the spectrum of radio waves or microwaves for the detection and determination of the position and, if required, the speeds of objects whether fixed or mobile, such as aeroplanes, ships, vehicles, cloud formations or the ground.
Robo-taxi		A self-driving taxi or driverless taxi is an autonomous car (typically of level 4 or 5 SAE) that operates for on-demand ride-hailing services.
Self-driving car / Autonomous vehicle / Driverless car	AV	By this term is generically meant a vehicle equipped with systems of automation of any degree and type, that permit “automatic” actions without human intervention.
Advanced driver assistance systems	ADAS	Various types of electronic systems that aid the motorist while driving or parking.
Society of Automotive Engineers	SAE	Standards developing organization in the aerospace, automotive and commercial vehicle sectors, with headquarters in the United States.

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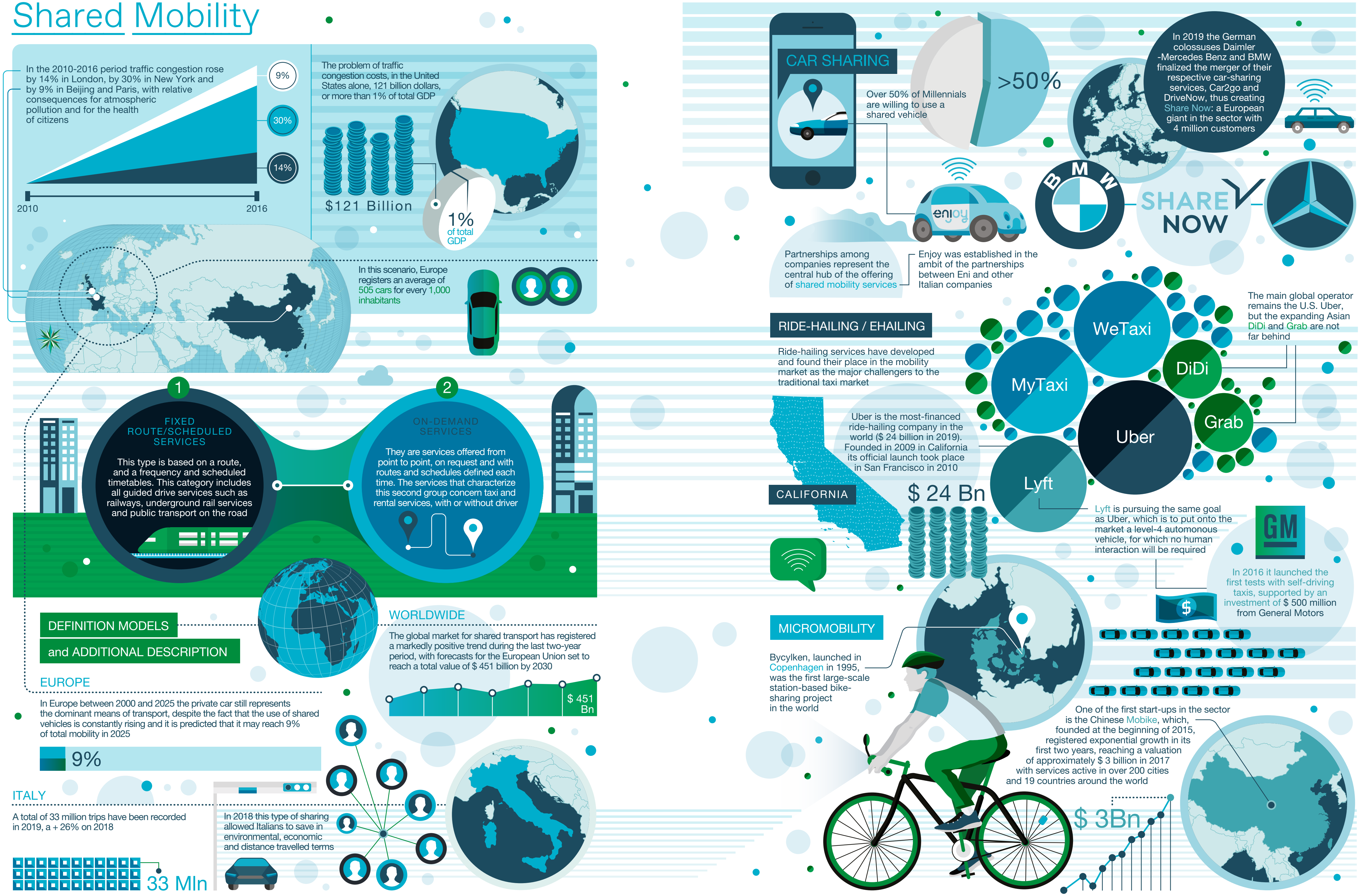
Shared mobility

5

Shared Mobility



Introduction

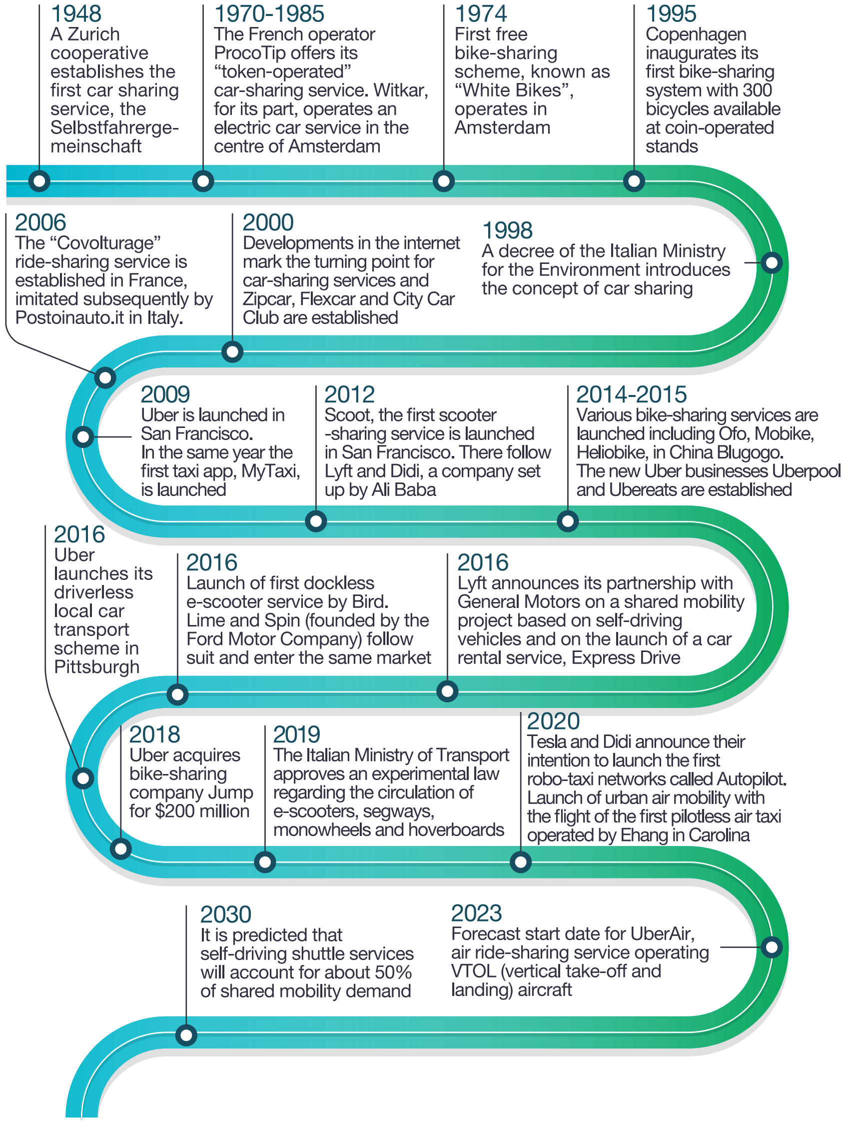
Sharing instead of owning or using instead of owning are concepts commonly used in modern society, regarding a new model of *sharing economy*.

Through solutions enabled by modern ICT technologies, it is today possible to put forward new economic models that leave behind the classic paradigm of the consumer society focused on the individual and based on private ownership of goods.

The various versions of the sharing economy model are today applicable to multiple sectors of both the economy and society; among these, the field of mobility has taken on a predominant role with a phenomenon commonly known by its English nomenclature: "car sharing" or "ride-sharing".

In Italy the concept of "shared mobility" was introduced in the Ministry of the Environment's Decree of 27 March 1990, when the terms "*services for optimal collective use of motor cars*" and "*forms of shared ownership of cars intended to be used by multiple persons*" first appeared.

Since the turn of the century the attention of the state, and of its citizens, towards new forms of more efficient and environmentally-sustainable mobility has been growing constantly. Public intervention supports and finances various forms of shared mobility such as car sharing, car pooling and bike sharing in order to discourage the use of private vehicles.



Among consumers demand for rapid, multimodal and environmentally-sustainable travel continues to grow. Generational change and the advent of the Millennials have had a fundamental impact on the market, altering the individual's relationship with the car and, in general, with private forms of transport and opening up new forms of mobility.

Technological evolution and innovative digital platforms have, for their part, made possible the development of management procedures for rapid and immediate services as well as forms of communication and collaboration between individuals and operators, through interactive tools such as apps for gathering feedback or online chatbots. In this context consumers take on the part of the "Prosumer", a term used to indicate the leading role played by users, active in the evaluation and the designing of the service, conscious thereof and influential therein.

The consumer's active role facilitates, moreover, the formation of relations of collaboration and trust between individuals through the creation of communities and interactive tools. Digital reputation and trust building systems represent platforms' distinguishing features and reputation enhancers, in addition to promoting ties of loyalty and to allowing elements of sociality to be integrated into tools and thus create reputation-based profiles of users and foster trust among them.

Among other basic principles of recent models of shared mobility mention must also be made of "availability according to need" (that is to say that there are no limits of any type to the use of the service, neither in terms of time, nor concerning the journey to be undertaken or the number of passengers, but rather user needs are met in full), flexibility of use and scalability.

Indeed, there are various types and sizes of shared vehicles according to the purpose of the journey, from small electric economy cars for travel around the city to station-wagons for family trips, from commercial vehicles for transporting goods to motor scooters and e-scooters. No time limits are contemplated for the use of vehicles and the charges can be adapted simply to the various tiers of users according to the customization of the service.

While in 2020 shared mobility already constitutes an established reality, it still represents a niche market.

In global terms the use of private vehicles is still the basic transport choice of citizens, but the trend-bucking approach of the new generations is a reason for optimism. The digital natives, the main targets of these services show themselves to actually be increasingly interested in the concept of "access" to, rather than in the "possession" of vehicles.

In parallel with the cultural change underway, there has been a progressive diffusion of those electric shared vehicles that have registered decidedly positive trends over the last few years. These, however, are still a niche phenomenon and require further decisive institutional intervention.

With the modern smart digital platforms and the birth of numerous private operators, the market landscape has changed radically and, as a result, not only have new regulations been made necessary, but also a new model of organization for the sector.

The new models of mobility represent an important opportunity for industrial development and growth for operators. An analysis of the value chain clearly shows how multiple players have developed new activities the length of the supply chain despite the fact that traditional core-businesses were focused on different sectors. The insurance world and the process of diversification of the services offered, the sectors of Financing & Payment, Telco & Media, Energy and Technology are examples of such.

There remain, nonetheless, important gaps to bridge and issues still to be tackled, such as the environmental sustainability and economic viability of these very services.

In the first case, the role of shared mobility is still under discussion: if, on the one hand, it is one of the strengths of the business in that it is crucial for the reduction of the number vehicles in circulation, on the other, there are still no solid data on improvements to the environment and to urban traffic.

The same scepticism is also raised by the economic aspect of these services since both in Italy and abroad, various players have been operating at a loss and it is not yet clear what a model for sustainable business might look like.

Ultimately, there is a strongly-felt need to devise development plans for these businesses that are as efficient as possible and, above all, that are integrated into broader urban planning. It is, in fact, fundamental for public administrations to incentivize consumers to make priority use of local and sustainable public transport.

Although they still represent a niche market, the rapid spread of new models of shared transport leads us to believe that in the near future shared mobility will radically change both the travel habits of individuals and the urban structure of *smart cities*.

The models of shared mobility

Every shared mobility service has its own unique characteristics and differing effects on user behaviour, on journeys, on the environment and on urban development: greater accessibility of transport, a reduction in driving time and in vehicle ownership. Shared mobility services can be used by several users according to two time frames:

- simultaneously, when, for instance, journeys are made using a public means of transport (underground, bus) or the user is part of a crew established by a private user for journeys with an irregular frequency (such as the case of BlaBlaCar).
- in succession, as occurs when a car sharing service is used.

Compared to traditional public transport scheduled services, shared mobility services are "tailor-made" and marked by high flexibility of use.

Alongside the "classic" sharing tools, other potential solutions still mot much explored in Italy are emerging.

Frequency: fixed route/ scheduled and on-demand services

A first macro-distinction of the services offered, provided by the National Observatory on Shared Mobility, allows us to draw up 2 main groups:

- **fixed route/scheduled services**: this type is based on a route, and a frequency and scheduled

timetables. This category includes all guided drive services such as railways, underground rail services and public transport on the road.
- **On-demand services:** these are not subject to the aforementioned conditions. They are services offered from point to point, on request and with routes and schedules defined each time. The services that characterize this second group concern taxi and rental services, with or without driver.

On-demand services are able to offer levels of accessibility, availability, versatility and continuity comparable with the use of a privately-owned vehicle and can satisfy a demand that arises episodically, discontinuously and in ways that are difficult to predict.

On-demand services as a whole can be subdivided further into traditional services, taking into consideration local public transport, and services that represent the core of modern shared mobility. These, in turn, are divided into "vehicle-sharing" services and "ride-sharing" services.

The element that characterizes shared mobility services and known as vehicle-sharing concerns the user: the same person is the temporary driver of the vehicle shared by third parties, whether provided in the public or private sectors. In ride-sharing services, however, the user, in satisfying his own travel needs, makes use of a service that envisages interaction with a third party driver.

Further general basic characteristics differentiate the numerous services offered by both private and public organizations.

Parking: station-based and free-floating services

If we consider the user's sharing experience, the first distinction between the services offered regards the pick-up points of the vehicle intended to be used.
These places may be identified in specific docking areas that form a station where the vehicle can be collected without interaction with staff.

These systems are described as being *station-based*.

The registered user books and rents the vehicle selected on an online platform or a mobile app and then returns it at the end of its use.
This type comprises two subsystems that concern the term for the experience of temporary use: the *round trip* service, in which the return takes place in the same station as the collection, and the *one-way* service that permits, in contrast, the vehicle to be left at a different station from that of collection. The first provider of a *one-way* car-sharing service was Daimler, through its subsidiary car2go: the launch of the pilot project took place in Ulm (Germany) in 2008, with a fleet of 200 diesel Smart ForTwo vehicles.

In more recent years the possibility to take advantage of free-flow services, known as *free-floating,* has also been introduced.

The procedures for the selection and booking of the vehicle desired remain the same as *station-based* services, that is through specific platforms. The distinguishing feature is the possibility to pick up and then drop off the vehicle at the end of its use within the limits of a broader geographical area. The individual vehicles in the *free-floating* fleets are equipped with GPS, which permits geolocation by users at the booking stage. This type of service concerns both car sharing, bike sharing and other micromobility services.

The following table illustrates those that may be considered the benefits for citizens, the features of the services and the actions to be undertaken by local administrations regarding the two types of sharing services examined.

<table>
<tr><th></th><th>Station based</th><th>Free-floating</th></tr>
<tr><td rowspan="2">Citizen</td><td colspan="2">The use of shared mobility systems allows for a gradual reduction in the number of cars in circulation, with regard to the needs of the individual citizens and of nuclear families, incentivizing systematic journeys on local public transport. The shared services make it possible to effect journeys, predominantly short ones, which are not possible by other means of transport.
Furthermore, these services can be economically beneficial also for medium-long-distance journeys outside urban centres.
In order to incentivize shared mobility it is necessary to guarantee users certainty about the availability of vehicles.</td></tr>
<tr><td>The lesser flexibility of station-based services is reflected in the obligation to collect and return the shared transport vehicle at specific infrastructures or stations.</td><td>Free-floating services enjoy of a high degree of flexibility and immediate availability, presenting a level of economic benefit greater than the use of a privately-owned vehicle and, in some cases, of local public transport (this depends in fact on the travel habits of individuals and on the fares charged by specific local authorities for public transport).</td></tr>
<tr><td rowspan="2">Public administrations</td><td colspan="2">Local administrations can offer, together with a public transport service, various sharing services with the aim of reducing the use of privately-owned cars and the number of vehicles in circulation, incentivizing, in particular, the sharing of two-wheeled vehicle or micromobility solutions. The economic and environmental advantages that derive therefrom are directly proportional to the size of the service offered.</td></tr>
<tr><td>As regards station-based shared mobility investment in dedicated stalls for vehicle parking are is needed.</td><td>Local administrations intervene in management of the market ecosystem locally. Not being able to intervene actively in the creation of infrastructures, in the free-floating model administrations regulate the presence of the various providers through public requests for proposals.</td></tr>
<tr><td rowspan="2">Market</td><td colspan="2">It is a service adoptable both in large, and in medium-sized cities.</td></tr>
<tr><td>The station-based services market is a niche segment, with a high potential for development in terms of geographical distribution.</td><td>The free-floating market presents a greater expansion when compared with that of fixed-station services, this is because it requires larger fleets but little investment in docking infrastructures.</td></tr>
</table>

The greater flexibility enjoyed by free-floating services compared to station-based ones, represents one of the driving factors behind the growth of shared mobility services. Although the market is expanding rapidly, this approach possesses, however, a lower degree of maturity compared to the former, since most providers have been in the market for under five years.

Ownership: vehicle and service providers vs private users

If one thinks about the concept of ownership, it is possible to identify two categories to which this characteristic refers in the context of shared mobility.

The first provides that the market operators, who make fleets of vehicles with generally the same characteristics available to users, own the vehicles themselves. All vehicles are equipped with a GPS location system that allows service providers and vehicle owners to keep track of their location and, at the same time, allows users to identify the vehicle they intend to rent. Typically, a service based on this ownership arrangement is based on a partnership between the service provider, on the one hand, and car manufacturers and manufacturers of other vehicles on the other.

The second approach, in contrast, which is the basis of peer-to-peer shared mobility models, sees private users as owners and suppliers of vehicles and the presence of market operators who act as intermediaries and managers of shared services. The market segment in question is a growing area that is based on the sharing of private vehicles, through registration of the same on dedicated platforms, for the purposes of exploiting idle moments and generating a profit for individual owners.

This model, in particular, orients users towards a change both of paradigm and of mentality, which turns from individual ownership for exclusive use towards the concept of sharing proprietary vehicles.

The table that follows briefly describes the various sharing services, providing a classification that will be referred to again in the pages that follow to illustrate the market in question and the ecosystem of the players (large companies, start-ups, automakers) that make up the panorama of shared mobility.

Service	Definition models and additional description		
Car sharing	Short-term car rental service. The vehicles, supplied by the provider, are distributed around a network within a specific geographical area and can be collected by users via app, with no need for interaction with designated staff.	Station-based	The vehicles are parked in specific areas thus forming a station. Types of service: - Round trip: the vehicle is returned to the same station from which it was collected - One-way: the car can be left at a different station from that of collection
		Free-floating	The cars can be collected and returned within a predefined area. No stations or stalls are contemplated for collection and/or return of vehicles.
		Peer-to-peer	Rental service between private individuals: the owner of a vehicle rents his own vehicle to other users temporarily through an intermediary platform.
		Geofenced	Closed network systems that serve small geographical areas or specific communities, such as residential complexes, universities or industrial areas.
Ride-sharing	Mobility service based on the shared use of private vehicles between two or more persons who intend to travel the same route. Ride-sharing, also known as carpooling, does not take the form of a business activity strictly speaking as there is no profit for the driver and the intermediary platform receives a minimal revenue through the commissions charged for the booking of the journeys. The ownership of the vehicle is thus of the private user who makes use of an intermediary platform to find any passengers interested.		
Ride-hailing	The ride-hailing service takes the form of a journey requested by one or more users, which takes place in return for payment for all driver activities and for the making available of the vehicle. The model can take the form of a station-based or free-floating service and the vehicles can be supplied by a provider or by private users (P2P).		
eHailing	The eHailing service concerns booking operations and procedures for of payment of a ride-hailing service. It envisages that both the aforementioned actions, performed by the user, take place through the use of a digital platform. In particular, as regards payment, use of e-wallets or digital cards is taken for granted.		

Service	Definition models and additional description		
Bike / Scooter sharing	Short-term rental of bicycles or motocycles distributed around an area, without the need for the assistance of staff. Use is enjoyed in return for a fee, usually composed of a fixed sum for the subsription and a charge based on time/consumption.	Station-based	The bicycles, placed in stations with special racks, are equipped with a locking system. They may be collected by means of the use of a code/ mechanical key (low-tech) or magnetic card/QR code (IT dock-based). The return at the end of use can take place typically in a different station from that of collection.
		Free-floating	The bicycles, equipped with a GPS system and a locking/unlocking system, can be collected and left and within a predefined area as they are georeferenced and detectable through the specific app. Scooter sharing services are typically free-floating.
		Peer-to-peer	The system shares the same technical characteristics as the GPS-based one but the bicycles are made available by a private individual, through a sharing platform.
Micro-mobility	The vehicles belonging to this category are several: e-scooters, hoverboards, segways and monowheels. The sharing services for e-scooters are free-floating and can be booked via specific app as they are equipped with a system of GPS geolocation and QR Code for unlocking.		
DRT	The Demand Responsive Transit (DRT) service permits users to make use of means of transport usually considered public, such as buses, in a flexible fashion. The DRT system gathers, through the platform, the travel requests communicated by users, and plans the route of every vehicle used on the basis of requests. The models used to manage these systems are also adaptable to goods transport.		
Shared mobility services are also considered to include local public transport (scheduled both by road, and by rail) and the rental with driver (professional independent drivers).			

The shared mobility market

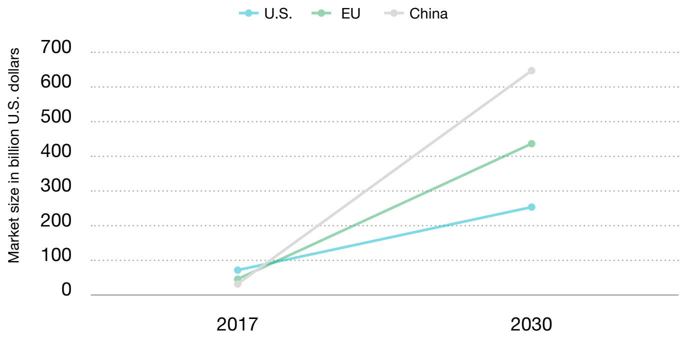
The rapid technological evolution and the development of efficient digital platforms have made possible the progressive diffusion of shared mobility services in the major cities of the world.

The number of users who prefer to take advantage of shared transport rather than having a privately-owned vehicle is, in fact, growing constantly, above all among the new generations.

Worldwide

According to Statista estimates, the global market for shared transport has registered a markedly positive trend during the last two-year period, with forecasts for the European Union set to reach a total value of $ 451 billion by 2030.

Mobility services: global market size by region 2017 & 2030



Source: Statista

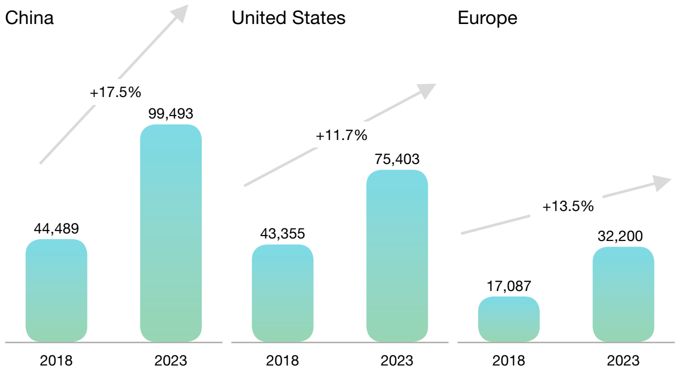
If we observe global demand for mobility in terms of miles travelled from 2018 to 2025, it emerges that journeys in private vehicles remain by far the most preferred by citizens and that they will remain such into the near future.

Nevertheless, sharing services are undergoing rapid growth and it is predicted that they may represent a much more significant market share in the future. It is predicted that in 2025, 4% of the miles travelled by passengers will be in shared vehicles; in 2030, 9%; in 2035, 18%.

The ride-hailing business represents the second segment by size and by rate of growth in the area of digital mobility services globally. In 2018 alone, global sales revenues from this service amounted to a 153.6 billion dollars (that is to say the 22.7% of the overall market of online mobility services) with an average rate of growth of 15.7% per year.

Entering into the analysis by geographical macro-area, China boasted sales revenues of $ 44.5 billion in 2018, followed by the United States with $ 43.4 billion and by Europe with $ 17.1 billion.

Revenue forecast in million US$



Source: Statista

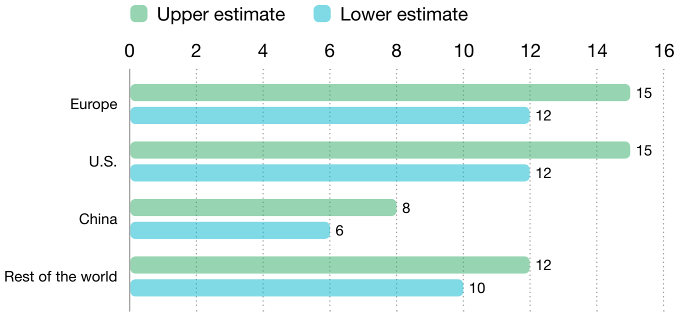
Shifting the focus onto on-call services, Statista data shows that DRT may reach 551.61 billion dollars in 2030 (from the 2.8 million of 2017), with a CAGR of 50.3%. This result would see Europe and China among the main players.

Frost&Sullivan forecasts that the growth in the DRT services market will occur above all after 2022, when driverless versions of these vehicles will be commercialized, and which are predicted to represent 50% of the shared mobility market by 2030.

The recent success of the shared e-scooter services market has involved the whole world, with particular popularity in the cities of San Francisco and Copenhagen, thanks to companies like Lime. In Europe alone this service should reach 12 billion dollars by 2025, though it still needs to be regulated in all its aspects.

Regional breakdown of the global shared e-scooter market 2025

Market size in billion U.S. dollars

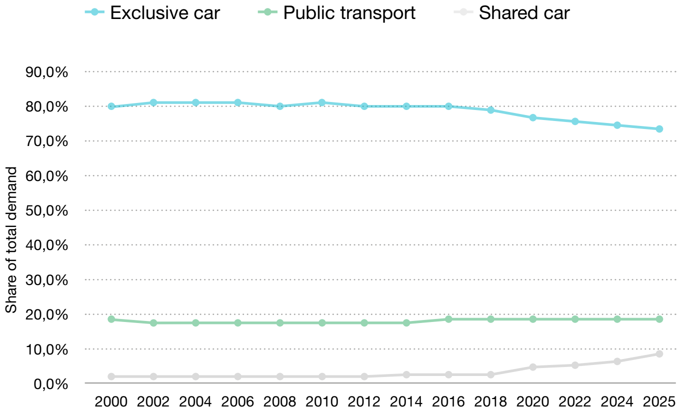


Source: Statista

Europe

In Europe too, between 2000 and 2025 the private car still represents the dominant means of transport, despite the fact that the use of shared vehicles is constantly rising and it is predicted that it may reach 9% of total mobility in 2025.

Development of mobility demand in the EU-28 2000-2025, by transport mode



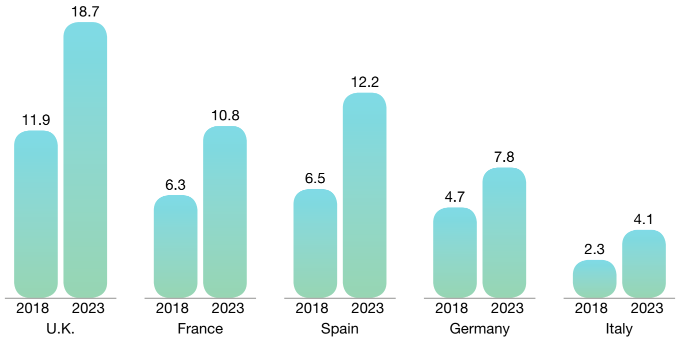
Source: Statista

Specifically, one can observe a growth trend in terms of the users of ride-hailing services with a CAGR in double figures for the next 4 years (13.5% by 2023).
The United Kingdom is the leading country in the sector with sales revenue of $ 6 billion in 2018.

Although the European legal framework is somewhat stringent and despite the great presence of private cars, the ride-hailing segment has been registering a more marked growth than other sharing services, probably dictated by the already saturated markets.

Number of users forecast in millions

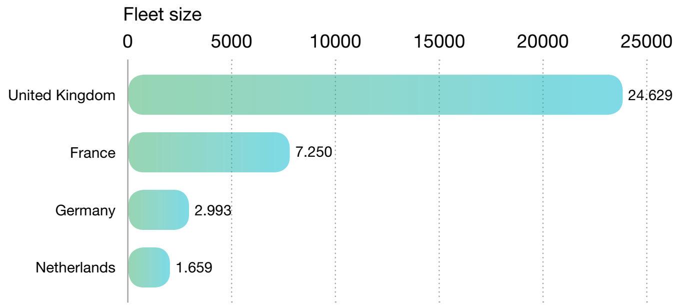
Source: Statista



Another record held by the United Kingdom concerns the size of the DRT market, with 24,629 vehicles present.

Fleet size of demand responsive transport in European countries

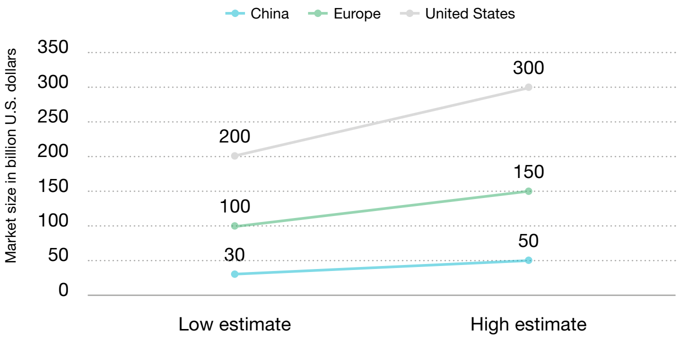
Source: Statista



As confirmation of the success of the business models associated with shared mobility, we can see the equally exponential growth in the number of registered users of car-sharing services in the last decade (2011-2020), rising from approximately 700 thousand to 15 million in Europe alone.

Shifting our focus onto micromobility, a constant growth can be traced throughout the European market. One exceptional result regards the bike sharing service that, on our continent, can boast the record for the number of operators and for the widespread use that will probably persist into the next decade.

Micromobility market size by region 2030



Source: Statista

Italy

The 2019 data processed by the "*National Observatory for Shared Mobility*" confirm the constant growth in the market for shared services and the progress of the various types offered in our country.

In 2018, the supply of the latter increased by 14 units, reaching a total of 363 operators active in 271 municipalities (100 services more than in 2015 with an average growth rate of 12% per year).

The study recorded a total of 33 million recorded trips (+ 26% on 2018) and a record 5.2 million users were registered at the end of 2018 (one million more than in 2017).

New users registered for car sharing services in 2018 exceeded 1.8 million, registering an average growth rate of 22% in the last three years (2015-2018) for station-based services and 40% for free-floating ones.

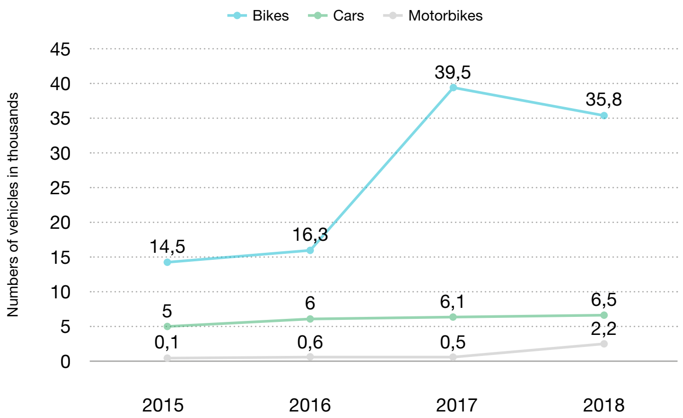
In 2017, the birth of free-floating bike sharing services, for its part, significantly changed the performance of the sector, ensuring greater availability of vehicles in the cities.

Indeed, the number of shared bicycles more than doubled between 2016 and 2017, going from 16.3 thousand to 39.5 thousand, however, as in the case of free-flow sharing cars, this phenomenon is confined to the Municipalities of Northern Italy, with the exception of Florence.

The car pooling and scooter sharing service also appears to be growing, albeit at more modest rates. The latter, in 2018 alone, quadrupled its shared motor scooter fleet to reach 2.2 vehicles, with 90% of which electrically-powered.

Sharing mobility fleet size in Italy 2015-2018 by vehicle type

Source: Statista



There is also an increase in the percentage of electric vehicles in terms of the total, rising from 27% in 2017 to 43% in 2018. This rise is mainly due to the boom in electric scooter sharing services, which went from 6% in 2017 to 22% in the following year.

A further area of increasing shared mobility is that of carpooling, in particular suburban and corporate schemes, with the latter recording an average growth rate in subscribers of 75% per year since 2015, with a record 277 thousand users in 2018.

Blablacar went beyond 2.8 million users in 2018 (+ 15% on 2017) displaying the opposite trend to urban carpooling which saw the suspension of some services due to the currently poorly defined regulatory framework.

Lastly, the potential development of digital services for the booking of taxi services is clear to see, having in the first months of 2019, across 120 cities with active digital platforms recorded 3.1 million bookings via digital apps taking into consideration only MyTaxi, WeTaxi and itTaxi.

Digital platforms and technologies for shared mobility

The development of physical, organizational and digital platforms has been one of the enabling factors in the evolution of the shared transport and the birth of initiatives of collaborative economy.

Over the last twenty years, technology has led to the universal use of the smartphone as a personal interface tool with multiple services.

The growing supply of technological systems has made possible a revolution in the management of the latter, of booking and of access, in addition to enhancing and making extraordinarily more efficient the performances of the platforms themselves and considerably reducing costs.

If, on the one hand, innovation in technological aspects has had a central and decisive role in the revolution in electric and connected mobility and will all have an even greater one in the future for autonomous mobility, in the shared mobility market technology has never represented the most significant cost item. It remains evident, however, that the support of digital platforms is necessary for the creation of such services, and that the use of Internet is equally crucial for the management of these applications, capable of permitting high levels of interaction between supply and demand and of imposing forms of mass consumption.

<table>
<tr><th>Low tech</th><th>First platforms (web)</th><th colspan="2">First digital platforms (web+mobile)</th><th>Platforms and services of the future (web)</th></tr>
<tr><td>Hitch-hiking</td><td colspan="3">Carpooling / Ride-sharing</td><td rowspan="6">Shared and autonomous vehicle</td></tr>
<tr><td>Informal relations between colleagues and friends</td><td colspan="3">Vanpooling</td></tr>
<tr><td colspan="3">Taxi telephone booking</td><td rowspan="2">Ride hailing / eHailing</td></tr>
<tr><td colspan="3">Rental plus driver</td></tr>
<tr><td rowspan="2">Car rental</td><td>One-way car rental</td><td>Station-based car sharing</td><td>Free-floating car sharing</td></tr>
<tr><td>Round trip car rental</td><td>Geofenced Car sharing</td><td>Peer-to-peer car sharing</td></tr>
<tr><td colspan="3" rowspan="2">Traditional public transport service</td><td rowspan="2">Demand responsive transit</td><td>Autonomous bus and electric bus</td></tr>
<tr><td>Shuttle autonomo</td></tr>
<tr><td>Traditional bicycles and kick scooters</td><td>Station based bike sharing</td><td colspan="3">Bike sharing free floating</td></tr>
<tr><td>Parola</td><td>Electric hoverboards and monowheels, e-scooters</td><td colspan="3">Shared e-scooters and electric motor scooters</td></tr>
</table>

The use of internet sites, smartphone applications and other mobile devices has made it possible to develop collaborative, useful and scalable services, in addition to making possible interaction between supply and demand in real time. The mass adoption of these tools has since led to the overhauling of established business models and to the conquest of new market segments.

The reliability of technological elements thus assumes a key role in the success of shared mobility services.

Most providers develop white label platforms that can be customized according to company needs. As an alternative to software, the providers offerings have evolved towards specific hardware solutions and end-to-end solutions for service management.

Currently, many new technologies that concern shared mobility are principally to do with booking systems for shared vehicles, with the on-board telematic units for the same and with the applications that manage the service. The support of these tools is essential both to provide consumers services that are efficient from the point of view of time and costs, and to guarantee operators an effective management of the service.

Among the main characteristics of the platforms for the management of shared mobility services is the predisposition for simple and intuitive interfaces which can ensure an optimal user experience: for example, making the detection of the available vehicle a rapid process and providing simple and clear indications regarding the use of the same.

European Carsharing Technologies Market, Forecast to 2022, 2018

Source: Frost & Sullivan

Front-end solution

- Real-time fleet management software – provides detailed insights into the live activities of the vehicle fleet and use
- Intelligent automation processes to proactively manage fleet and customer service
- Easy and quick to add/modify/improve any feature
- Easily integrated with external apps

App Interface

- A simple smartphone app offering a seamless customer experience
- Users can locate and get directions to the nearest available vehicle in just one tap
- Users open the doors with the app and begin using the vehicle immediately

Back office tools

- Sophisticated and robust operating platform
- Server processing and DBMS Onboard client app
- Yield Management Software/Tools to handle billing processes, payment providers, and letting users to monitor their user accounts
- Data Analytics/Customer Service management tools like customer service ticketing, driver authorization, etc.

In-car tech

- Certified and tested hardware
- Easy installation/ Compatible with all models of cars
- Support of RFID access media
- Hybrid use with or without a customer's smartphone
- Voice guidance

The software developed by ShareNow, for instance, represents a prime example of car sharing, capable of enabling functions both for the user and for the provider. The user interface makes possible identification of the vehicle, its unlocking and the reporting of available parking spaces through its application.

As regards the provider, however, the fleet management software makes it possible to obtain detailed information in real time about vehicle activities, to receive requests for maintenance or repairs and to provide assistance to customers.

No less important is the possibility that the platform may manage payment processes and monitoring of users' own personal profiles, which represents the most interesting market segment for the main tech providers.

For active technology players, opportunities in the car sharing market alone are expected to grow from $ 152 million in 2017 to $ 438 million in 2022, registering a CAGR of 23.5% (source Frost & Sullivan). Driving this trend, as we will see more clearly below, is largely the growth in the P2P fleet market and in the corporate segment. The technologies of the car sharing sector are evolving towards more and more automated solutions, while an interesting path to follow would be that focused on greater customization of the service and on guarantees of its security.

In general, tech providers are harnessing the Internet of Things to revolutionize shared mobility services and to offer better user experiences. In fact, thanks to the use of sensors on board the vehicle, it is possible to obtain a wide range of data and information on user behaviour, advantages of predictive maintenance systems that allow mobility suppliers to identify faults and problems and technologies for driver and passenger safety.

Source: Frost & Sullivan

European Carsharing Technologies Market, Forecast to 2022- 2018

Biometrics to open cars	Business Model Expansion	Insurance Telematics
From Smartphone-based access to open cars to using facial recognition technology	Expansion of product suite to include other shared mobility	Encouraging good driving through usage-based insurance
EasyOpen by Omoove	Ridehailing Integration by Vulog Bikesharing by Omoove	Insurance Telematics by Omoove
Microcarshare Programs	**Smart Parking**	**Autonomous Technologies**
Individuals and companies can easily set up their own Carsharing mobile communities	Integration of Smart Parking solution with the Carsharing solution	Autonomous mobility solution that enables on-demand autonomous shuttle services
Sharemine by Omoove	MySmartPark by Omoove	Autonomous Platform by Ridecell

The diffusion of 5G connectivity will play a key role in the development of shared mobility services, guaranteeing omnipresent wireless networks, with extended coverage and high data transfer speeds.

According to a Frost & Sullivan report, the hardware technology installed on the fleet of the shared cars requires replacement every 4-6 years; the software solutions need frequent updates and the installation of new functions. The study estimates that these tech components require, on average, an expenditure of between 2% and 10% of the overall costs of the shared-mobility operators, that is to say between $500 and $700 for car sharing and between $200 and $300 for eHailing.

Among those companies working in the field of technologies and solutions for shared vehicles, Omoove represents a leader in the market of innovative tech providers for mobility, possessing 35% of European market share.

One of the features developed by Omoove is the EasyOpen solution, which makes it possible to replace vehicle keys with a personal smartphone and, moreover, it ensures driver authentication through facial recognition (following registration with an identity document on the app, the user can access the vehicle with a selfie).

If currently the Rfid (Radio-Frequency Identity) system is the most dominant, it is predicted that after 2020 the greatest attention will shift towards new smartphone technologies based on NFC/QR code, which by providing bidirectional short-range wireless connectivity allows both devicesto send/receive information and enables vehicle use. The trend towards more fluid user experiences and towards the customization of these service is evident.

The shared mobility ecosystem

The heterogeneous set of mobility practices and models, supported by modern digital technologies, facilitates the sharing of resources and makes it possible to maximize the use of vehicles compared to an exclusively individual use of the same. As we have mentioned, there follows a general transformation of user behaviour, which progressively favours temporary access to mobility services, made available by local authorities and private companies, rather than the use of privately-owned vehicles that have high overheads and are often hardly used.

Specifically to meet consumer new needs, and in particular those of the new generations (the so-called Millennials), the mobility ecosystem, also in the context of shared mobility, has been populated with new subjects. It follows that the shared mobility panorama is characterized by partnerships between established companies from the automotive sector, both vehicle manufacturers and OEM's, and by the diversification of their core businesses, with the aim of finding new spaces in the market. Considering instead the most innovative services, such as micromobility, the ecosystem is composed of a varied number of start-ups and emerging companies.

Car sharing

From a survey carried out and published in 2017 by the consulting firm Bain & Company and involving 2,700 people from Italy, Germany and the United Kingdom, over 50% of Millennials are willing to use a shared vehicle. Among the elements that guide consumers' purchasing behaviours, we observe a desire to identify solutions that facilitate the use of the asset and consequently reduce its ownership costs.

Car sharing has experienced greater growth than other services that fall under the shared mobility paradigm. This service is developed within sustainable mobility policies, to facilitate the switch from the ownership of the vehicle to the mere use of it. In this way, the privately-owned vehicle moves from the sphere of consumer goods to that of services, replacing the concept of "ownership" with that of access.

A report published in 2018 by Ipsos, a French consulting firm, highlights how, globally, daily average use of a car is only 63 minutes per day. In addition, there are 67 days in a year on which the car is not used and half of car owners consider it will be cheaper to use shared mobility services in the future.

All car sharing service providers offer users the ability to access a distributed network of shared vehicles 24 hours a day, 7 days a week. The availability of cars is guaranteed without restrictions, at prices that include fuel, insurance and maintenance and that are directly proportional to use, providing a convenient alternative to car ownership. Car sharing is designed primarily for short-term journeys and over short distances, as an extension of the local public transport network.

The first organized car sharing models originated in the mid-1900s, but it was in the early 1970s that the first real shared car projects developed, such as the ProcoTip system in France, which used cars activated by a "token-operated" system or the Witkar project, launched in 1974 in Amsterdam. The service, which lasted until 1988, was based on small electric vehicles, electronic controls for reservations and redeliveries, and a large number of fixed stations across the whole city.

↳ "Witkar, the world's first electric car-sharing scheme"

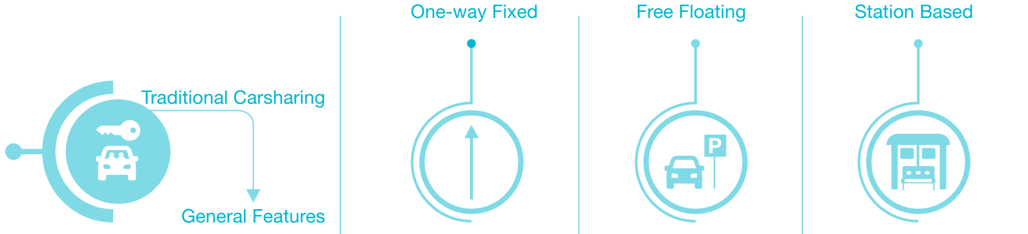
The development of telecommunication networks and the diffusion of smartphone applications represents the turning point for car sharing offerings. In 2000, the shared mobility services of Zipcar, Flexcar (purchased by Zipcar in 2007) and numerous other international car rental companies entered the market. Subsequently, starting from 2010, the first peer-to-peer mobility systems were introduced. In more recent years, the car sharing model has also been extended to include vans and vehicles for the transport of goods.

The predominant position of car sharing compared to other shared mobility services, can be explained by the broad range of business models capable of satisfying different user needs and by the habits of these users, which typically derive from the common use of a private vehicle.

The advantages and benefits for users, generated by the sharing of a car, are multiple; expenses related to ownership can be avoided, including those of insuring and maintaining the private vehicle, and those related to use, such as fuel and parking. Car-sharing services in fact require users to pay on the basis of time and the distance covered by the car, in addition to an initial charge for registration on the platform.

Source Frost & Sullivan

Global Shared and Autonomous Mobility Industry Outlook, 2019



- Flexible, very short to short time rental of a vehicle, often by the hour
- Drivers have a registered membership
- Can use the cars parked at designated spots of travel
- Dominant powertrain are gasoline or diesel, but increasingly fleets are being electrified
- Cars owned/leased by the carsharing operators (CSOs)
- Complete revenue taken by CSOs
- E.g., Zipcar, car2go, DriveNow, emow

Carsharing between two fixed points A&B (Oneway). User picks the vehicle at point A and drops post usage at point B (E.g., AAA's Gig Carsharing)

Carsharing where there are no fixed stations (free-floating) for vehicle pick-up or drop. User can access vehicle located at various parking spots or specified locations around the operational area and leave them at the closest available drop spot. (E.g., car2Go)

Carsharing with a fixed station for pick-up and drop of vehicles. User returns the vehicle to the same station from where the vehicle was initially reserved from. (E.g., Enterprise Carshare)

Free-floating car sharing, in particular, is mainly used for short journeys in urban areas, setting itself up as an alternative to taxi services. Compared to station-based car sharing, the free-floating form has higher consumer prices. Given the terrain of urban areas and in order to facilitate parking, most providers offer cars of small and medium size.

Parking policies for car sharing oblige providers to collaborate with local authorities to avoid any restrictions. In this regard, for instance, in 2014 Car2go, the sharing division of the Daimler AG car manufacturer, ceased operations in London after only 18 months, since the local authorities were not able to guarantee parking permits for all the separate districts of London.

In 2019 the German colossuses Daimler-Mercedes Benz and BMW finalized the merger of their respective car-sharing services, Car2go and DriveNow, thus creating Share Now: a European giant in the sector with 4 million customers that is looking to challenge Uber, present in 26 cities and 14 countries with a total fleet numbering over 20,000 cars around the world, including over 3,000 electric ones.

Share Now acts as an intermediary, in terms of use, not of sale, between the car manufacturer and the end user: it does not actually own the vehicles made available as in the case of the Tesla electric vehicles provided. Share Now provides its service in free-floating mode and makes available various models of car, in return for a proportionate fee, in order to meet the user's various needs. There are, moreover, no limits to the use of cars in terms of time: via the dedicated app, it is in fact possible to book the vehicle even for several days.

Partnerships among companies, even ones belonging to different sectors, represent the central hub of the offering of shared mobility services. By way of example, Enjoy was established in the ambit of the partnerships between Eni and other Italian companies.

The meeting of different sectors actually makes it possible to offer additional services. As for every car-sharing service, the costs associated with the use of the car are borne by Eni: in the case of Enjoy, in fact, this applies, for example, to fuel costs. For a complete and efficient service even outside the vehicle, Eni has, for instance, made a partnership with CartaSi for payments; with Trenitalia, in order to integrate and improve connections between the rail network and the road network, making car sharing a new potential extension of high-speed rail transport; with FCA, which supplies the car fleet; with Vodafone, which encourages its customers to use car sharing through periodic promotions; with Chicco, which collaborates with Eni by equipping shared vehicles with child safety seats.

The services offered by Enjoy go beyond traditional car sharing: there is in fact a van section, Enjoy Cargo, which presents a fleet of commercial vehicles with a large load capacity.

The automotive sector, which is experiencing a slowdown in sales of new vehicles at a global level, is also feeling the effects of the diffusion of shared mobility services and in particular of car sharing.

According to McKinsey data for 2016-2017, by 2030 about a third of the expected increase in sales will not occur due to the diffusion of shared mobility services. To counter the expected large losses in turnover, numerous car manufacturers are therefore launching their own car sharing services.

↳ "Citroen AMI 1 Concept, una piccola CARROZZA per il car sharing"

By way of example, in 2019 Citroen presented its model of car sharing Ami One: a zero-emissions two-seater usable, in some European countries, by over 16's. The prototype of the model was presented at the Geneva Car Show in 2019 and possesses particular features that mitigate some of the problems of mobility in urban centres. Via the app the driver has access to information such as consumption, level of charge as well as to the «Free2Move Services» portal, for access to French PSA group's associated services.

Other car manufacturers too are expanding their own offerings, orienting themselves towards car-sharing models.

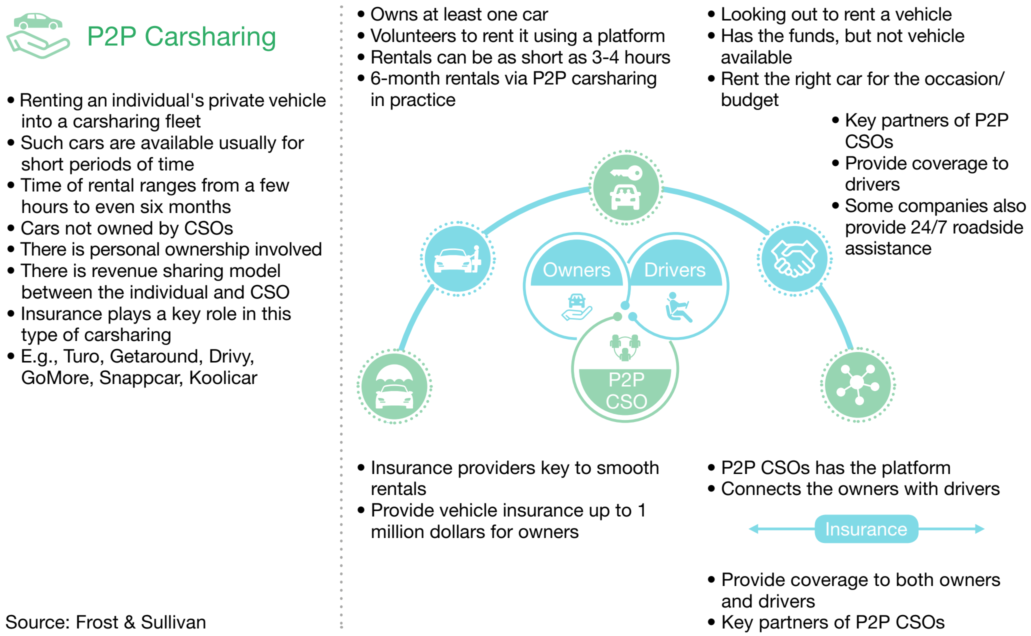
In 2017 Renault Spain, in collaboration with Ferrovial Service, launched Zity: the largest Spanish shared electric car service. The project combines Ferrovial's capacities in the sector of municipal services and environmentally-compatible solutions with the experience of Renault as the principal European manufacturer of electric cars and brand leader in the field of sustainable mobility.

Zity is a shared electric car service, operated via a free app, and its business model is based on the rental of electric vehicles by the minute in the city of Madrid. One of the distintive characteristics of Zity is its parking system: it is, in fact, possible for users, thanks to the StandBy features, to park the car temporarily outside its designated space before resuming the journey.

P2P Carsharing

P2P CSO's initialy offered the service as a new concept of sharing cars between vehicle owners and renters, however even OEMs are now offering P2P carsharing to their respective vehicle owners.

Shared and Autonomous Mobility Industry Outlook: P2P Carsharing Definition, Global, 2019



Source: Frost & Sullivan

One recent variation of car sharing concerns the sharing of vehicles among private individuals, the so-called peer-to-peer (P2P).

This is an approach to sharing present above all in North America, in France and in Northern Europe. The model consists in a practice of car sharing among private citizens: the single individual who owns a motor car, in those periods in which he does not use it, can make it available to others.

This rental arrangement between private citizens is supported by platforms that function as intermediaries and match demand with supply, also providing adequate insurance cover, additional to standard forms, for the vehicle in the period of its use by third parties. The car owner is paid a reimbursement fee for the variable costs incurred and a reimbursement for the overheads proportional to the use that he makes of the vehicle, calculated on the basis of time and of the distance in kilometres travelled.

The legal and regulatory framework is varied and not consistent globally, which is why in some countries of the world this car sharing model has been able to develop more fully. Germany, for example, incentivizes the sharing of vehicles and works on public policies to support these new forms of sustainable mobility. As for the Italian regulatory context, on 3 July 2018 a second bill was presented (the first was in 2016) containing provisions for the promotion of the shared use of private vehicles.

Overall, in 2018 there were more than 40 players active globally in different markets with some of which growing strongly.

Among these, Turo, a short-term peer-to-peer rental service established in the United States in 2009, is the start-up with the largest expansion in the world. Users who need a car for a limited time - ranging from one hour to more than a week - can sign up to Turo and search for cars available in the area for the time required. After choosing from the different cars according to models and charges, the user makes an appointment with the owner of the car and takes possession of it.

The Turo contract provides for insurance to be taken out against, amongst other things, any damage that the driver may cause to the car, to himself or to others, mechanical breakdowns with costs borne by the owner, and a replacement car supplied by Turo itself. The start-up, set up under the name of RelayRides, had a sharp rise in subscribers in September 2017, when the Daimler group invested over $ 90 million in it to expand the platform in Europe, in particular thanks to the German car rental service Croove.

In European terms the largest peer-to-peer car-sharing platform is the French start-up Drivy, founded in 2010. After its success in France, which made Drivy the largest peer-to-peer car rental market in that country, P2P car-sharing activities have spread all across Europe with the service first available in Germany and Spain.

The service allows car owners to rent out their own cars to neighbours and includes specific insurance cover to ensure safe rentals for both parties. One of the particularities of the service offered by is based on the proprietary technology Open: thanks to a small telematic device the customer can access all cars without the use of a key and without meeting the owner.

In 2019 the American company Getaround acquired the French start-up Drivy for $ 300 million, with the intention to consolidate its own position as leader in the car-sharing market.

In Italy, the Auting platform, which allows the sharing of cars between individuals, has been online since 2017. Registration for the service is free and the extended insurance policy also covers the temporary user. In September 2018 Reale Mutua entered the share capital by designing a specific insurance policy, which provides for temporary coverage that is valid from the delivery of the keys to the return of the car. Payment for the service, of which 30% of the vehicle owner's fee is retained, is made using Banca Sella's payment platform.

Another intermediary is SnappCar, the second largest international peer-to-peer car sharing player in Europe, with its Drive & Share service, which in 2018 formalized its collaboration with the Europcar Group. With Drive & Share, customers have access to a long-term car rental to meet their mobility needs. After a successful first pilot scheme in France, the Drive & Share solution was launched in Germany and Denmark, with the Europcar group as the main investor.

The service includes vehicle, insurance and maintenance: customers choose a package based on their preferred vehicle category and rental package (for a period of three to 12 months, with mileage and insurance package included). The owner, on the other hand, should he agree to share the vehicle at least twice a month, will receive a kind of bonus above and beyond the SnappCar rental fee.

SNAPPCAR

SnappCar offers an online marketplace for car owners and drivers, enabling peer to peer car rental. This online community connects car owners looking for extra income and drivers, conscious of car costs, looking for a wide range of vehicles, that are always available, right on their doorstep. SnappCar.nl makes P2P car sharing easily and safely accessible for both private car owners and drivers.

Total Funding
$22.12 mln

Last Round
Sep 2019 Series A-II
$8.74 mln

Country
Netherlands

snappcar.nl

The ecosystem of the players involved in car sharing includes already established companies and start-ups operating in the consumer market, and in the corporate sector. Many operators, in fact, offer specific services for companies and self-employed workers who need a single vehicle or a fleet for their own businesses.

“Corporate car sharing” is managed as a closed system in which employees can access shared vehicles and it can represent a valid alternative for companies that manage their own fleets.

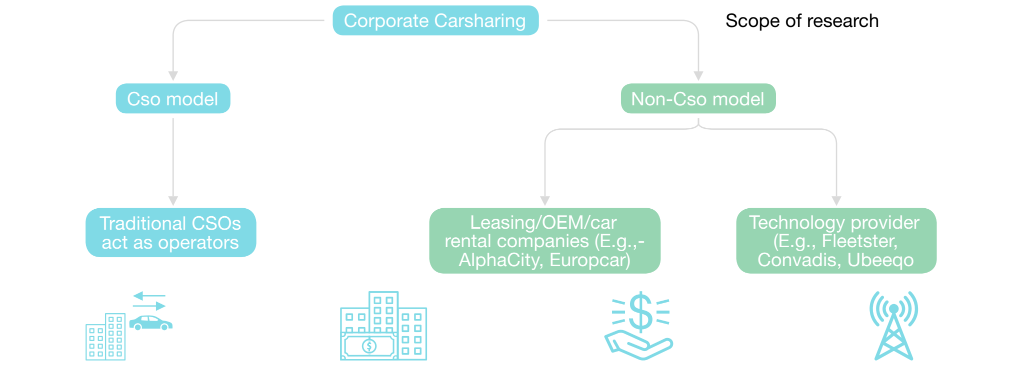
This model of car sharing makes employees’ work simpler, reducing the time expenditure and stress associated with the search for a vehicle, simplifying and speeding up their own work activities and leaving them more satisfied thanks to the possibility of using, if required, the shared cars also during the weekend.

Corporate Carsharing

Corporate carsharing services are offering increased benefits to organizations with improved solutions to manage employee mobility budgets and reduce overhead costs and enable effective utilization of fleets.

Source Frost & Sullivan

Shared and Autonomous Mobility Industry Outlook: Corporate Carsharing Definition, Global, 2019



Corporate carsharing is a natural extension of services offered by leasing and rental companies because they already have access to a wide base of corporate customers.

For leasing companies, partnering with third-party technology providers is a quicker route to market rather than going for in-house IT development as the latter is a very costly option given the current small size of this market.

OEMs have been actively investing in corporate carsharing programs with factory-installed technology in cars. Opportunities exist in aftermarket solutions.

Technology providers offer corporate carsharing solutions directly to companies. Companies use their own fleet and leverage the technology solution to offer carsharing to their employees.

For the company the use of this form of mobility represents a real saving in travel costs compared to the alternatives. According to a field analysis conducted by LoJack on medium-sized fleets, the insertion into the pool of 20 shared cars brings about substantial reductions in expenditure by employees compared with the use of a short-term rental car (-34%) and compared with the use of a taxi (-29%).

The innovative solution of LoJack Connect, a new division in the American company of the same name, worldwide supplier of tracking and recovery systems for stolen vehicles, is based on an organizational model of car sharing focused on the management of a company car pool.

It allows a fleet of cars that companies use internally to be managed directly, making them available to employees as an alternative to taxis for moving around the city and for transfers for employees who do not have a specific car assigned to them. The telematic platform dedicated to the service allows the fleet manager to access and manage information from on-board telematics (for example, real-time distance covered, diagnostic alerts, tank level and refuelling in real time, crash alert, location in the event of theft) and allows staff to always have a car available that is easy to book from a personal smartphone.

↳ “Ubeeqo Business Presentation”

Other companies offer corporate car sharing services too. The Europcar Group, for instance, offers the corporate car-sharing service Ubeeqo Business.

Founded in Boulogne-Bilancourt, on the edge of Paris, Ubeeqo is a start-up (acquired by Europcar) that, since 2008, has made it possible to convert classic corporate fleets into a car pool composed of vehicles that can be used by all employees as shared cars, both for journeys for work and for private ones. The service is active in various European cities and specifically as regards Italy it can be used in Milan. Staying in Italy, Ubeeqo is one of the approved suppliers of the Car Sharing Initiative (ICS in its Italian acronym), backed by the Ministry of the Environment and of the Protection of the Territory and of the Sea. The company also offers a traditional station-based car-sharing service. The booking of the vehicle, whether as per the B2B model or as per the B2C one, allows this operation to be performed starting from a minimum of one hour up to several days before actual use.

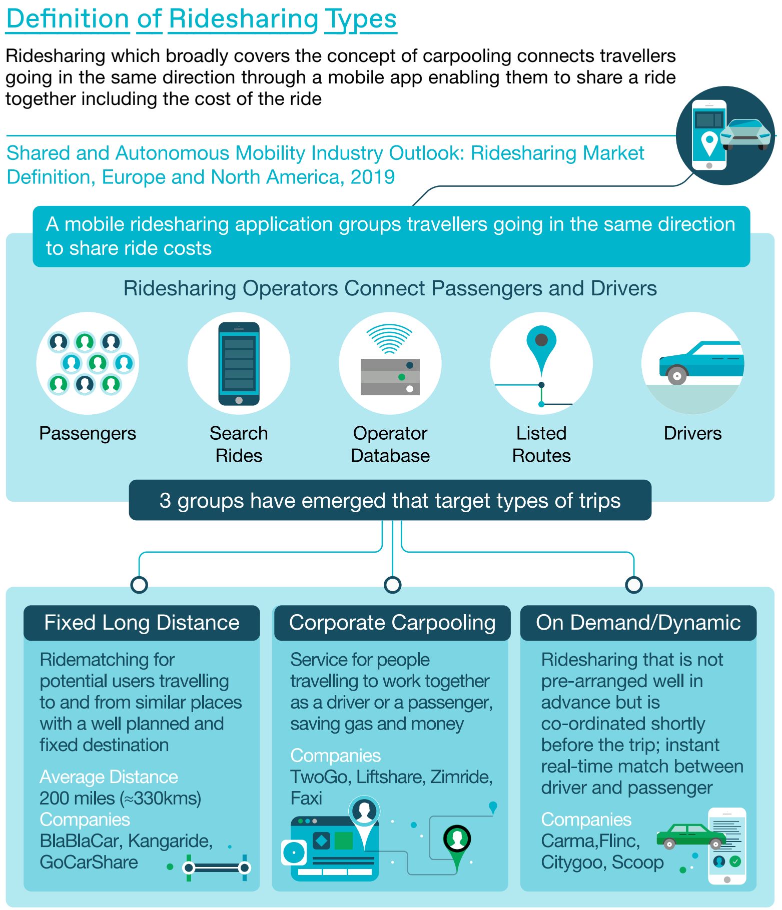
Currently car sharing fleets, regardless of the particular characteristics of the business model, are made up of both traditional vehicles and electric vehicles. Data published by the National Observatory for Shared Mobility show how in Italy there is a greater presence of ICE vehicles even though completely electric providers are expanding their businesses.

Sharen’go, in particular, is the first electric car-sharing service, established in 2015 on the basis of an Italian project, which promotes sustainable urban mobility. The company CS Group, owner of the Share’ngo brand, offers free-floating car-sharing services. The advantage for users is in not having to locate charging stations and in booking vehicles always fully charged. In 2019, Share’ngo can boast the most important electric fleet in Europe.

Ride-sharing / carpooling

Staying on the theme of shared cars, sharing the same vehicle can be a simultaneous experience common to multiple users who must travel in the same direction. In this case, the service offered is called ride-sharing or carpooling.

Ride-sharing or carpooling is one of the on-demand, on-request, shared mobility services, where one of the users of the service (P2P) is the vehicle owner.



Source: Frost & Sullivan

Ride-sharing services can be divided into three main groups based on the specific characteristics of the trip: “fixed long distance”, “corporate carpooling” and “on demand”. The composition of the crew is the constant that unites the three types: by carpooling, in fact, we mean a special car sharing mode in which multiple people share the same vehicle for the purpose of reducing transport costs. The providers on the market, i.e. platforms facilitating the matching of supply and demand, are numerous for each category.

The first carpooling platforms enter the market in the first decade of the 2000's. For example, Kangaride is a Canadian company, established in Montreal in 2006, which provides a ride-sharing platform for the publication and booking of long-distance journeys in North America.

Kangaride has a three-fold approach to safety. Firstly, each driver is checked, the validity of the driving licence is checked with confirmation provided by the transport authorities. Subsequently, all the rides are evaluated by the driver and by the passengers and Kangaride's worldwide customer assistance team carries out quality control on all new members.

One of the European platforms that matches supply and demand, and which is ranked as global leader in medium-long distances, is BlaBlaCar. The platform of carpooling that has practically monopolized the sector market in Europe, and which in 2015 arrived in India, was founded in Paris in 2006. In 2019 CB Insights included BlaBlaCar among the 50 European unicorns, with a valuation of $ 1.6 billion. The pool of BlaBlaCar users is of two different types: on the one hand, the demand, composed of those seeking a ride to a specific destination, and, on the other, the supply of routes generated by vehicle owners.

The former are given the possibility to find the best solution by inserting the location of departure, that of arrival and the time, without any registration on the platform. The owner and driver of the vehicle can for their part publish the offer of a ride only after having registered on the platform. The cost of the trip is suggested by BlaBlaCar on the basis of the type of journey, leaving, however, to the advertisers room to modify the fare. BlaBlaCar users share travel expenses and there is no profit motive on the part of the driver. The profits generated by the platform are supplied by those who book their trip and pay a commission on the booking, based on the journey costs as indicated by the driver.

BlaBlaCar also offers trips with particular characteristics, meeting certain user needs: it offers, for instance, “Pink Trips” for women who prefer to travel in a car with other women only.

In 2018 BlaBlaCar added a new feature to its payment transactions by eliminating the advance payment for trips through the app at the time of booking and introducing the possibility of paying the driver in cash.

The platform has made carpooling a common practice even for users who are unfamiliar with apps and digital platforms by changing business model and making it necessary to purchase a pass, weekly or half-yearly, which allows a virtually unlimited number of passes to be booked without paying surcharges on each route. Subsequently, the driver can decide how the trip is to be to paid for (in cash or electronic money, via PayPal or bank transfer). There is also the possibility of taking advantage of an insurance extension for carpooling services.

BlaBlaCar users benefit from a free insurance coverage underwritten by AXA, which is in addition to the private one associated to the vehicle.

In 2019 BlaBlaCar also launched a low-cost bus service for medium and long distances through a new platform, called BlaBlaBus, in direct competition with companies such as FlixBus. The offering of shared car travel on long routes is thus integrated with a large network of bus connections throughout Western Europe. BlaBlaBus stems from the acquisition of Ouibus, French bus market leader and BlaBlaCar has integrated into its platform the journeys previously offered by the company acquired and by its partners including, in Italy, MarinoBus.

Based on the same principles of saving and sustainability as corporate car sharing, corporate ride-sharing or carpooling is a sharing service for “rides” among employees in the same company (typically of medium-large size) home-work journeys, using an intermediary platform.

Internationally, the carpooling platforms on the market are numerous: among these TwoGo, released by SAP, to which companies such as Porsche, Puma, Roche, Amazon and others adhere. The TwoGo system integrates perfectly with e-mail programs such as Outlook, and with corporate travel and online expense management systems such as Concur. After the partnership with HERE, the world's leading platform for location systems, various routing technologies were integrated into the TwoGo platform in 2019, giving users the possibility to obtain information on traffic conditions while providing road authorities with access to public transport data in real time.

↳ "Here Technologies at Smart City Expo World Congress"

In Italy, in 2018, according to the data published in the 2018 *Sustainable Corporate Mobility Report* drawn up by the carpooling platform Jojob, this type of sharing allowed Italians to save in environmental, economic and distance travelled terms: over 3 million kilometres in fewer journeys, 420 tonnes of CO_2 not emitted into the atmosphere (an increase of 89% compared to 2017) and more than € 650,000 of total savings.

The same report shows that if 10% of employees of Italian SMEs went to work sharing a car with a colleague, in terms of fuel, the total economic savings for employees would be € 1,200 per head, removing more than 250 thousand cars from the roads.

↳ "Jojob.it Il carpooling con i colleghi"

Among Italian carpooling operators, we may find, for instance, Jojob, which originates from the experience of Bringme Srl, a company incubated by the I3P of the Polytechnic of Turin, and which offers a service designed to respond to the needs of commuters who each day travel back and forth between home and work.

Jojob supports companies that sign up for the carpooling service through two types of incentives: the assignment of reserved parking spaces and fuel vouchers, company products or other kinds of awards presented to employee-users. The companies must bear an initial item of cost connected to the activation of the service, which permits the issuing of a customized platform, and an annual fee established on the basis of the number of employees-users.

The customization also allows for the integration of extra services like "Jojob Bici e Piedi" (Jojo Bike and Foot) that makes it possible to certify home-work journeys made with alternative vehicles. In 2019 Bringme Srl was the

leading Italian start-up in the sector of corporate carpooling with a further presence in Spain.

Also the Emilian start-up Up2Go that offers an online platform that adapts to various corporate structures, which can create an online community for the sharing of journeys that are typically made in the course of the day. Well-known users of this platform are companies and organizations such as Barilla, Credit Agricole or the University of Verona.
Some ride-sharing operators in collaboration with other sectors are offering customized solutions based on the specific needs that emerge from customer data collected. One such is GoKid, which allows its users to organize carpooling trips with other families by adopting a peer-to-peer model.

GOKID

GoKid delivers complete carpool solutions for busy families. The app allows parents to easily schedule and manage carpools with their trusted network of friends, families and neighbors-no strangers and no paid drivers.

Total Funding
$3.75 mln

Last Round
Jun 2018 Seed VC-II
$1.5 mln

Country
United States

gokid.mobi

The app functions as a facilitator to bring together all those parents who have to reach particular events or destinations and intend to share the trip with other families. The service is also active in the form of school carpooling: a single parent driver accompanies their own children and those of others to school, in such a way as to support the daily activities of a both child and parents.

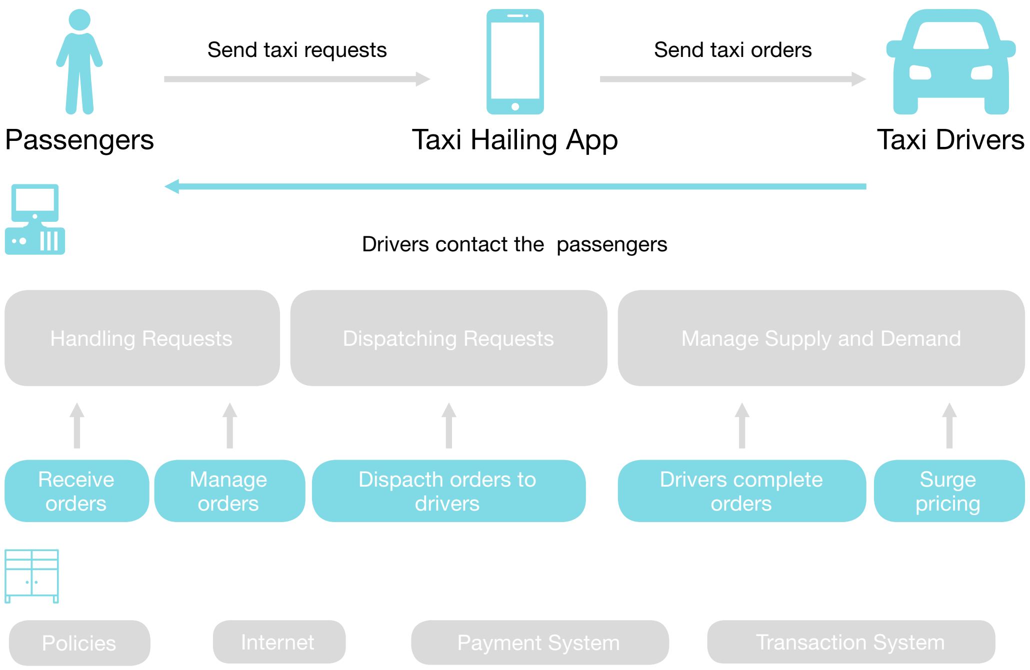
There are numerous startups and companies in this market segment. Most of these, concerning as they do, the transport of minors, have a meticulous control system for drivers. Furthermore, these business organizations diversify their product portfolio by offering other types of service similarly dedicated to childcare. One example is Kango, which has since 2015 expanded its ride-sharing services by adding babysitting services to the former.

Ride-hailing / eHailing

Ride-hailing services have developed and found their place in the mobility market as the major challengers to the traditional taxi market. The element that largely differentiates a ride-hailing service from that of a traditional taxi is bound up with the concept of eHailing, that is, in the procedures of vehicle booking/request and online payment guaranteed by user-friendly smartphone applications that are based on the geolocation of users and of the vehicles available.

The applications for the booking of traditional taxis or of cars made available by private citizens through intermediaries make the process of booking rides and of payment simpler, safer and more efficient, while, in many large urban areas, reducing vehicle waiting times. From what emerges from the study "Urban Mobility and Technology: the impact of eHailing" conducted by myTaxi, over a period of 12 months (October 2016 - September 2017, in Rome and Milan), the benefits generated by the diffusion of eHailing are flexibility of access and use of services, with positive effects on journey efficiency, and the simplified use thanks to a greater knowledge and transparency of the steps in the journey.

Source: Frost & Sullivan



As illustrated by Frost & Sullivan, eHailing services display various business models, envisaging the use of public or private taxis or else those made available by private users, in a peer-to-peer approach.

Definition of eHailing Business Models

Source: Frost & Sullivan

Taxi business models have changed over the years with advancement in technology and increasing mobile penetration rates redefining the way people hail a taxi today.

Shared and autonomous mobility industry outlook: eHailing market, global, 2019

	Public Taxi	Private/Radio Taxi	P2P-based Taxi
How passengers hail the ride	Taxis can only be hailed off the street or from taxi stands	Taxis can be booked in advance using the dispatch service (telephone/mobile)	Taxis can be booked by sending requests using the smartphone app
How passengers accept the ride	Once a taxi is located the passenger hails it	The passenger will be informed about the acceptance, possibly through a message	The passenger will be informed through the smartphone app
Driver requirements	Only Licensed drivers; must meet the basic prerequisites and complete training	Drivers should have a PHV license, and the vehicle should also meet specific age requirements	Works with licensed taxi drivers and private drivers who own a car

As regards the first two business models, one example of an emerging company in Europe - but today also world leader - that has been providing an intermediary service for taxis is MyTaxi, founded in 2011 in Germany. The MyTaxi app fulfills the user's need to book a taxi where and when required, and then to pay directly by credit card without the need for cash. One of the peculiarities of the service is arises from the possibility of previously calculating the duration of the ride to be booked and therefore also the final cost.

MyTaxy represents the gateway to the ride-sharing and eHailing segment for the Daimler automotive holding, which acquired the start-up in 2014. Furthermore, in 2019, following the joint venture with the BMW Group, some actions of rebranding that saw the replacement of MyTaxi with Free Now and the birth of various additional services were undertaken. As evidenced by internal studies performed by the eHailing company itself, 40% of the rides taken in Italy are for business, both for Italian customers and for foreign ones. In order to meet the needs of this market segment, Free Now makes it possible to receive the receipt in electronic format straight after the end of the ride and this can be integrated into the expense reporting system Concur, used by many Italian companies.

In 2017, the Wetaxi platform was founded in Turin, which intends to make its way in the market as a traditional taxi enhancement service.

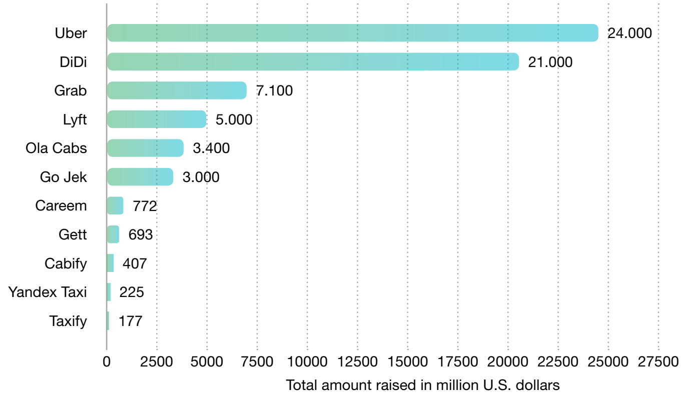
Thanks to its close partnerships with the major radio taxi cooperatives in over 20 Italian cities, Wetaxi makes it possible to book a taxi ride and know the maximum cost of the trip in advance. Subsequently, at the end of the journey, the system guarantees charging of the lower value between that calculated at the time of booking and that signalled by the taxometer. It also allows the user to share the ride with others who also need to cover a similar route, thus ensuring further savings on transport costs. There are basically two payment methods: at the end of the journey, the user can pay through the Wetaxi app or in cash on board the vehicle.

Some companies offering ride-hailing rely on the sharing of vehicles by private users.

The American market has always ranked as the largest geographical area for ride-hailing services and the expansion of provider companies. From Asian and the emerging markets, new organizations are continuing to grow: among the companies offering a ride-hailing service, the main global operator remains the U.S. Uber, but the expanding Asian DiDi and Grab are not far behind.

A Statista ranking of January 2019 allows us to identify those big players in ride-hailing that are most highly financed in global terms.

Total investment in the leading ride hailing companies worldwide as of January 2019 (in million U.S. dollars)



Source: Statista

Uber is the most-financed ride-hailing company in the world ($ 24 billion in 2019). Founded in 2009 in California its official launch took place in San Francisco in 2010. In May 2019 it went public. The company operates in 77 countries and more than 600 cities around the world, and its cars can be booked by using the website or the mobile application, via which customers can also keep track of the position of the car booked in real time. While the app is the same around the world, the services offered vary. At the end of 2019 Uber had approximately four million drivers thanks to the ease of access to this activity and its extremely flexible (and for many controversial) labour practices.

Since Uber continues to operate at a loss, in order to reach break-even point it is resorting to diversification of its business. Uber offers 13 different products, 3 of which attributable to the use of a car. Apart from the principal ride-hailing services it is actually possible to take advantage of food delivery with UberEats and of the rental of bicycles and e-scooters.

The two main gambles for the future of the company are alternative forms of transport (such as e-scooters) and self-driving vehicles. The expansion into alternative forms of transport, such as bicycles and e-scooters, represents for Uber a model of establishing customer loyalty in the long term. To meet these needs, in 2018 the Californian ride-sharing company acquired the bike-sharing start-up Jump for the sum of $ 200 million and also that belonging to Lime's micromobility sector. It has, moreover, collaborated with the peer-to-peer car-sharing company Getaround to launch Uber Rent and with the London company Masabi on a ticketing system for public transport.

In connection with autonomous vehicles, in 2015 Uber ATG (Advanced Technologies Group) was founded in Pittsburgh, USA. In 2019, the division had over 1,000 employees split among offices in Pittsburgh, San Francisco and Toronto: the company declared that it was investing the hefty sum of $ 20 million a month to develop driveless technologies. After its first activities linked to the development of technologies for the automation of heavy goods vehicles, Uber has been concentrating on robo-taxis positioning itself as a competitor of Waymo

(Google), nuTonomy (MIT) or Drive.ai (Apple) and Tesla. This technology would permit considerable savings on the cost of drivers.

> A robo-taxi, also known as a robo-cab, is a self-driving taxi usable through an eHailing service. The elimination of human intervention in driving will make it possible to reduce operating costs, making the solution more economical both for users and for the service providers.

In the shared mobility ecosystem too, there are numerous partnerships between established companies, OEM's and start-ups, set up with the aim of harnessing synergically innovations and technologies developed by different companies. Uber, specifically, launched in 2016 a collaboration with Ford and with Volvo with the intention of integrating Uber competencies into self-driving systems for car manufacturers' vehicles. The following year the partnership with Daimler was signed with the objective of introducing self-driving vehicles in the fleet of the ride-hailing services provider.

2020 saw the announcement, at the Ces in Las Vegas, of the partnership between Uber and Hyundai to rapidly put into service a generation of extremely agile electric aircraft capable of vertical take-off and landing (eVtol) by 2023.

Various other operators in the sector are collaborating with a view to developing and launching robo-taxi services over the next few years.

Company	Spin-off	Partnership
MIT	nuTomnomy	Renault and Mitsubishi (vehicles). Grab, Gruope PSA (Peugeot), Lyft (service in Boston).
Apple	Drive.ai	Stanford University. Lyft, Grab.
Google	Waymo	FCA, Renault, Nissan, Jaguar (vehicles). Avis, AutoNation (maintenance). Lyft.
GM	Cruise Automation	Chevrolet (vehicles)

Lyft is pursuing the same goal as Uber, which is to put onto the market a level-4 automonous vehicle, for which no human interaction will be required in the management of travel. Lyft was founded in 2012 with a mission to build a peer-to-peer transport solution that could help to make transport in the city safer and more economical. In 2016 it launched the first tests with self-driving taxis, supported by an investment of $ 500 million from General Motors.

↳ "Introducing Lyft Rentals: Car Rentals Reimagined"

To compensate for its bottom lines in the red, Lyft also diversified its product portfolio by entering the rental car market, offering the service to users under the age of 22 too. The attempt to enter the rental car market, dominated by a few players with large market shares, had already been made by Uber through a partnership with the car-sharing company Getaround, which ended at the end of 2018. In 2019 both Uber and Lyft went public.

In the Statista ranking, the Chinese ride-hailing company DiDi, formed in 2012 from the merger between rivals DiDi Dache and Kuaidi Dache, controlled respectively by Tencent and Alibaba, overtakes the giant Lyft in terms of financing received and is presented as the world's largest transportation service platform with an 87% share of the Chinese market.

Like all companies in this segment, DiDi has not yet posted a profit, declaring a loss of $ 1.6 billion in 2018. Since DiDi is currently able to satisfy only 65% of ride-hailing requests, in 2019, it announced that it would launch its robo-taxi service with level-5 autonomous cars by 2030, thanks to which it expects to close the gap between supply and demand.

DIDI CHUXING

Didi Chuxing is a multi-modal transportation platform.
The company offers a full range of app-based transportation options including taxi, express, premier, luxe, bus, designated driving, enterprise solutions, bike sharing, e-bike sharing, car sharing, and food delivery. It was formed by the merger of Kuaidi Dache and DiDi Dache.

Total Funding
$19,166.9 mln

Last Round
Jul 2019 Corporate Minority $600 mln

Country
China

didiglobal.com

Shared micromobility: bike sharing and e-scooters

Micromobility services reduce the number of cars on the road within urban centres and provide a convenient and cheap means of transport for travel over short distances.

For city dwellers renting a bicycle or a scooter can, in fact, be much more economical than owning a car or paying taxi fares. Nevertheless, there are still some challenges associated with bicycles, motor scooters and e-scooters, which range from their general adoption to issues concerning regulation and infrastructure.

The concept of micromobility has developed through three stages, each of which is articulated on one of the main basic characteristics of the service: station-based, free-floating and peer-to-peer.

In Europe the first stage of micromobility began with the possibility of taking advantage of a service of on-demand station-based sharing. In the mid 1990's locking devices were introduced for shared vehicles along with payment systems that made possible the diffusion of these new forms of mobility.

Bycylken, launched in Copenhagen in 1995, was the first large-scale station-based bike-sharing project in the world, with a coin-based payment system: users, by inserting a returnable deposit in one of the bicycle supports, could use the service in a specific central area of the city without limits of time.

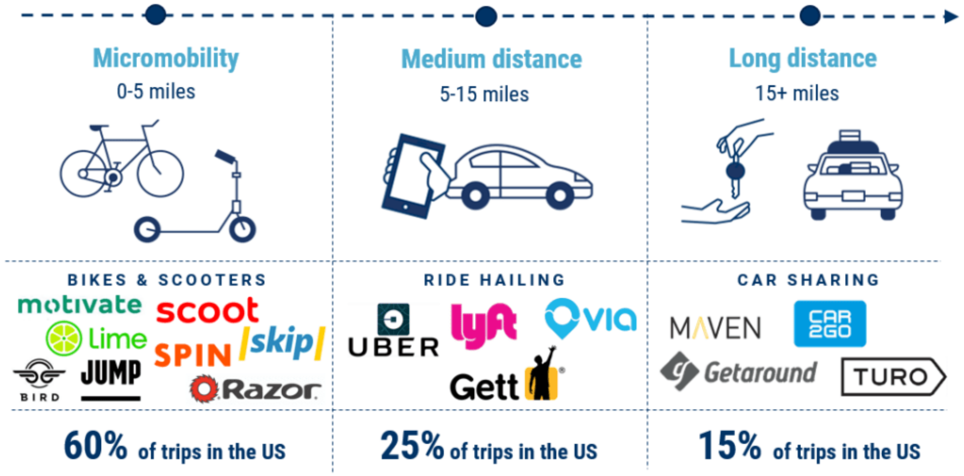
The system was upgraded and relaunched in 2014, assuming the characteristics of the free-floating model, and in 2019, thanks to an agreement with the Italian Sitael, it was integrated with Vaimoo features (system of secure locking, satellite geolocation, access to usage data and diagnostic information on fleets in real time, prompt intervention in the event of accidents and bicycle repairs) developed by the Italian company. The ultimate goal of the Danish operator is to replace completely, as early as 2020, the current fleet of bicycles with new generation electric models produced in Italy.

The weaknesses of station-based bike sharing are linked above all to economic issues: these are not very profitable systems and typically the provider's costs are greater than revenues. Costs, in addition to those relating to the vehicle itself, include those related to the construction and maintenance of docking stations. Precisely in order to reduce these overheads, operators have switched to free-floating solutions, thanks also to the strong penetration of the smartphone globally and to the diffusion of GPS technologies for the geolocation of vehicles and users.

The following stage sees lastly the introduction onto the market of motorized vehicles: not only shared electric bicycles, but also motor scooters and e-scooters.

Disrupting the car

Alternatives to car ownership by trip lenght

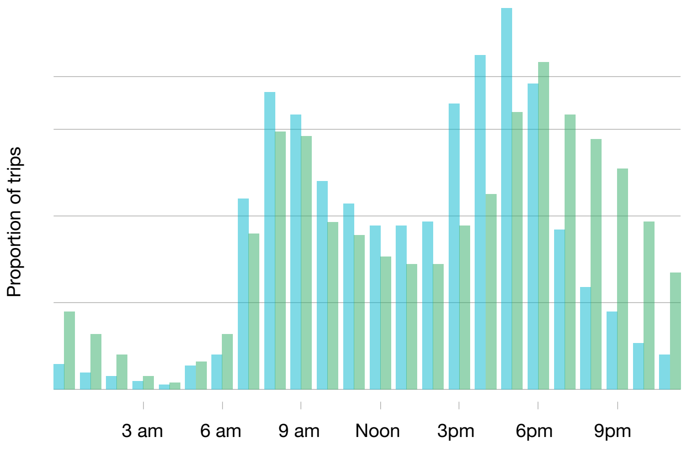


Source: CBInsights

CB Insights highlights how start-ups that deal with short-distance transport (less than five miles) have, over the last few years, populated the shared mobility ecosystem. Shared transport systems such as bicycles and e-scooters are spreading precisely because they seem to resolve a series of inefficiencies in local public transport, facilitating so-called "first" and" last mile" journeys, as well as journeys from and towards public transport hubs (bus terminuses, underground stations, interchange car parks, etc.).

In July 2019, Uber declared that the rides taken on the electric bikes provided by Jump, the e-bike sharing platform acquired by Uber itself, had cannibalized the rides traditionally belonging to the core business of the parent company (ride-hailing services).

Jump is cannibalizing Uber rides during high congestion periods



Source: CBInsights

Jump Uber

Asia, thanks to the presence of less stringent legislation, has been the pioneer and leading continent in the panorama of micromobility and, in particular, of bicycle sharing: China was, in fact, the first nation to implement a free-floating bike-sharing platform in 2015. This lack of regulation, however, has brought with it a number of issues: the market has quickly reached a point of saturation and millions of bicycles have begun to accumulate on urban roads.

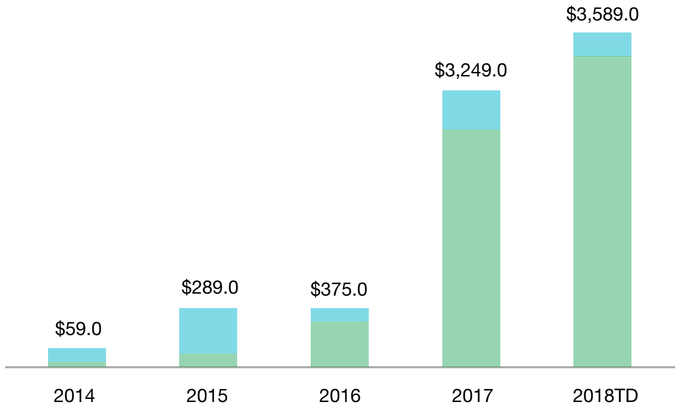
The problem of uncontrolled parking of vehicles on city roads is also apparent across Europe. The city of Berlin, like others, has given permission to a provider of station-based bike sharing to build its own stations, but it has not set limits on the number of free-floating companies. In a situation like this, the providers of services based on the sharing of bicycles with stalls are subject to the barriers to market entry and to a drop in their market shares, if the role of main provider has already been identified by city authorities and if the free-floating does not present particular limitations. The latter can still be limited by the authorities: for instance, the city of Barcelona allows the presence of bike-sharing services only if station-based.

The choice of suitable locations for stations is, moreover, crucial for guaranteed efficient use of the station-based system: the stations should, in fact, be situated at regular and convenient intervals across the whole service area, with particular attention to the design for the matching of the stalls to the urban landscape.

As highlighted by CB Insights, although infrastructures represent a huge cost for companies, almost all the funding in support of shared micromobility has been allocated to the creation of digital platforms, rather than to the construction of hardware useful for enabling the service and for real vehicles vehicles.

Sharing platforms drive bulk of bike/scooter funding

Deal activity from 2014-2018TD (8/29/2018) in millions



Bike/scooter hardware
Sharing platforms

Source: CBInsights

Observing the players populating the bike-sharing ecosystem, one of the first start-ups in the sector is the Chinese Mobike, which, founded at the beginning of 2015, registered exponential growth in its first two years, reaching a valuation of approximately $ 3 billion in 2017 with services active in over 200 cities and 19 countries around the world.

The Chinese company has brought to Europe its model of free-floating bike sharing and a low cost for users.

The Italian bike-sharing activities and related Mobike bicycles are managed by the company Idri Bk, which in 2019 also took over the European activities thus extending its presence all across the old continent. The operation will lead to the birth of the new brand Movi, which will replace Mobike, above all in the area of Southern Europe, where there are over 1.5 million service subscribers. With Movi, Idri Bk could therefore become one of the most important companies both in Europe and globally in the field of shared mobility. There is, moreover, an intention to expand the existing core business: Movi will not just focus on bicycles, but will increase the number of electric vehicles -among the new features proposed there are new models of electric bicycles, various versions of e-scooters and electric motor scooters on two and three wheels, in addition to a covered vehicle for the winter months.

One recent new feature that has contributed to facilitating last mile mobility in urban areas was the rapid diffusion of the shared electric scooter service. In 2012, Scoot Networks launched a first motor scooter rental service replicated subsequently by operators Bird and Lime, which, in 2017, introduced onto the market e-scooters earning themselves a clear success.

The service took off in Italy at the end of 2017 in the cities of Rome and Milan, with the operator being Italian market leader MiMoto, active to date in Milan and also in the cities of Turin and Genova. In 2018 alone, in Italy the fleet of shared motor scooters increased more than fourfold (90% of which with an electric engine) and the average rate of growth of registered users has reached 350% in the last four years.

MiMoto offers a service of free-flowing electric scooter sharing, usable via app and without the use of keys. The system allows for the rental of vehicles approved for two persons and equipped with two helmets of different sizes, usable across the whole urban area without the need to pick up or drop off at charging stations.

One year on from the launch of the service, in 2018, the fleet had reached 400 units in the city of Milan, reproposing the same service in Turin (with 150 vehicles). Registered users have reached the 30 thousand mark, attracting the particular attention of the young and of the female populatio. The service facilitates city travel, offering a quick, environmentally sustainable and easy to ride alternative.

If we focus on the e-scooter ecosystem, we observe that the sharing services are free-floating, and can be tracked through an app and thanks to a GPS system. At the end of the rental, payment is made automatically, through the app connected to the user's credit card. On average the costs are lower than those of a bus or underground ticket and all the expenses related to charging the vehicles are borne by the provider.

The vehicles belonging to this class – which includes, in addition to bicycles and e-scooters, also hoverboards, segways and monowheels – display two key characteristics: low weight and low speed. These two aspects mean that the new micromobility vehicles need a minimum quantity of energy to move – so emissions are very low or non-existent – and are not bulky, whether on the move or parked. The use of small lightweight vehicles with zero emissions, and easily shared, represents a strategic opportunity for the promotion of an ever more sustainable urban mobility.

Micromobility represents a fertile and profitable seedbed for start-ups (such as Bird and Lime, which at the end of 2019 have valuations in excess of $ 2 billion), well-established companies in the sector of shared mobility (such as Lyft and Uber) and automotive giants (such as Ford Motor Company, which acquired the Californian bike and scooter sharing start-up Spin).

The first models of on-demand electric “kick scooters” or “push scooters” were introduced in the United States, implemented for the first time in Santa Monica by Bird using a consumer product developed in China.

Bird, which is positioned as one of the colossuses of micromobility, founded in 2017 in California by the ex-president of Uber and Lyft, after a year of activity it was already present in over 100 cities around the world reaching 10 million rides taken on its e-scooters in September 2018. After little more than a year in business, in 2019 it acquired Scoot Network, expanding its coverage of cities served. The first vehicles with the Bird brand were produced by Xiaomi, a Chinese electronics company, and Segway, an America bicycle producer. In 2019 Bird launched some models produced in-house,

BIRD RIDES

Bird Rides is a micromobility company that lets customers rent dockless electric scooters with the tap of an app then leave them on the street when they're done.

Total Funding
$693 mln

Last Round
Oct 2019 Series D
$275 mln

Country
United States

bird.co

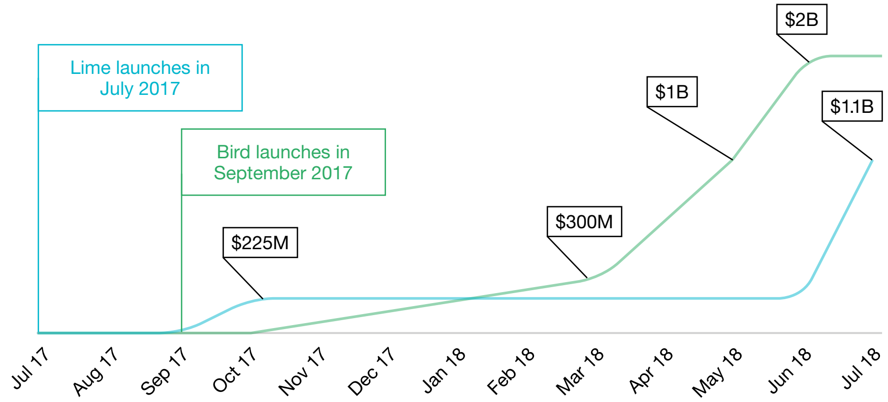
more robust and thus more suitable for an on-demand rental service.

The other American colossus of shared micromobility is Lime, a company founded in 2017 in the United States that offers e-scooters, electric bicycles and pushbikes with its free-floating scheme. Tests with electric bicycles and e-scooters started at the beginning of 2018 and in the middle of that same year began the collaboration with Segway for the production of vehicles. Again in 2018 Lime also formed a partnership with Uber, the aim of which is to provide the ride-sharing giant with a fleet of electric bicycles for the expansion of the Uber Bikes service. To differentiate its own business, Lime has also expressed its intention to develop self-driving electric transit "pods" and has launched a car-sharing service with a fleet of FCA cars branded LimePod, available only in some U.S. cities.

Bird, Lime reach unicorn status in a matter of months

Source: CBInsights

Private market valutations for scooter startups Bird and Lime



The two companies, Bird and Lime, have reached unicorn status in less than a year of activity. The global growth of these companies was enhanced by the launch their own services in the cities before adequate regulation had been approved, as a result forcing public administrations to tackle the uncontrolled diffusion of bicycles and e-scooters.

In this area of shared mobility too, new partnerships are being established with the intent of increasing business opportunities for the players involved.

Some forms of cooperation for instance provide for the integration of mobility services into local ecosystems, with local businesses such as hotels, restaurants, cinemas, shopping centres or university campuses. By way of example, the Italian-American e-scooter company Helbiz – founded in 2015 and with headquarters in New York - is working closely with hotels not located on the beach in the cities of Miami and Los Angeles. This collaboration helps guests reach the beach easily, increasing the hotels' competitive position. Helbiz, in Italy, has also initiated a collaboration with Telepass, to permit booking and payment of e-scooter rentals through the Italian operator's app.

Even companies distant from the world of mobility are investing in micromobility: for instance, the German company, which is part of GDO Lidl, has launched, in partnership with German railways, a free-floating bike sharing service based on the previous Call a Bike sharing scheme.

Europe and China, pioneers in on-demand micromobility in the area of bike sharing, with their consolidated cycling cultures and because of the lack of legislation, did not initially grasp the market value of e-scooter sharing services but remain markets active in the area of vehicle production.

According to data published in Innoz's "*Global Scootersharing Market Report 2018*", in 2018 the e-scooter manufacturers that provide vehicles for sharing services are less than 30 in number worldwide with a production of electric vehicles markedly broader than of those with a combustion engine. The manufacturers that dominate the global market – and that come, above all, from Europe and Asia - are Govecs (with a market share of 26%), Torrot (15%) and Gogoro (14%).

HELBIZ

Helbiz is an intra-urban transportation company aiming to solve first- and last-mile transportation problems of high-traffic urban areas. The company offers HelbizGO which provides users living in urban areas on-demand access to affordable, easy-to-use scooters for small trips, and feature on-board connectivity and electricity-powered batteries.

Total Funding
$15.13 mln

Last Round
Oct 2019 Corporate Minority $8 mln

Country
United States

helbiz.com

Even in this portion of the market are to be found well-known brands from the automotive sector that have decided to expand their business and follow the trend of the moment: SEAT, for instance, in Spain, has already launched its eXS scooter produced in collaboration with Segway and Volkswagen and is ready to introduce its Cityskater into several markets.

↳ "Volkswagen Cityskater and Streetmate"

As far as the diffusion of e-scooters is concerned, this, in many countries, is a consequence of the introduction of new regulations. In Italy, the first operators in this segment made their entry in some big cities only in the last months of 2019, while in other European countries e-scooters are already part of the urban landscape.

The first European city to take advantage of these innovations was Paris, where their widespread diffusion, buoyed also by the many purchases made by private customers (over 200,000 in 2018), has resulted in the city council banning their use and parking on pavements. In Paris, as elsewhere, the circulation is generally permitted in specific areas, on the road – in Turin in the areas with speed limits of 30 km/h - or on cycle paths, while their use and parking is forbidden on urban footpaths.

Since legislation and local authorities can incentivize the diffusion of shared mobility or, in contrast, be a barrier to operators in the market, public-private partnerships and, in some cases, the co-financing of the physical infrastructures necessary for the enhancement of urban mobility can represent a boost for the whole ecosystem.

For example, in the United States, Bird has undertaken to collaborate with city councils to finance the construction of cycle paths that would facilitate their bike sharing service: in this way, the city will be able to reduce the traffic providing residents with various means of transport and Bird will be able to gain new customers who previously were unable to use the service.

Demand-responsive transit (DRT)

Source: Trendwatching

On-call transport – known as Demand Responsive Transport – DRT, Dial-a-Ride, or also Paratransit - is one of the instruments of sustainable mobility implemented in various situations in support of the local public transport systems.

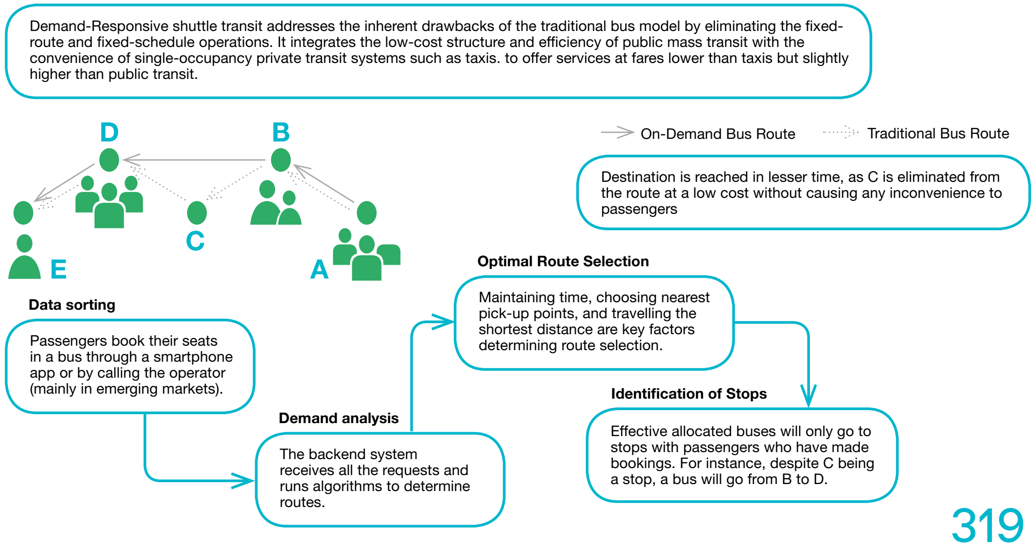
This consists in using a fleet of small public vehicles, for instance, minibuses, which can make possible personalized journeys on the basis of user requests, with starting point and destination chosen as required each time, transporting a group of users and managing the succession of journeys with a certain level of flexibility so as to be able to satisfy all requests.

The Concept of Demand-Responsive Transit

On-demand buses leverage big data to determine bus routes and timing, improving efficiency of the system, reducing congestion and emissions, and delivering convenience at a fraction of cost of private transport.

Source: Frost&Sullivan

Demand-Responsive Shuttle Market: Demand Responsive Transit Concept, Global, 2018–2030

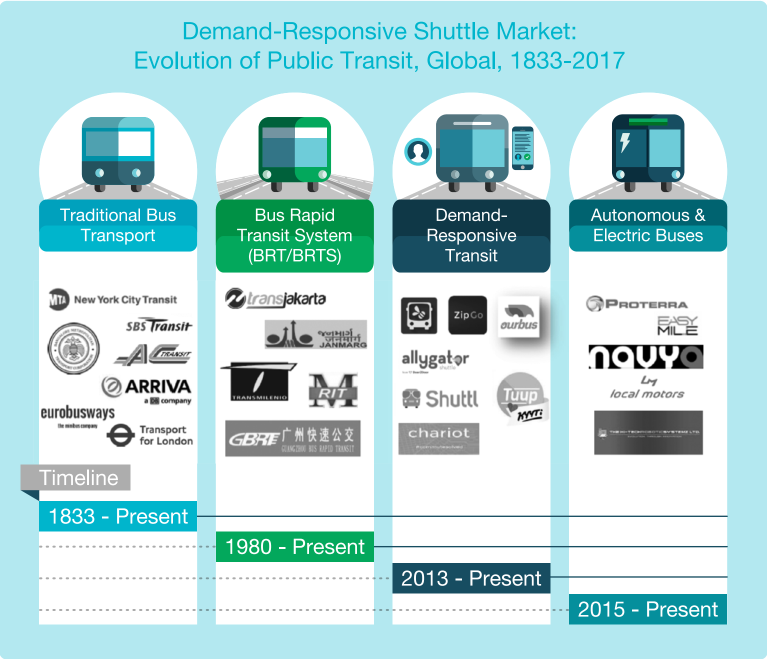


The demand-responsive system of transport is able to plan the route of every vehicle used on the basis of requests received. The models used to manage these systems are also adaptable to the transport of goods, albeit with a slightly greater level of rigidity. In general, operators seeks to meet two opposing needs:

- minimization of operating costs, which can still soar in the presence of the maximum possible flexibility;
- maximization of the level of service offered to the user, which diminishes if the waiting or journey times increase.

Evolution of Public Bus Transit Systems

Mass transit transport systems, among the most important, have evolved continuously, primarily to make themselves more efficient, effective, and economical, with better utilization of time and resources



Source: Frost & Sullivan

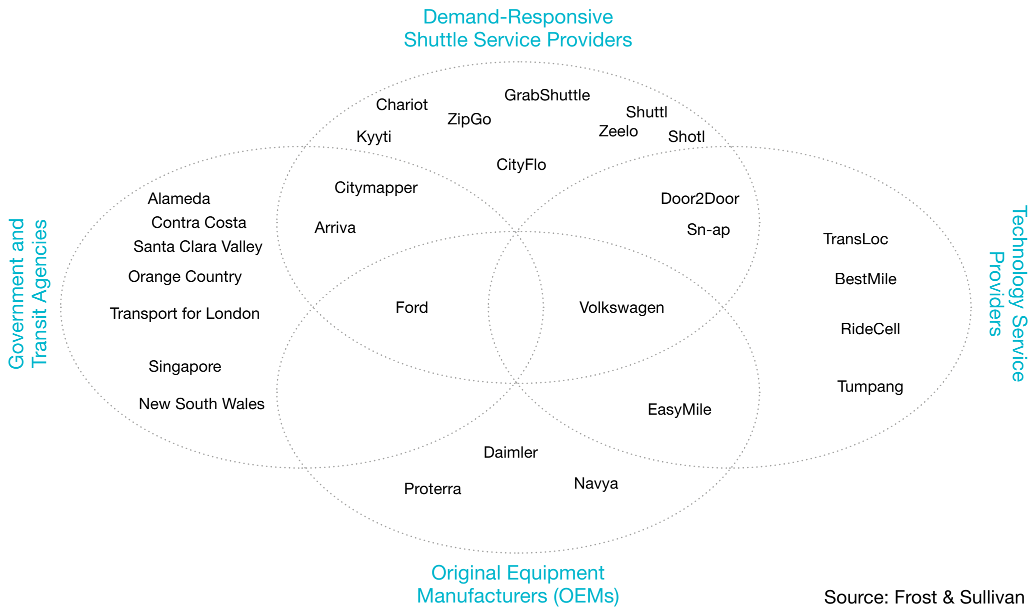
DRT transport services are the evolution of on-road public transport, and are principally organized along three main models, differentiated according to user type:

- **Corporate**. B2B solution with the company paying for the transport of its employees from and to their homes, transit centres and offices. For example Chariot, founded in San Francisco in 2014 and which discontinued its service at the end of 2019, offered commuter shuttles, specifically to facilitate home-work journeys.
- **Public**. The service can be provided over short and long distances and can be structured like a traditional route with a predefined itinerary or on a flexible route. For example, Go-Ahead (GOG) in partnership with the Oxford Bus Company offers PickMeUp: a minibus service for ride sharing on request.
- **Charter**. In this case is meant a transport service from and to specific events. This type of DRT is, for instance, offered by Skedaddle.

According to Frost & Sullivan, the size of the global fleet for the DRT market should grow to over 4 million by 2030.

Stakeholder and Player Ecosystem

As the number of service providers increases, there is a growing integration and inter-operability between different segments.



Source: Frost & Sullivan

The Demand-Responsive Transit market ecosystem is composed of different organizations, ranging from start-ups through well-known car manufacturers to local government.

DRT services seek to ad offer solutions for routes with a high demand, above all in the central areas of cities. The customer experience offered is usually better than mass transport, in particular thanks to the ease of ride booking via app and by involving users willing to pay slightly more than the cost of public transport in order to have a personalized travel experience.

The importance of DRT systems stems from their provision of access and geographical coverage, although the still insufficient revenues represent a challenge for the attainment of this objective. The long-term financial sustainability of these systems continues to be put in question, with a limited number of systems acknowledged as being commercially sustainable given the cost of the activity. The result is that some DRT services have been terminated or, in some cases, replaced by conventional bus services.

One example of this evolution is that of the aforementioned Chariot, which ceased its activities in December 2019. Established in 2014 in San Francisco, it used algorithms to develop transit routes on the basis of the requests of users registered through an app. In 2016 Chariot was acquired by Ford for $ 65 million after having penetrated other local segments of the U.S. and U.K. markets.

In Great Britain, in fact, it is possible to use a service of Demand Responsive Transit handled by Oxford Bus on behalf of the ride-hailing company Go-Ahead. The offering, known as PickMeUp launched in 2018, is a minibus service for ride sharing on request, initially launched to serve the business park on the eastern side of Oxford, together with the city centre. The fleet, in a year of activity, went from six buses to nine and 26 jobs were created. Through an app the user can indicate a travel need need, thanks to geolocation technologies the platform is able to detect the user's position and collect the user nearby. The passengers are matched with others who wish to make similar journeys to permit the ride to be shared. Payment for the service can be made by means of the registration of a credit/debit card or a PayPal account.

Go-Ahead has formed a partnership with the ride-sharing start-up Via (New York) to launch its service in New York City, Chicago, Washington DC, London and Amsterdam. The company has a growing number of partnerships with cities, public transport authorities and private operators around the world.

New start-ups in the sector are emerging in the Italian context too. For example, PickMeApp is a start-up from the south of Italy, present on the market since 2015, whose particularity is its specific user focus: it is aimed, in particular, at serving the needs of the elderly and of children, remaining, however, available without limitations.

Motorists possessing a rental with driver licence, passenger transport companies and/or associations or rental services with drivers can apply for commercial affiliation with PickMeApp. The start-up provides its affiliate with its own brand, its own commercial and technological know-how, it manages the fleets and customer relations, as well as marketing campaigns and communication; the affiliate establishes their own operating hours, performs the services booked and collects the revenues from its activities.

According to the report dedicated to DRT by Frost & Sullivan, the on-demand transport will not completely replace public transport, but will position itself as a service that is complementary to that of the traditional fixed route. In addition, as we have seen in the chapter dedicated to autonomous mobility, in the next 5-7 years we will witness the introduction onto the market of self-driving shuttles. Experiments with autonomous shuttles have already begun in countries such as Switzerland, Japan and United States, as well as in the Middle Easte.

PICKMEAPP

PickMeApp is a mobile application providing transportation services aimed at route optimization in Italian cities.

Total Funding
$0.46 mln

Last Round
Aug 2018 Unattributed VC $0.46 mln

Country
Italy

pickmeapp.it

Opportunities and challenges of shared mobility

The diffusion of different models of shared mobility presents us with ambitious challenges in environmental terms (the redrawing of urban geography), as well as in social terms (user uncertainty vis-à-vis emerging technologies) and in economic ones (new business models).

The consumer's profile as "Prosumer"

The main aim of the new business models is to create an integrated and connected ecosystem, revolving around the user and intended to guarantee an optimal and personalized experience.
Shared mobility service operators assign a key role to the element of interactivity and collaboration with the consumer, who is no longer seen as a mere user of vehicles and digital platforms but rather as an active user.

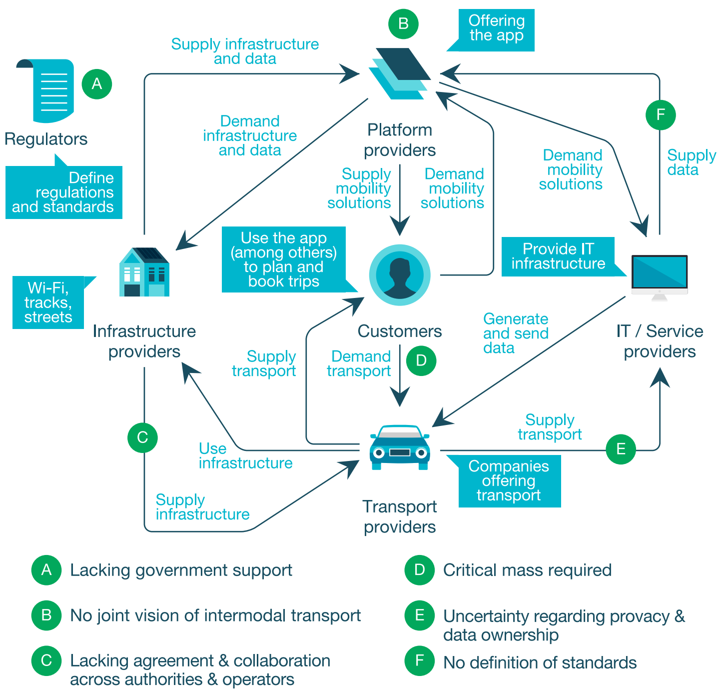
The term "*Prosumer*" indeed highlights the new leading role of users, capable of being consumers and producers of information at one and same time, in addition to being directly involved in product design or in the provision of the service.

This is made possible by an efficient system of feedback, online chatbots and comments left by the users themselves in the appropriate communication channels developed in the platforms, which permit the constant monitoring of the degree of user satisfaction and continual improvement of the service.

In only a few years a shift has taken place from a market oriented to the product to one focused on people, in which real-time interaction allows the provider to constantly modify the contents of services and to adapt them to consumer needs.

The possibility of tracking vehicle movements and of analyzing the associated data allows operators to draw on a huge amount of information; the data, and their processing through software and algorithms, are then used for targeted and ever more personalized business actions.

Supply-and demand-side factors



Source: Statista

Particularly in the field of shared peer-to-peer services, the platform assumes the essential function of creating an extended community that lends itself to the creation of bonds of mutual trust between drivers and passengers.

The relational dimension, besides representing a distinctive element and a driver for users, is also an output of the service itself. The systems of *digital reputation* and *trust building* used by operators assume a key role in promoting transactions between strangers and the creation of bonds of trust among users. Through elaborate algorithms that process a plurality of user information (personal data, feedback received, level of experience), it is possible, in fact, to draw up a reputation-based profile of the members of the platform.

The impact of these systems, summed to brand loyalty, leads users to increase the number of possible transactions on the platforms and to create interpersonal and community relations. It is therefore essential for a service of efficient shared mobility to create a relationship based on mutual trust between driver and passengers, as well as that towards the digital platform adopted by the operator.

Urban traffic and the environmental question

The need to provide an answer to the problem of global urban traffic is becoming ever more urgent. The disruptions and costs associated with traffic congestion, as well as the total number of hours spent in cars by a large part of motorists have increased to alarming levels worldwide.

According to McKinsey analyses, in the 2010-2016 period traffic congestion rose by 14% in London, by 30% in New York and by 9% in Beijing and Paris, with relative consequences for atmospheric pollution and for the health of citizens.

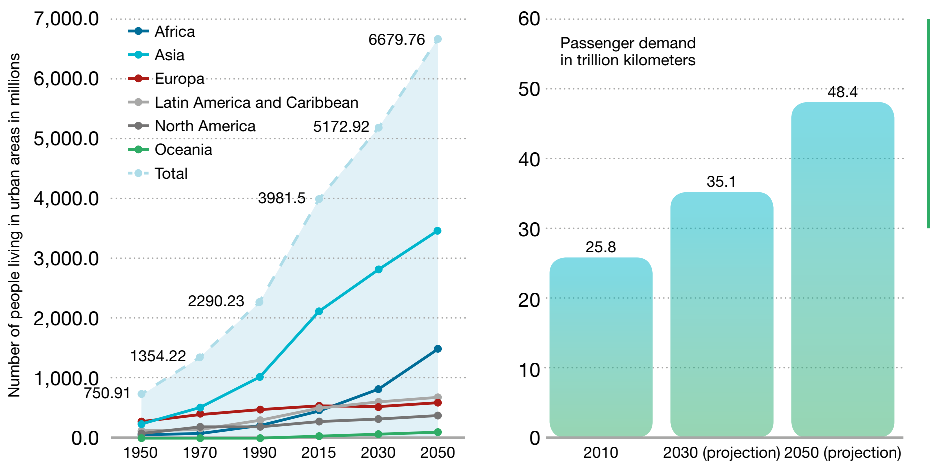
The same study estimates that the problem of traffic congestion costs, in the United States alone, 121 billion dollars, or more than 1% of total GDP. In this scenario, Europe registers an average of 505 cars for every 1,000 inhabitants, which, in view of the constant increase in urbanization and in business of e-commerce, risks becoming unsustainable.

According to Statista data, it is forecast that the demand for single-user mobility in urban centres may almost double over the next few decades (from approximately 26 trillion km in 2010, to almost 50 trillion in 2050).

Population growth in urban areas will continue to fuel mobility demand

Urban areas are expected to spur demand throughout 2050

Source: Statista



In this alarming scenario, the question of how to exploit the unused capacity of privately-owned vehicles remains open.

According to McKinsey, cars are inactive for approximately 96% of their useful lives, spending 0.5% of the time in traffic and 0.8% in the search for a parking space. Moreover, if it is considered that often the vehicle is carrying only the driver (75% of cases), it can be concluded that overall the vehicle is used for 2.6% of its life and that it does not make full use of its potential capacity.

The huge overheads, regarding use and maintenance inherent in the use of a vehicle, thus have a far greater weight than actual use.
The same analysis calculates that if all the cars in circulation made available a ride for at least one passenger, every vehicle would permit a saving of 3.36 tonnes of CO_2 per year.

The *National Observatory on Shared mobility* estimates, moreover, that, in the event that parked vehicles' residual capacities were fully harnessed and shared, as occurs more commonly in the United States with the P2P car-sharing platforms, these would eventually produce an estimated income of about $10,000 per year, raising the level of use of the vehicles.

Many users are ever more aware of this question and identify a potential solution in the use of shared mobility services.

The OECD asserts that replacement of private motorized transport with the various services of shared mobility integrated among themselves, would lead to a reduction in urban road congestion and accident rates, as well as to a reduction by a third in CO2 emissions and by 95% in the need for public parking spaces.

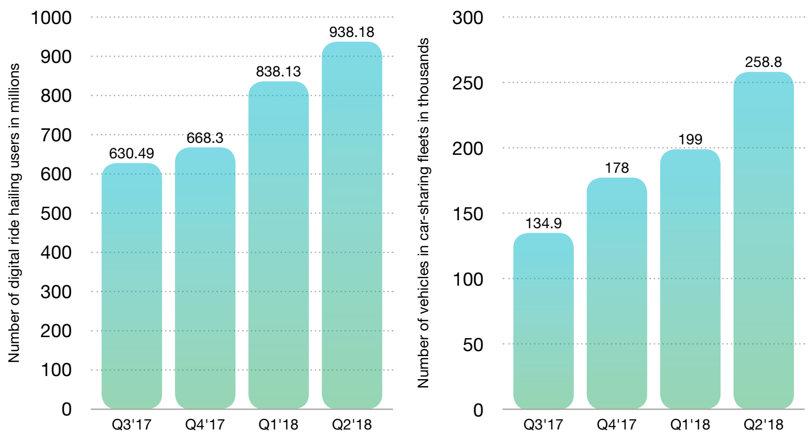
The analysis shows that, although shared vehicles circulate for a higher overall number of hours than private ones (approximately 10 times the number of kilometres covered by a private vehicle), the concentration could still be reduced in the rush hours (by 37%) as could the vehicle's life cycle, allowing for a more rapid penetration of fleet electrification.

This position is also supported by a study conducted by a group of researchers from the Massachussetts Institute of Technology who have calculated that a total of 13,000 New York taxis could be replaced with a fleet of 3,000 carpooling vehicles. According to an algorithm elaborated by experts, in this way 98% of demand would be met with waiting times of 2.8 minutes. The transport would require only 2,000 vehicles, on the other hand, in the event that "vanpooling" (with a capacity of from 5 to 10 passengers) were considered.

These numbers are contested by data processed by Statista that show how, in 2018 alone, globally numbers of ride-hailing users increased (938 million by mid-year), but the number of vehicles in circulation also increased due to car-sharing fleets, which have almost reached the 260 thousand unit mark.

Number of mobility service users and vehicles on the rise globally

User base grows in tandem with vehicle fleet as of 2018



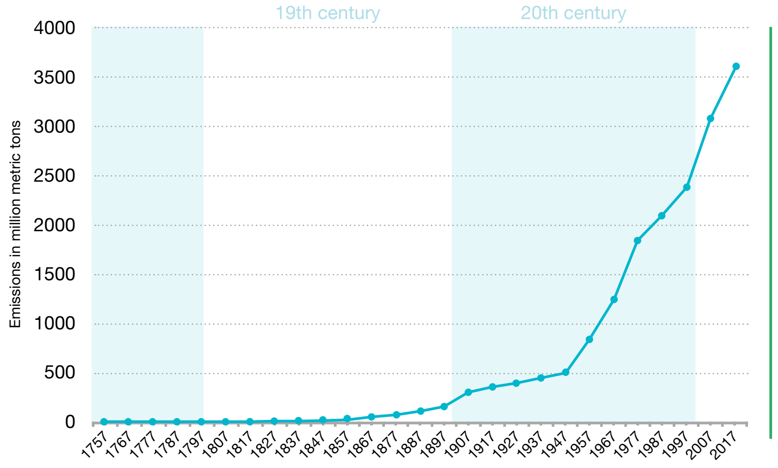
Source: Statista

Considering, moreover, that the percentage of shared PHEV's is currently low, the increase in the number of vehicles in circulation is aggravating the already critical situation of urban atmospheric pollution.

The initiatives for the safeguarding of the environment undertaken in various countries have led to the diffusion of operators of bicycle services, or ones for electric scooters or cars (Lime, Bird, Ola Electric, VW's MOIA), including Uber's Jump and Lyft's Motivate. This could have significant effects on CO2 emissions, since in the United States alone, in 2018 a ratio of 800 vehicles for every 1000 inhabitants was reached.

Carbon dioxide (CO2) emissions rise in tandem with growing car parcs

Global CO2 emissions from fossil fuel combustion and industrial processes 1757-2017



Source: Statista

The Transport & Environment report (2019) raises, for its part, considerable concerns about an uncontrolled development of the phenomenon of the new shared and autonomous mobility.

It is easy to think that the economic advantage will facilitate passenger journeys, but this will entail negative factors such as the increase in kilometres covered, the negative impact on urban traffic and on polluting emissions, as well as collateral effects on the quality of life in urban areas. Particularly as regards autonomous shared vehicles, the lack of adequate regulation could incur the risk of heightening users' dependency on cars and increasing traffic and the possibility of seeing empty cars in circulation.

One prime example of the improper and unsustainable use of a car sharing service is that of Car2Go in the city of Turin. It has been found from the records of journeys made that most of the routes taken by vehicles are in the city centre and correspond exactly to routes served by public transport, which can be covered by bicycle or by other more sustainable means of transport.

For this reason, shared services – in particular car sharing, ride-sharing and ride-hailing – become, to all effects, a competitor to sustainable public transport and heighten the positive perception of car travel as flexible and comfortable, to the detriment of changes in habits.

According to the "MobilitAria 2019" report presented by the Kyoto Club and the Cnr-Iia, in Italy in the last two-year period the use of public transport and of shared mobility in the central areas of Milan, Turin, Florence, Rome, Palermo and Cagliari has increased. A negative piece of news, however, is the fact that the number of vehicles registered has again risen in cities and metropolitan areas, above all inTurin (+5% 674 vehicles/1000 inhabitants) followed by Bologna (+3%, 531/1000 inhabitants), where the car remains the most used vehicle.

Thus the impact that shared mobility solutions may have on traffic jams and on atmospheric pollution globally remains a matter of debate.

The development plans of such business models can be fully effective only if integrated into a broader urban planning that incentivizes consumers to make priority use of local public transport (railways, undergrounds, buses), or of micromobility (bicycles, motor scooters or e-scooters), defining circulation plans for private traffic, reducing the space available for cars, through a reduction in parking spaces and road space, and adopting electric solutions for fleets of shared vehicles.

Shared mobility inclusion

If on the one hand the new shared mobility services have evolved in a rapid and compact way in urban centres, the same cannot be said for peripheral districts and rural areas.

A 2019 Fondazione Sviluppo Sostenibile (Sustainable Development Foundation) study provides an emblematic picture of the distribution of shared mobility services in our country, highlighting how operators are concentrated in those metropolitan areas with more than 150,000 inhabitants and in Northern Italy.

If we switch our focus across the Atlantic, we see that in the United States approximately 4.2 million families live in rural areas and do not own cars. Due to the lack of public transport and the high cost of taxi rides, alternative modes of transport are an important issue.
Although well-known eHailing companies like Uber and Lyft are already active in more than 500 regions across the U.S.A., these remain nevertheless underused in rural areas.

A research paper published in 2019 by the Pew Research Center has demonstrated that, while 45% of U.S. urban citizens have used ride-hailing services, only 19% of the inhabitants of the rural areas use them. The technological infrastructure and the exclusive use of credit cards represent significant deterrents to the use of the service by some types of users. In addition, the lower population density, the greater distances to travel and the limited incentives for drivers are often cited as the main obstacles to be overcome.

Confirming this, a survey conducted by McKinsey has distilled the major current difficulties facing shared modes of transport: they are unlikely to be sustainable in cities with less than half a million inhabitants, and car ownership still appears more economical and convenient for many users.

83% of the consumers who responded to McKinsey's survey in the United States stated that the greatest advantage is to be found in the convenience of the service and in the better travel experience and not in the price, if compared with traditional taxis.

Economic viability of the service

Even though shared mobility services have enjoyed an extremely strong acceleration over the last few years, not all players in the field have experienced the same growth; many smaller organizations in the sector, for example, have had to cease trading.

Although many micromobility companies have been hugely financed, many businesses in the sector still today exhibit unsustainable bottom lines.

If we observe bike sharing services, many are the instances of operators testifying to the difficulty of staying in the market and being competitive. Ofo, for instance, has had huge liquidity problems and has decided to pull out of most of its foreign markets and to concentrate exclusively on China. The same fate has befallen the Chinese BlueGoGo, GoBee of Hong Kong, and Obike of Singapore.

The complaint of these operators concerns not so much reduced demand (according to the numbers recorded in various cities a clear demand is actually evident) as the lack of interest from public bodies, crucial for the success of such businesses.

The U.S. Bird has had to resort to increasing charges for users to tackle the issue of its too slender profit margin, to the point of even doubling prices in some cities.

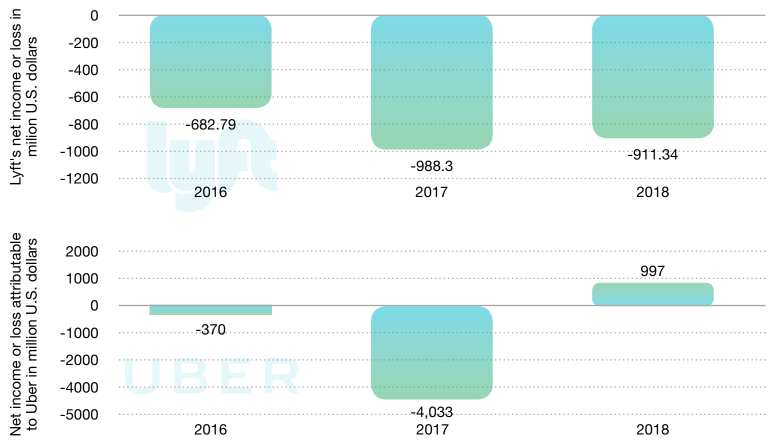
According to a 2017 survey carried out by specialist car monthly Quattroruote, one of the main reasons behind this phenomenon is the heavy costs of management of services, specifically the maintenance and repair of vehicles, and fees paid to city councils for access to Limited Traffic Zones and for parking on blue lines.

2019 saw the merger between Daimler (car2go) and Bmw (DriveNow) who launched the car-sharing joint venture (FreeNow, ReachNow, ParkNow, ChargeNow). In the same year, we saw the downsizing of General Motors' car-sharing company (Maven) and the bankruptcy Ford's ride-sharing service (Chariot). Lime, one of the biggest e-scooter sharing companies in the world, made public its forecast for the end of 2019 showing losses of $300 million.

The financial results of players such as Uber and Lyft are not impressive either and the same can be said of the stock market listings of the two companies. These data can be interpreted as signs of businesses in difficulty, with high costs and weak pricing.

Net losses soar at Uber and Lyft

Net losses hint at weak business model as of 2018

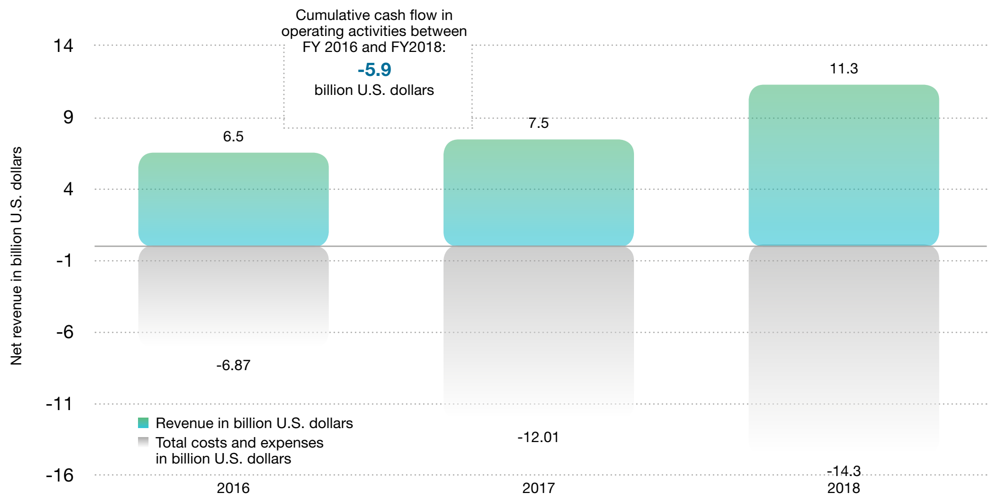


Source: Statista

As previously mentioned, in the last ten years Uber has invested in new "on-demand" activities such as the delivery of food, bike sharing and a goods transport service that have registered growth in user numbers and considerable profits. Despite this the bottom lines are still in the red and corporate revenues are yet to meet analysts' expectations.

Global net revenue of Uber crosses the 10 billion U.S. dollar mask

Uber's net revenue worldwide between 2013 and 2018



Source: Statista

We have witnessed, largely, the entry of multiple players offering similar services, with a subsequent rise in the levels of competition and vulnerability vis-à-vis users' bargaining power. The increased level of competition on the market, moreover, has resulted in operators reducing transaction prices, forcing company earnings down.

Fragmentation in supply and in car-sharing service models is one of the main obstacles to the market's success. It is, however, not unlikely that the dichotomy between the flow free of vehicles and that of booked ones will soon disappear, leaving both solutions their own space, optimizing the service and satisfying overall user needs. The weaknesses in the business will be eliminated thanks also to the contribution of the spread of Mobility-as-a-Service platforms that will integrate multiple types of transport operators through a single platform.

Nonetheless, a good balance and synergies among private initiatives, planning and public regulation remain crucial to wipe out existing lacunae and overcome the obstacles highlighted thus far.

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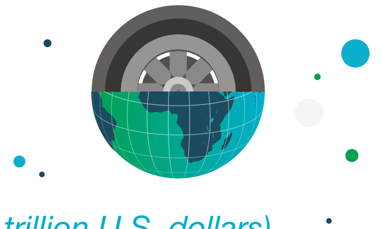
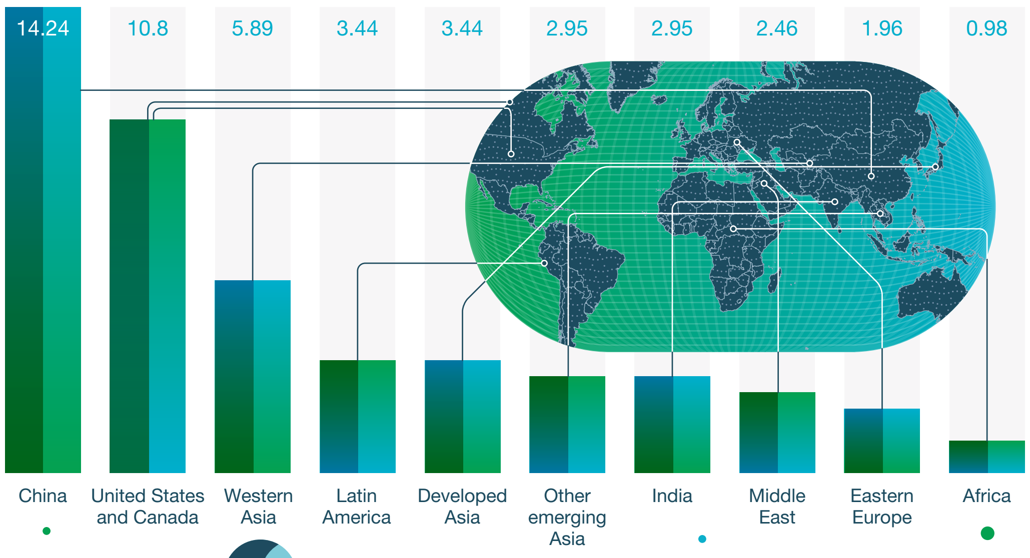
Infra-structures and business models

6

Infrastructures and Business Models



Projected infrastructure spending from 2016 to 2030, by region or country *(in trillion U.S. dollars)*

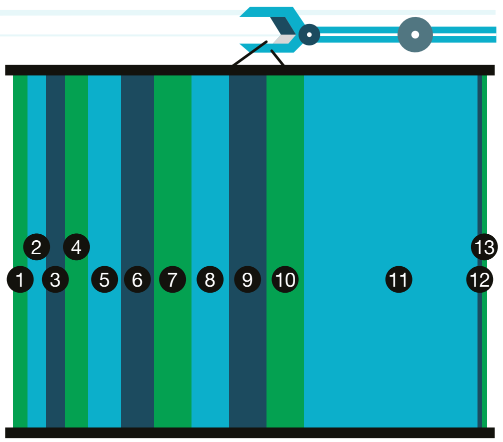


Smart Road

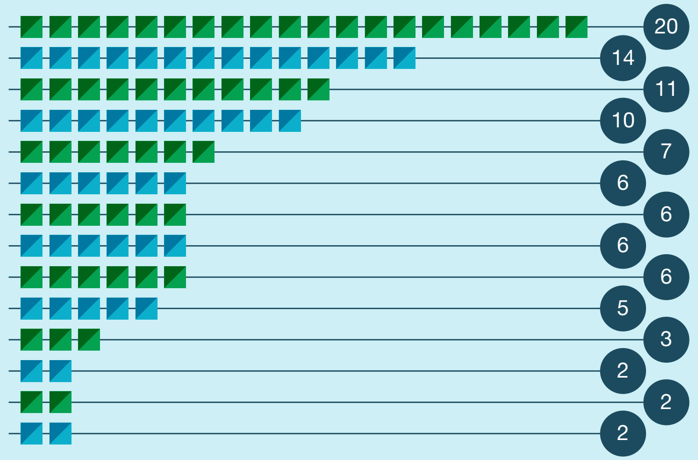
Smart road means a road infrastructure, which through a connected system is capable of interacting with other systems in order to improve traveller experience

Percentage of projects submitted per port infrastructure category

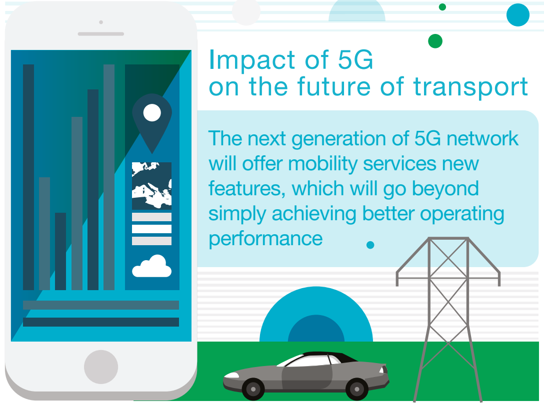
1. Sites for port related logistic and manifacturing 3%
2. iCT/digital infrastructure 4%
3. Road Transport connection 4%
4. Intermodal/multimodal terminals 5%
5. Rail transport connection 7%
6. Energy-related infrastructure 7%
7. Equipment en superstructure 8%
8. Other 8%
9. Infrastructure for smooth transport flows 8%
10. Maritime access 8%
11. Basic infrastructure 37%
12. inland waterway transport connection 1%
13. Infrstructure for reducing environment footprint 1%



Number of infrastructure projects worldwide in 2017- 2018, by sector



The transformation of the electricity sector will produce **$2.4 trillion** of value by 2030 in terms of "clean" energy generation, job creation and greater opportunities for consumer choice



Impact of 5G on the future of transport

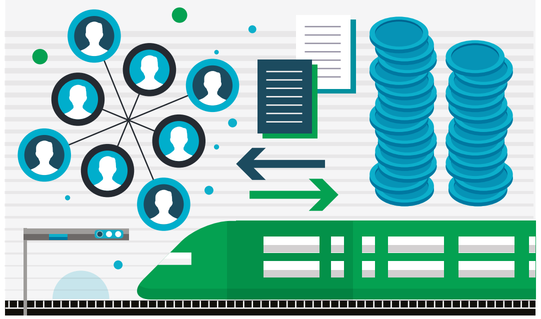
The next generation of 5G network will offer mobility services new features, which will go beyond simply achieving better operating performance

Payment services

The new platforms will guarantee an increase in the volume of online payments

Mobility-as-a-Service (MaaS)

MaaS describes a new business model based on the provision of multimodal transport services.



Cybersecurity for critical infrastructures

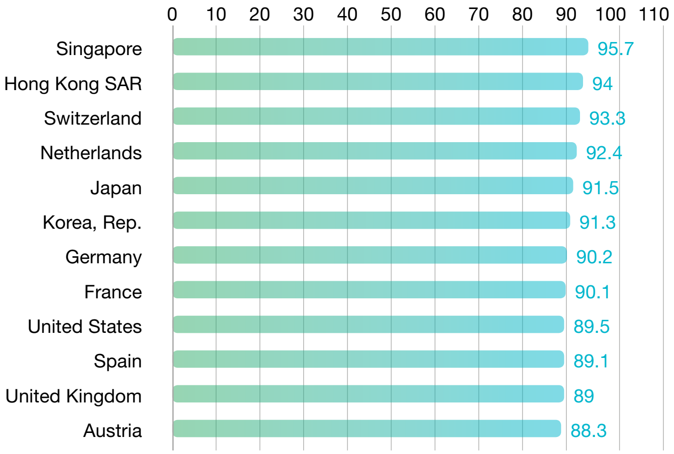
Failure, destruction or tampering with critical infrastructure by hackers or attackers can have a devastating impact on a State's physical and economic security and on public health.

Smart infrastructures for mobility: technological innovation and new business models

Public investments in the mobility of means of transport and of people, such as in roads, ports and railways have been strategic in fostering the economic growth of those nations that are most developed today. According to the World Economic Forum (WEF), quality of infrastructure is indeed one of the 12 basic pillars for determining the competitiveness of a nation, and as such a direct correlation is drawn with the growth of gross domestic product.

This correlation is consolidated by the fact that well-developed infrastructures may reduce transport and transaction costs and facilitate the circulation of goods and people, as well as the transfer of information both within a country and outside its borders. In the WEF ranking relating to the countries that display the best infrastructures globally, in 2018 Singapore occupied first place, followed by Hong Kong, Switzerland, the Netherlands and Japan.

Top 100: Ranking of countries according to their quality of infrastructure in 2018



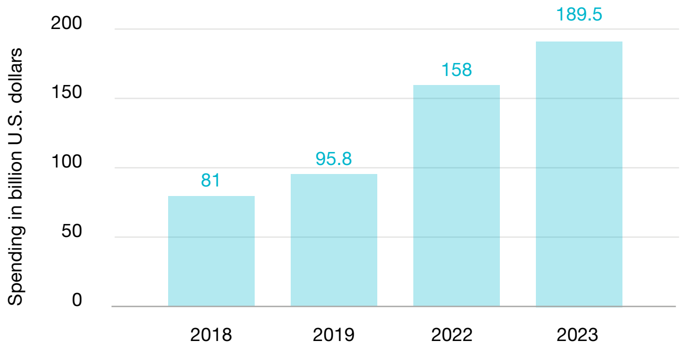
Source: Statista

The recent developments in technology in the first years of the new century have paved the way for the introduction of “smart” elements within mobility infrastructures, through sensors and systems for the analysis and management of data. An ICE (*Institution of Civil Engineers*) research project defines “smart infrastructure” as the result of the combination of physical infrastructure with digital infrastructure, capable of producing information to allow better, quicker and more economical decision-making processes.

Considering the strategic nature of a nation’s mobility infrastructures, a more aware management thereof and a capacity to take decisions on the basis of accurate information may be an element capable of determining a competitive advantage. This deduction is valid both for advanced economies, which generally do not need to create new infrastructures but rather systems for a better management of the same, and for emerging ones, which through technology can make their infrastructures capable of responding to rapid demographic growth and to environmental challenges.

According to IDC, globally speaking an increasing quantity of resources will be allocated to the introduction of technologies within the mobility infrastructures, in particular in urban areas. Given the technological innovations available, the use of advanced materials, robotics, 3D printing, the Internet of Things and data analytics, they seem to have the potential to transform the whole system of infrastructures, favouring the design and the creation of more sustainable and efficient Smart infrastructures, as well as upgrading existing ones.

Technology spending into smart city initiatives worldwide in 2018, 2019 and 2022



Source: Statista

According to a Deloitte study, the integration of Smart infrastructures will be a key element in the development of more sustainable mobility systems, promoting the safe and efficient transport of people and goods. Through digital technologies, infrastructures such as transport stations, roads, motorways and parking will be able to meet the needs of the users of increasingly multimodal transport.

Although investments in Smart infrastructures for mobility present considerable economic advantages, such as increased productivity and a lasting rise in competitiveness, some reluctance to integrate the most innovative technologies into infrastructure design on the part of public decision makers remains. Given the critical issues, the economic and political impact of the infrastructures, the reasons for such resistance could be linked to the wish to avoid further risks pertaining to the design, which is still difficult to manage. If data are truly the "new oil", then digital infrastructure for connectivity becomes crucial, entailing the need to provide adequate levels of connectivity, but above all high levels of security and reliability. These reasons could be among the causes still relegating the infrastructure for mobility engineering and construction industry to a position among those least influenced by *digital transformation,* despite its potential effects.

In order to unleash this value and to express the aforementioned potential new regulation and *governance* models must be introduced, and business models linked to transport and mobility need to be developed. The planning of infrastructures should provide for systems for data valorization, electrification of vehicles and for the connection between systems for mobility and utilities systems.

Physical infrastructures for mobility

To frame the evolution of physical infrastructures for mobility correctly it is necessary to consider the growing social phenomenon of demographic urbanization. According to United Nations data, 55% of the world's population was concentrated within urban areas in 2018; this percentage will rise to 68% by 2050, recording in this period an increase of about 2.5 billion people residing in city areas.

The greater housing density will lead to a consequent increased complexity in the management of urban agglomerations, so that it will be necessary - amongst other issues - to mitigate traffic congestion on the one hand and on the other to implement a more efficient use of energy.

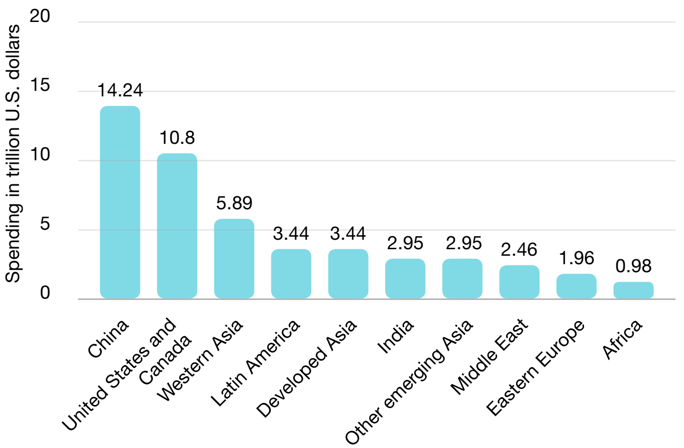
Urban planning therefore cannot but employ all the tools available to it to create an urban system as sustainable and suited to human life as possible. To this end, the integration of the latest technologies into the physical infrastructures for mobility will make it possible to enable systems and models required to respond to the needs of the cities of the future.

Global Data estimates an average annual global growth in infrastructure construction investments of 4.8% in real terms in the 2019 - 2023 period. Of the approximately 14,000 infrastructure projects planned, over 4,000 concern the road network while almost 2,000 the rail system. The overall value of the latter stands at around $ 5.4 billion, while the value of road projects is estimated at $ 2.6 billion.

In addition to the traditional infrastructure projects, numerous projects have also been launched to innovate the infrastructure of the transport system: for example in 2019 the European Union invested over € 117 million in 39 transport projects in order to build the continent's missing connections, focusing on sustainable modes of transport. Consulting firm Altran estimates rail-related IoT investments to be $ 30 billion between now and 2030, while forecasting a value of $ 20.6 billion by 2021 for the *smart railways* market.

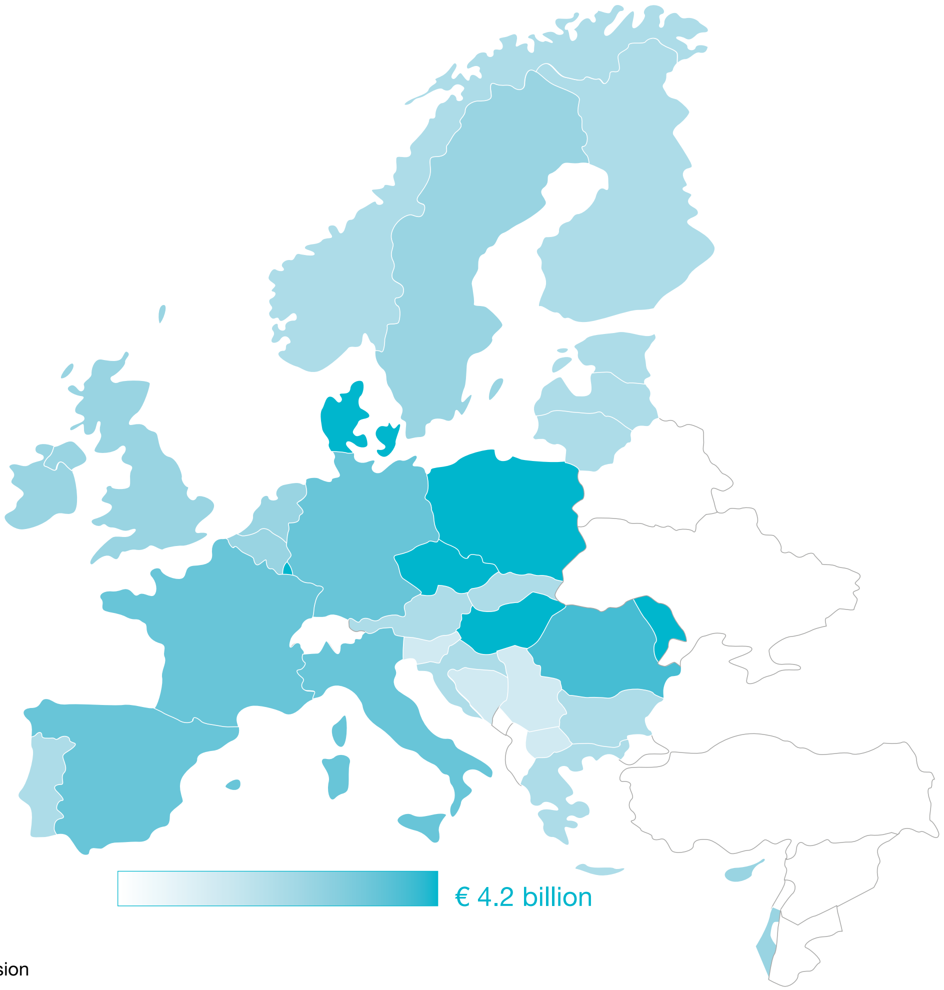
According to CG / LA data reported by Statista, in the two-year period 2016-2017 Great Britain positioned itself as the most advanced country in the world in terms of infrastructure projects. Looking to the future, though, and considering investments in absolute value, China appears to hold the record for spending on infrastructures budgeted for between 2016 and 2030, with a budget of $ 14.24 billion.

Projected infrastructure spending from 2016 to 2030, by region or country



Source: Statista

As far as the old world is concerned, however, since 2014 through INEA (Innovation and Networks Executive Agency) the European Union has allocated funding to support European connections (CEF) pertaining to the telecommunications, energy and transport sectors. These investments are made with a view to fostering enhanced competitiveness in the states of the Union through the creation of trans-European systems. In this regard, the budget allocated for the 2014-2020 period amounts to € 23.7 billion.



EU Member State	FUNDING (€ million)
AT	884.3
BE	636.9
BG	417.5
CY	63.1
CZ	1,143.5
DE	2,284.1
DK	824.6
EE	220.5
EL	573.6
ES	1,080.3
FI	179.6
FR	1,947.2
HR	430.5
HU	1,091.8
IE	103.0
IT	1,592.2
LT	389.2
LU	67.3
LV	271.9
MT	49.2
NL	508.1
PL	4,211.6
PT	722.4
RO	1,233
SE	348.5
SI	331.2
SK	712.4
UK	341.4

Source: European Commission

"Smart Road"

Smart Road means a smart road infrastructure, which through a connected system is capable of interacting with other systems in order to improve traveller experience. Smart roads also function as platforms for the integration of services aimed at the various stakeholders involved in mobility, such as for example systems for the observation and monitoring of traffic, data and information processing models, advanced services for the operators of the roads themselves, as well as for public

administrations vehicle users. The combination of the aforementioned solutions is intended to define a technological ecosystem capable of promoting greater efficiency in mobility and a significant improvement in safety standards.

The Smart Road represents the key element in the European Union's plan named "Cooperative Intelligent Transport Systems", in which the political will to intervene in order to advance current paradigms is formalized with the aspiration to achieve urban and suburban, cooperative, connected and automated mobility.

In the local legal framework, in Italy the concept of Smart Road was introduced in the 2018 Budget. In the same year, the Ministry for Infrastructures and of Transport (MIT) established its "*Osservatorio tecnico di supporto per le Smart Road e per il veicolo connesso e a guida autonoma*" (Technical support observatory for the Smart Road and for connected and self-driving vehicles).

With its Smart Road decree of April 2018 the Italian government wished to prepare the path for the implementation of smart roads, identifying the functional standards in relation to the new technologies to be used and forecasting the various phases of development. In the early phases, by 2025 the decree formalizes the undertaking to intervene as a priority in the Italian infrastructures belonging to the European TEN-T (Trans European Network) network and subsequently in the whole network of motorways and national roads.

↳ Decreto Smart Roads – aprile 2018 -

The smart road project realized by Turin City Council together with TTS Italy, producer of smart systems applied to transport, won the Global Road Achievement Award 2019, a prize awarded as part of the competition organized by the International road federation Global, that identifies the most innovative programmes around the world in the road-building industry.

By 2030 additional services will be activated including smart systems for the diversion of traffic flows and suggestions for freer-flowing routes, interventions on average speed for the purpose of preventing congestion, dynamic management of elements necessary during journeys, such as smart parking and the location of stations of reference, above all aimed at e-mobility.

According to an April 2018 Mordor Intelligence study, the smart roads and smart highway market could reach a value of $ 54 billion by 2023, with an estimated increase of around 172% compared to $ 20 billion in 2017.

The market is characterized by start-ups that apply the latest sector technologies; among these, Integrated Roadways has developed a road paving system to connect the infrastructure to the vehicles that pass over it, exchanging data through digital technologies and fibre optic connectivity. Through paving slabs the driver can be informed in real time about traffic conditions.

Technologies of this type do not only benefit the mobility system but they also bring positive externalities that effect urban agglomerations in general.

Effects of urbanization on infrastructures for smart mobility

↳ 2018 Revision of World Urbanization Prospects

The phenomenon of urbanization correlates to economic development, thus proving functional to the reduction of poverty and to human development. Nevertheless, the United Nations stress the need for public decision makers to study, understand and consider the trends linked to urbanization in order to achieve a sustainable and inclusive development. In doing this, mobility issues play a leading role.

According to Frost & Sullivan's *Smart Mobility City Tracker* report, the negative effects of rapid urbanization include increased vehicle density, the ageing of infrastructures and the increase in emissions released by public transport, affecting the urban mobility ecosystem. The same source quantifies the global pool of vehicles at about 1.3 billion in number, of which 15% belong to city residents. These vehicles represent a factor heightening traffic congestion, generating a cost of over $ 300 billion and contributing 20% of greenhouse gas emissions.

In a 2017 study, McKinsey estimates that the benefits deriving from integrating various mobility-related infrastructures would amount to approximately $ 600 billion for the 50 metropolitan areas under consideration. The achievement of these results depends on the ability of local public decision makers to identify and pursue the most correct investments, especially regarding infrastructures. McKinsey also estimates that European governments in 2019 will have spent from 50% to 70% of the budget dedicated to mobility infrastructures by carrying out maintenance work or by replacing obsolete systems.

The adoption of public policies that embrace the new mobility paradigms represents an opportunity to redesign the urban travel system in a forward-looking perspective, in order to generate future economic and environmental benefits. These policies should propose actions that consider three fundamental principles:

- The adoption of a multi-stakeholder and market-specific approach. Energy, transport and infrastructure companies, together with political leaders, regulators and urban planners, should collectively contribute to the definition of a new paradigm for cities. Investments and infrastructures supporting e-mobility can vary significantly in consideration of specific characteristics and the market.

- Supporting vehicles with higher usage rates, concentrating investments on the electrification of public transport fleets. In a comparison between public and private vehicles it is found that the latter register a lower overall mileage and are in movement less than 5% of the time.

- Moving in advance of the electric transition by creating charging infrastructures in strategic areas, above all in critical hubs situated in the vicinity of public transport terminuses. Infrastructure should be implemented in combination with edge grid technologies - such as decentralized generation, storage and smart buildings - and integrated into smart networks in order to take full advantage of the flexibility of electric vehicles, guaranteeing, at the same time, the stability of the energy system.

The combination of new technologies and changes in people's habits is fostering the birth of a real revolution in travel across the urban environment. From physical infrastructures to digital platforms, the mobility value chain is ever more connected, low-emission, autonomous, shared, on-demand and multimodal.

The optimization of the public transport system will be facilitated by the installation of technological infrastructures capable, for example, of making traffic light systems and the management of vehicle parking smart, in order to be able to provide more efficient services and to modify the cityscape.

A smart parking system is composed of sensors and various connected objects, platforms for real-time data collection and digital payment services. The smart parking pillars are the combination of technological innovation - connected products, big data, cloud and analytics - environmental sustainability and the psychophysical well-being of users deriving from the ability to identify the parking space by consulting a real-time map on a device.

In Italy, the flagbearer city for smart parking facilities is Treviso. Thanks to smart parking, in 2019 the Veneto municipality saw municipal revenues increase by 11%, prompting municipal authorities to review parking charges: the average charge for 30 minutes fell from 1.73 € to 1.55 €, while tickets sold rose from 131,000 to 161,000 (+ 23%). The cities active on this front also include Venice and Turin.

↳ Smart Parking, a Torino parla la sperimentazione dedicata alle persone disabili

In June 2019 experimentation began in the Piedmontese capital to provide a smart parking service reserved for the disabled. The project sees the collaboration of Turin City Council, in-house company 5T Srl and Iren SpA. The experimentation will be activated on 132 disabled stalls in the areas adjacent to city hospitals. Disabled users will have an application to check the availability of reserved spaces and on reaching the parking area automatically identify and certify their right to occupy the stall. 5T Srl will deal with enabling a sensor system in the stalls used, capable of detecting its state of occupation. Iren SpA will provide an IoT telecommunications network made up of gateways in order to guarantee coverage of the city area and platforms for data management, maintenance and display.

Technologies for the design and maintenance of physical infrastructures

The road network represents one of a country's most critical infrastructures: essential for citizens, any malfunction, disruption or closure of the network, even if partial or temporary, would have the effect of significantly weakening the efficiency and normal functioning of the country itself, its security and its economic-financial and social system.

With reference to 2017, the American company Cyient estimated the socio-economic impact of the scant maintenance of roads:

- In the United States 33% of road accident casualties are due to damaged roads. Road repairs cost $ 68 billion a year and the estimated expenditure, up to 2022, is around $ 240 billion. Furthermore, about 27% of urban roads are considered to be in a poor state of repair.
- In Great Britain potholes cause damage the repairing of which totals £ 2.8 billion and the consequent compensation claims amount to £ 30 million.
- In Australia over $ 50 billion was invested in road infrastructures.

The contribution of new technologies supporting infrastructure maintenance activities is particularly useful in proactive approaches, implemented in order to prevent damage from occurring. Through the use of statistical and data mining techniques to analyze historical and current data sets, it is possible to better assess the risks and use available resources more effectively.

One of the most delicate and crucial aspects of road infrastructure maintenance is monitoring the integrity of bridges and viaducts. Numerous research projects and activities have been focusing for some time now on the monitoring of these infrastructure elements. Technology optimizes these processes by supporting predictive maintenance activities with risk calculation models using data relating to the identification of anomalies in measurement or early warming parameters, i.e. The issuing of an alert, real or potential, against imminent dangers.

As regards the role of new technologies in the infrastructure construction phase, an important use of applications based on artificial intelligence in the urban design phases through the creation of virtual 3D models is to be observed. The data processed for the creation of the models often derive from collection activities performed by drones, sensors installed on physical objects or supplied by users themselves through the use of personal devices that interact with the transport system or by companies, through technological integrations on products. For example, Tesla uses Autopilot software on its cars, capable of automatically providing information on the road and traffic situation when the vehicle is moving. Stored in a cloud, these big data can be harnessed by urban planners for data-driven decision-making. The data were used to identify the actions necessary to make traffic flows more efficient, for example by repairing or widening certain roads, or by changing specific configurations of signals.

The standardization and use of digital information also makes it possible to create virtual representations of the different phases that involve a project, called “digital twins”.

> The key concept of the Digital Twin paradigm is the creation of a digital model of a physical object, system or process that exists (or could exist) in the physical world. This is possible using, in particular, digital and IoT technologies. Companies use digital twin technology to simplify design and the functioning of complex processes, optimizing performances and enabling predictive maintenance.

According to a research study conducted by Juniper Research, the economic impact of the use of this technology globally in the transport sector is estimated to reach $ 2.5 billion by 2023.

The most common use cases of such solutions, in the mobility sphere, concern the management of traffic flows, planning of the urban area and travel simulations, as well as predictive infrastructure maintenance operations. According to a study by ABI Research, the use of digital twin technology in the mobility sector will progressively establish itself over the next few years, going from the few installation events of 2019 to more than 500 by 2025.

By way of example, in 2017 the SmartBridge project was launched in London. The project consists of continuous monitoring of the conditions of the Watford bridge through real-time data collection, carried out thanks to sensors installed on it that map the infrastructure generating an updated digital twin.

Still in the United Kingdom, the railway plant company Alstom has built a digital twin to simplify the management of train maintenance operations on the main west coast line, the busiest in the nation.

In Singapore in 2018 the city-state's authorities established the Virtual Singapore platform: a 3D map representing a dynamic digital twin of the city. By harnessing the big data environment and aggregating public and private sector information, it is possible to identify alternative routes towards which to redirect the flow of traffic in order to minimize congestion.

↳ Virtual Singapore

Ports and Airports

Crucial mobility hubs are to be found in ports and airports, in which new technologies can contribute significantly to rendering operations more efficient and more effective, enabling new services for passengers and companies and reducing journey times.

In the sphere of port infrastructures, through digitization, the use of detection technologies and of data processing capacities significant benefits can be obtained. In particular, smart ports can help to deal with three important infrastructural challenges:

- Greater operational excellence
- To mitigate the effects of the migration of activities towards emerging regions
- New commercial opportunities

Despite these opportunities, as yet investments in these technologies seem not to be a priority for the majority of decision makers. An ESPO (European Seaports Organisation) study finds projects for the creation of ICT and digital infrastructures within European ports to be relegated to just 4% of total projects submitted.

Such a lack of attention towards this type of project, despite the potential benefits, could in part be explained by the scant resources available for allocation. An EU study reveals that European (EU-27) seaports are currently facing investment needs of approximately 48 billion euro (5 billion euro a year) for the 2018-2027 period. Despite the considerable resources deployed, both in Europe and globally a lack of investment persists: according to Global Infrastructure Hub's data, around the world the difference between the investments in infrastructure necessary ($ 75 billion) and those actually made ($ 59 billion) represents a shortfall of $ 16 billion for 2019 alone.

There do exist, however, examples of excellence that make ample use of the latest technologies harnessing them to establish a competitive edge over other operators.

↳ Port of Rotterdam

One significant example is the port of Rotterdam, the largest and busiest maritime port in Europe. In 2017 it was declared the port with the best infrastructure anywhere in the world by the World Economic Forum. Investments in this infrastructure by local authorities range from 150 to 200 million euro per year, involving not only port authorities but also numerous private companies, amongst which stand out prestigious tech companies such as Axizans, Cisco and IBM.

The port of Rotterdam relies heavily on digital technology for operations management: a series of sensors applied throughout the entire dock structure and also implemented on buoys make it possible to collect the data necessary to create a precise digital reproduction of the infrastructure. During unloading operations, the possibility of identifying in advance those areas already occupied by means of this system allows time savings that translate into economic efficiency: each hour saved is equivalent to approximately

$ 80,000 in lower costs for ship operators, in addition to allowing a larger number of ships to pass through the port each day.

A similar situation is that which can be observed with regard to airport infrastructures. According to the *Smart Airport Market - Growth, Trends, and Forecast* report, the market linked to smart airports should record compound average annual growth of 3.48% between 2019 and 2024.

However, despite the growth in the associated market, in general the gap between necessary investments ($ 85 billion) and those implemented ($ 70 billion) for infrastructures in the air transport system is around $ 15 billion. It is forecast that this ratio will increase significantly: in 2040 it is expected to be + 100% compared to 2019, with a growing gap of $ 30 billion.

Even in airports, however, there are significant examples of the use of the latest technologies in order to raise service quality standards.

Some airports, including London City Airport, have implemented a virtual air traffic control room that relies on multiple cameras, providing comprehensive monitoring. Through the possibility of superimposing radar information, the same is sent to a remote control room located 120 miles away where air traffic controllers have a much more complete and detailed view of air traffic, for a more effective management.

Underground roads / highways

Given the saturation of existing metropolitan spaces, underground road travel may be a concrete solution to mitigate surface traffic congestion and consequently to significantly improve the effectiveness of city mobility. Furthermore, the development of underground urban infrastructures allows surface spaces to be valorized: these can be used for the creation of public spaces available to the community, such as green spaces and / or pedestrian zones, and ultimately favour reductions in pollution.

For these infrastructures, the innovative technological applications provide solutions capable of making their realization less costly and difficult, above all in complex environmental conditions such as, for example, the depths of the sea.

The *ITA Tunneling and Underground Space Award* selects each year the most innovative projects from around the world. The finalists for 2019 include, among others, the project under construction in Hong Kong (China) for alternative access to the international airport, which will reduce travel times by 20 minutes. This is an underwater tunnel of about 9 km in length that is expected to open in 2020 and whose total cost is estimated at € 2.36 billion.

↳ The Boring Company | Tunnels

The Boring Company's tunnel test was inaugurated in Los Angeles in 2018. Over 2 km long and costing approximately $ 10 million, it uses mechanical systems for operations for the descent / ascent and onward journey of vehicles that are transported and then moved by carts on underground tracks. Through this system, vehicles can safely travel at 240 km/h and without using the car's engine, representing a valid alternative to the city traffic. In 2019 The Boring Company won a contract worth nearly $ 50 million to replicate the infrastructure in Las Vegas, in addition to having received multiple permissions also in China.

The Norwegian floating tunnel road project, named *Archimede*, is the alternative solution for reducing travel times along the country's west coast characterized by fiords that oblige users to switch means of transport. The infrastructure, worth $ 40 billion, comprises the creation of an underwater carriageway, composed of two floating tubes at a depth of about 30 metres. The choice not to position the tunnel on the seabed allows both the passage of ships on the surface and that of submarines below. Furthermore, it makes it possible to reduce the complexity of the structure given the particular structure of the seabed.

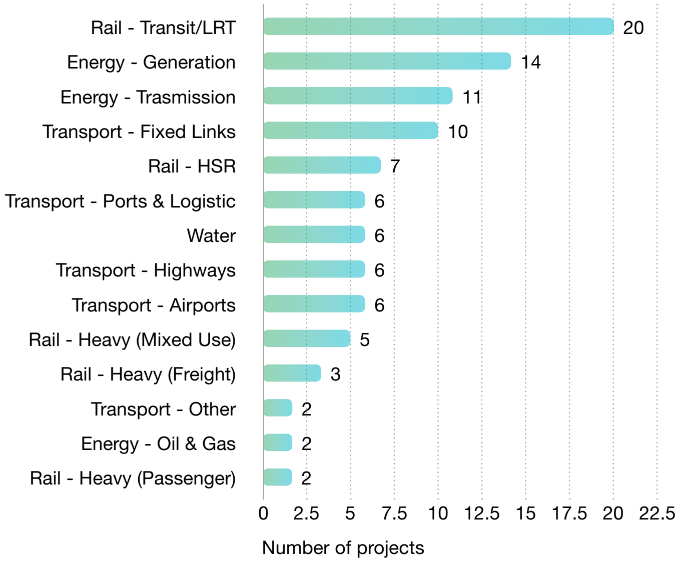
Railways & hyperloops

The advent of cars and aeroplanes has not interrupted the development and prosperity of rail transport generally around the world, also in cutting-edge economies, where the use of alternative mobility is more sustainable for the individual.

Rail transport is also one of the most efficient forms of transport from an energy point of view and also has the lowest emissions. It is estimated that rail transport consumes only 2% of total transport energy demand. Rail is also the most electrified transport sector: three quarters of passenger movements and half of those for transporting goods depend on electricity.

These facts seem to find support in data regarding the development of rail infrastructures: according to a CG/LA study, worldwide, projects linked to rail travel represent the top investment option for infrastructures between 2017 and 2018.

Number of infrastructure projects worldwide in 2017-2018, by sector



Source: Statista Additional Information: Worldwide

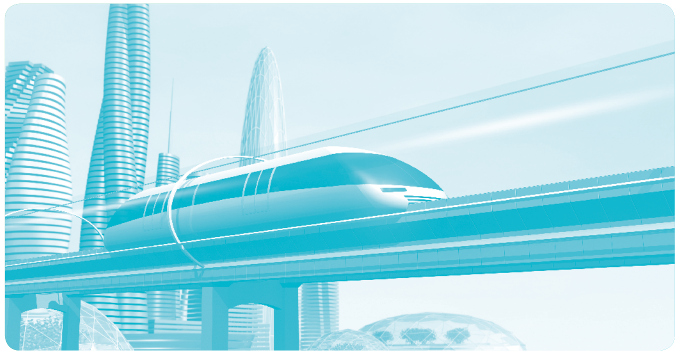
The effects of new technologies seem to be able to have an important impact on the rail mobility sector too, potentially revolutionizing the sector over the next few decades and creating opportunities for companies with competencies in ICT sectors to enter the market.

A significant number of technology start-ups actively work to upgrade the rail transport value chain, for example by providing the means to use video analysis for the inspection of locomotives and rolling stock or the use of *machine learning* and artificial intelligence for both route optimization and planning and for providing passengers with customized services. Lastly, there are the operators who focus their efforts on the development and introduction of systems with high or very high levels of automation.

Nexxiot develops cloud solutions for smart railway sensors. The Swiss start-up's servers and databases provide a secure and centralized repository for the access to, and analysis of big data. Their cloud infrastructure is made to measure and provides all that is required to connect resources, including device management tools to Nexxiot's smart sensor and to other IP-based third-party devices through standard interfaces.
In 2016, the Austrian Federal Railways (ÖBB) embarked upon an Open Innovation strategy to develop an innovation programme revolving around collaboration with start-ups. This programme was developed in response to the company's need to implement a strategy focused on offering better customer service. An ÖBB manager emphasized the company's need to add new competencies from outside to implement its own innovation strategies.

The match will be decided by the speed of the provision of services, by the implementation of smart systems for fault reporting and by systems for convergence towards autonomous driving. With regard to the latter, trials in the railway sector are progressing at the same pace as in the automotive sector: in August 2019 the project for the first autonomous freight train, with grade 4 automation, was completed in Australia. The result was achieved after 6 years of research and at a cost of approximately $ 940 million.

Driverless trains, unlike traditional ones, do not require any person on board to monitor and use train functions. Operations are automated with the aid of high-precision sensors, advanced video camera systems and GPS. Nevertheless, the increased possibilities of the system being hacked and the high cost of the automation of trains represent elements of risk to which the market does not seem able to respond fully.



NEXXIOT

Nexiot offers an integrated digitization solution for all companies concerned with the movement of physical goods, who want to increase efficiencies and unlock additional revenue potential.

Total Funding
$50.22 mln

Last Round
Nov 2019 Unattributed

Country
Switzerland

nexxiot.com

↳ Hyperloop explained
The B1M

Among the most pioneering technologies, the HyperloopTT transport system, launched in 2013 by Elon Musk, intends to revolutionize medium and long-range travel. Through an infrastructure composed of depressurized tunnels, the capsules within are capable of reaching a speed of 1,223 km/h. Hyperloop's technological innovation also involves a system of passive magnetic levitation, named Indutrack: the magnets arranged linearly as tracks allow levitation on a track not powered but conductive, thus permitting the capsules to move.
Moreover, magnetic levitation provides for a continuous recovery of kinetic energy, to the point that infrastructure equipped with integrated photovoltaic panels and a wind and geothermal energy system would not only power itself but also produce energy, to be put back into the network.

Infrastructures for e-mobility

Energy infrastructures and networks, as well as many other sectors, face important transformations, in particular in the generation and distribution of electricity. There are currently three main trends:

- Electrification of large sectors in the economy, such as transport and domestic and industrial heating;
- Decentralization, spurred by the great reduction in the costs of distributed energy resources such as distributed storage and generation, by flexibility of demand and energy efficiency;
- Digitization of networks, with the diffusion of remotely-managed meters, the use of smart sensors and the advent of the Internet of Things (IoT), automation and other network technologies.

These three trends act in a virtuous cycle, permitting, amplifying and enhancing developments far beyond their mere separate contributions:

- Electrification is crucial for long-term targets for the reduction of the polluting emissions and the harnessing of renewable energy.
- Decentralization makes customers active elements in the system and requires a significant coordination.
- Digitization supports both these trends allowing automatic real-time optimization of consumption, on the one hand, and of production, on the other, as well as of interaction with customers.

With increased production volumes and technological innovation it is reasonable to predict a reduction in costs and, potentially, also in the price of electric vehicles, bridging the accessibility gap with ICE vehicles. The current trend in the production of electricity sees a reduction in costs due to the diffusion of renewable sources of energy; this factor represents a further push to the spread of electric vehicles, as a result the entire infrastructure for the generation and distribution of electricity will experience the impact of this transformation.

Even the traditional boundaries between producers, distributors and customers in the electricity market are becoming less clearly defined, generating increased complexity for the regulatory *governance*. This evolution is accompanied by changed consumer expectations, with ever more services, but fewer products expected: the simple supply of electricity is evolving into in a portfolio of services available, designed to maximize the value of the energy resources distributed.

The transformation of the electricity sector, according to the World Economic Forum, will produce $2.4 trillion of value by 2030 in terms of “clean” energy generation, job creation and greater opportunities for consumer choice.

Infrastructures for charging

In the chapter on e-mobility some initial mention was made of charging methods and of the players in the electricity infrastructure ecosystem. These infrastructures are essential since the continuous increase in the numbers of electric vehicles in circulation produces an increasing need for publicly-accessible stations capable of supporting a fast charging system, capable of providing considerably higher voltages than those supplied by a domestic electricity plant. Precisely because of this complexity, a strategy is necessary for the deployment of charging points and for smart management charging itself.

EV charging is mainly possible through three solutions:

- Public or shared charging points, along stretches of road or in freely-accessible parking;
- Private charging points, in car parks or private areas
- Private charging points for public use, installed on private property, but accessible to users.

In 2018 there were about 630,000 public charging points worldwide, a number that now compares favourably with that of petrol and diesel filling stations. According to Statista, as of July 2019 there are about 170,000 public charging stations in Europe: since 2018 Germany has been home to about 25,000 public charging stations, 22,000 of which for “normal charging”. France possesses a similar number, while Norway, the country with the highest share of registrations of new electric vehicles, offers almost 11,000 charging stations. In Italy in July 2019, according to the Energy & Strategy Group of the Politecnico di Milano there are 8,200 public and private charging points very unevenly distributed across the regions. If only public charging stations are considered, this number drops considerably: according to Adiconsum, in Italy in 2019, there are about 4,000 public charging points.

Generally, charging infrastructures are used to meet the energy needs of vehicles for personal use. Users mostly recharge their vehicles at the most convenient times for them, at home or in the vicinity of the workplace, or also in private places with access to the public (public car parks, shopping centres, hotels).

HOME	**Slow Charging**
LOCAL	**Slow to Fast Charging**
DESTINATION	**Slow to Fast Charging**
FLEET	**Slow to Ultra-Fast Charging**
HIGHWAY	**Fast to Ultra-Fast Charging**

The presence of an adequate number of pillars can allow vehicles to be used also for journeys off the usual routes and can provide an alternative to those who do not own a garage in which to install a Wall Box or for those who do not have access to a shared apartment building charging space. Outside the urban setting, considering, in particular, the motorway network, the presence of fast charging pillars in all service stations would allow all owners of electric vehicles to find charging points easily.

In the Italian context, however, from the analysis of the Energy & Strategy Group of the Politecnico di Milano, it emerges that, as of the end of 2018, charging stations are predominantly located in an urban environment, amounting to 70-75% of the total, while charging points in other areas (shopping centres, hotels, etc.) represent 20-30% of the total. Outside urban areas less than 5% of charging points are to be found, even if these are typically for fast charging. In Italy charging points are, moreover, not distributed uniformly across the territory. With the exception of the concentration in certain urban areas in Central and Northern Italy, the rest of the Peninsula presents rather fragmented situations, influenced by local government regulations and by the presence of companies that are to varying degrees active in the sector.

With a view to pursuing a unitary expansion of the infrastructure, a national development plan has been drawn up, known in Italian by the acronym PNIRE, Piano Nazionale Infrastrutturale per la Ricarica dei veicoli alimentati ad energia Elettrica (the National Infrastructural Plan for the Charging of vehicles powered by Electricity), which should guarantee the presence of a network adequate to meet general territorial needs.

The two companies most engaged in Italy in the installation and management of public charging stations are Enel and A2A, to which number can be added a series of companies operating in specific local contexts (for example, Alperia in Alto Adige, Hera in Modena and Imola, or Silfi in Florence).

Some of the emerging players in the development of these infrastructures are oil companies, engaged in equipping themselves to face up to the transformation brought about by e-mobility through the installation of charging pillars at traditional filling stations, both in urban and non-urban settings and across the whole motorway network. All the major European groups, Bp, Eni, Equinor, Repsol, Royal Dutch, Total and Shell, have already embarked on this journey. Through its subsidiary RechargePlus, Shell has been active since 2013 in the smart charging of electric vehicles in California.

Business models for charging stations

The diffusion of electric vehicles opens up, in relation to charging needs, certain business opportunities such as:

- the manufacture and sale of equipment for the charging of electric vehicles;
- the deployment and running of public EV charging stations:
- the provision of management solutions for the charging of EV's;
- support for the planning of charging networks.

In terms of business models for charging stations, a heterogeneous situation emerges, with stations owned and managed by a wide range of players from the ecosystem including public bodies, car manufacturers, utilities and operators, purely and simply, of charging infrastructures. Slow charging is often associated with free electricity deals to attract customers (a model used by many retailers) or associated with a contract. Fast or *ultra-fast* charging station networks become more profitable when customers show a willingness to pay a premium for fast charging, for example, on motorways.

To cite some examples from Europe, Oslo City Council owns and manages a public charging infrastructure and supports private infrastructures accessible to the public and managed in collaboration with private real estate companies. The city rents parking areas during the nighttime and offers free charging to owners of electric vehicles. In Stockholm, the companies that deal with charging technology and the utilities own and manage charging stations, while the city council provides public land as a free concession for a certain number of years, according to the specific agreement.

Among current trends, it can be remarked that the methods of supply are generally aggregable according to the supplier:

- Some car manufacturers have implemented fast-charging networks with a particular focus on

motorways and points of interest, such as hotels and shopping centres.
- Oil and gas companies are approaching the fast-charging market in order to attract and hold on to customers at existing service stations.
- Companies working on charging infrastructures sell both the stations and the pillars, as well as some associated services, such as financing for infrastructure building or services linked to maintenance.

Another interesting example, in the sphere of business models related to charging infrastructures, is the acquisition by E.On, a company active in the renewable energy, of 30% of BikeSquare, an Italian start-up active in cycle tourism through the use of electric bicycles. The activity is based on the application of the same name for mobile devices that permits and simplifies bike rentals and sharing and guides the user in his/her exploration of the territory thanks to maps and itineraries that combine nature, culture, local traditions and food and wine specialities. The company draws on its own network of commercial partners, from bicycle rental businesses to accommodation providers, in the creation of itineraries.

Iren, through its e-mobility business line, named IrenGo, created a partnership with MiMoto in 2018 for the cities of Turin and Genoa. The Italian start-up offers its customers an electric scooter-sharing service in order to facilitate urban travel in the interests of the environment.

Another potential business model linked to battery charging and its associated infrastructures is battery exchange. This provides for the replacement of discharged batteries with charged ones, thus allowing a vehicle to continue to circulate. As an example, in India the Sun Mobility start-up is developing a service for the exchange of batteries for electric buses and two and three-wheeled vehicles. In China, too, the province of Zhejiang is developing a network of rapid charging and battery replacement stations.

Smart charging: smart technologies for charging

In order to make electric vehicles in circulation a further resource supporting the energy system - instead of representing a risk in terms of overall capacity and peak management -virtuous and sustainable charging models need to be devised and promoted.

> “Smart charging” envisages that charging of electric vehicles may be managed and regulated in a smart way: times and speeds of EV battery recharging can be controlled in a "smart" way, one that is sophisticated when compared to the simple use of an on / off switch. This innovative method entails the use of programmes or systems capable of adapting the charging cycle to the conditions of the power supply network and the needs of vehicle users.

In order not to overload the electricity grid, it would be opportune to encourage consumers to recharge their electric vehicles at off-peak times of the day, preferably in “slow charging” mode. In addition to pricing policies, “intelligent recharge” systems make it possible to set the automatic balancing of the use of the network in real time. Such systems allow for an optimized use of the distribution infrastructure, by reducing load peaks due to simultaneous recharging of multiple electric vehicles by adjusting charging speeds or by deferring the charge until the network is less stressed.

Aware of the importance of EV charging methods and of “smart” governance in the phase of creating sustainable electricity infrastructures, the British government has provided some guidelines for the definition of standards for charging and for the consequent reduction of emissions:

> “All government funded home chargepoints for electric vehicles must use innovative ‘smart’ technology from July 2019. This means chargepoints must be able to be remotely accessed, and capable of receiving, interpreting and reacting to a sig-

nal. Smart charging can also reduce high peaks of electricity demands, minimising the cost of electric vehicles to the electricity system – and keeping costs down for consumers by encouraging off-peak charging."

According to the IRENA - International Renewable Energy Agency - report illustrating the potential and the functioning of "smart charging", this charging mode could save a billion dollars in the network investments necessary to cope with loads linked to future electric vehicles in a controlled way, moreover making the systems more flexible for the integration of renewables. The report also studied the different charging methods accentuating the importance of times and speeds. Because if it is true that the construction of infrastructures for "fast" and "ultra-fast" charging is a priority for the e-mobility sector, it is also true that balancing and optimization of distribution grids "slow charging" is more suited to smart charging modes, making the batteries of electric vehicles plugged in for longer a resource available to the grid itself.

Smart grid and Vehicle-to-Grid

The rapid growth of renewable sources of energy, in particular, solar and wind power, brings about the production for the energy system of increasing quantities of energy that cannot be used immediately (if not locally), implying a variability or intermittence in the availability of energy. This engenders for the operators of the electricity system the need to find suitable solutions to guarantee greater flexibility, oriented towards maintaining a constant level of energy available through the digital management of demand, supply and storage. Such solutions take the name of smart grids, i.e. smart grids equipped with sensors capable of gathering information in real time to optimize the distribution of energy across the electricity grid. In this context, through smart charging, electric vehicles represent a distributed energy resource capable of stabilizing the network, given the energy storage capacity of the batteries and the possibility of "returning" the stored energy to the network in case of need. By reducing network loads at peak times, this system can help influence pricing by lowering energy prices at peak times.

One concrete example relating to innovative energy infrastructures is to be seen in the stadium in Amsterdam. Since 2018 the stadium has been able to boast the largest system of energy accumulation in Europe, powered by new or "second life" batteries from 148 Nissan LEAF EV's. The 3 megawatt plant – which also includes 4,200 photovoltaic panels - is devised to provide energy for the stadium, to charge up to 200 visitor electric vehicles and to stabilize the Dutch electricity grid.

↳ Amsterdam Energy ArenA at Johan Cruijff ArenA

In collaboration with its partner 4R Energy Corporation, in 2019 in the town of Namie in Japan, Nissan launched new lampposts powered by solar panels. In this project, too, called "The Reborn Light", energy from solar panels is stored in the battery packs of "old" Nissan LEAF's to provide clean and efficient lighting, in an attempt to give a street lighting system back to the Japanese town grappling with reconstruction after the tsunami of 2011.

↳ "The Reborn light"

A similar case is that proposed by BMW: to give a second life to the batteries of its BMW i3 model: instead of being recycled in the traditional way, the accumulators can power homes.

Amongst the advanced smart charging systems, Vehicle-to-Grid (V2G) has been tested in the United Kingdom, the Netherlands and Denmark: the technology allows the pillars to "talk" to the networks, using the car battery connected to it as a storage system. Along the same lines, Vehicle-to-Home or Vehicle-to-Building allow bidirectional charging between EV battery and building. With the diffusion of electric vehicles, there is expected to be a future transition to a decentralized energy system, in which, through distributed storage systems and technologies such as smart grids, it will be possible to enable new services by exploiting charging infrastructures.

As the energy system becomes "cleaner" and increasingly digitized, allowing a transition towards decentralized energy generation, storage and *smart buildings*, and thanks to the integration of *edge* and *smart grid* technologies, it will be possible to enable various new services by harnessing the charging infrastructure.

In a Vehicle-to-Grid system, during EV charging periods, the batteries of these EVs can be used as grid-connected energy storage systems. By transforming each user into a potential energy supplier, V2G technology seeks to make the grid more stable and efficient, to maximize the self-consumption of renewable energy and to optimize the flows of energy produced and consumed locally. At the same time, owners of electric cars can be remunerated for the services provided to the electricity system, with environmental and economic benefits - advantages that can contribute to the further diffusion of electric vehicles.

In general, most of the pilot projects in the which V2G technology is implemented rely on direct current charging. The bidirectional interaction between car and charging station requires the use of appropriate communication protocols. In 2019 the standard protocol for V2G is the ChadeMo. Across Italy, according to the Energy & Strategy Group of the Politecnico di Milano, about 5%

of charging points present nationwide at the end of 2018 were enabled with the ChadeMo 2.0 protocol and, as a result, are potentially usable for V2G experimentation.

Conformity of charging pillars, however, is not sufficient in itself for trialling the service. It is, in fact, necessary for the vehicles themselves to be "V2G-*compliant*": in the event of charging with alternating current it is necessary for the inverter on board the vehicle to be bidirectional, in contrast, using direct current no particular hardware specifications are required.

V2G technology has been tested above all by Nissan, but it is, nonetheless, common in vehicles using the direct current, while those that use alternating current are not natively supported (as of the end of 2018), with the exception of the Renault Zoe. Apart from the set-up of the individual vehicle, enabling and diffusion of Vehicle-to-Grid are also influenced by the modes of use of the vehicles themselves, for example, in terms of the halts made: short halts or long halts obviously entail greater or lesser support for the grid.

In Italy in 2019 working groups were set up for the creation of an ad hoc Decree to regulate methods for harnessing the potential of electric vehicles supporting the electricity grid. The draft decree prepared by the Ministry for Economic Development provides for the possibility to use the batteries of electric vehicles to create virtual units capable of providing services for the network, such as frequency regulation and energy reserves; the decree speaks of "Virtual units enabled for charging", constituted exclusively by charging points zero emissions cars.

In our country V2G was first used experimentally in 2017 in Genoa at the IIT (The Italian Institute of Technology), thanks to the collaboration between Nissan and Enel. Two years after the first tests, the second phase of experimentation of the system was begun in Milan, with the involvement not only of Nissan, but also of Enel X and RSE - Ricerca Sistema Energetico, a public research body for the electricity and energy sector.

↳ Mobilità elettrica, accordo tra Terna e Fca

Still in Italy, in September 2019, Terna and FCA signed a partnership agreement for the joint experimentation of technologies and services of sustainable mobility, such as Vehicle-to-Grid, by harnessing a smart charging architecture. The agreement provides for the creation, at Terna's Turin headquarters, of the E-mobility Lab, a technological laboratory designed to test the performances and capacities of electric cars in providing services supporting the flexibility and stabilization of the electricity grid, as well as their interaction both unidirectionally and bidirectionally with the network through a dedicated charging architecture.

Connected Infrastructures

Network technologies enable the creation of innovative applications, including the smart management of mobility, communication between vehicles and surrounding infrastructures, self-driving, environmental control.

Transport systems overall are evolving towards paradigms of connected, cooperative and automated mobility in which the vehicle becomes part of an ecosystem including smart road infrastructures, distributed sensors, private and public IoT control centres. The hubs in this network are capable of exchanging data and information dynamically, thus creating a cooperative and distributed environment supporting public administrations, companies linked to mobility and end users.

In this context, vehicles themselves no longer represent an independent element disconnected from the surrounding environment, but rather constitute a hub in a complex, physical and digital infrastructure. In order to optimize travel and user experience, traffic information is provided both by the physical and connected infrastructure, and by the vehicles themselves and their “behaviour” on the road.

Smart infrastructures and IoT technologies represent enabling factors for the development of connected and autonomous vehicles. However, these technologies are very different from the more familiar domestic networks, less “mobile”, slower and with a smaller range. In order to achieve the full potential of connected mobility, satisfying safety and reliability requirements, large-scale broadband telecommunications infrastructures and standardized IoT architectures need to be created and developed specifically for mobility applications.

Telecommunications infrastructures

According to the Global Infrastructure Hub, by 2040 worldwide investments of 7,800 billion dollars are expected in telecommunications infrastructures, resulting in a significant discrepancy compared to the sum of 8,900 billion deemed necessary to meet infrastructure needs and to seize development opportunities fully.

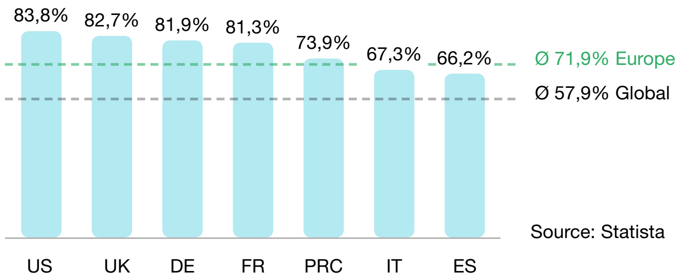
The global diffusion of digital infrastructures for connectivity appears today increasingly necessary for the development of new solutions linked to the automotive, transport and logistics sectors, as well as for the implementation of innovative mobility services.

In the sphere of the mobility of the future, it is indispensable to increase internet penetration, particularly broadband and ultra-broadband connections, the number of users connected globally, the speed of connection between vehicles, people and infrastructures.

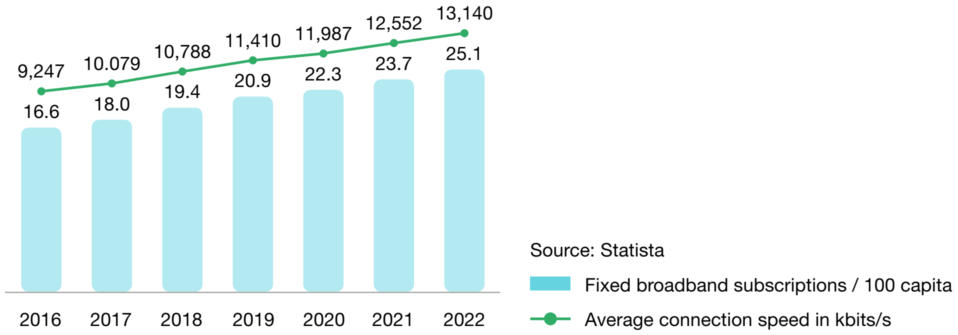
Internet penetration 57.9%	Percentage of the total population that uses the Internet on a monthly basis. The increase in Internet penetration constitutes the basis for vehicle connectivity.
Broadband subscription 19.4, 100 capita	Access to broadband Internet is fundamental for the creation of digital services. Only a change in mindset and in user habits and a large quantity of data traffic lead consumers to incorporate digital services in their daily lives.
Connection speed 10,788 kbit/s	Average Internet connection speed in kbit/s globally. With the increase in connection speeds, more advanced services and functions become available.
Smartphone penetration 44.9%	Percentage of the total population that uses a smartphone on a monthly basis. With the increased use of smartphones, customers request and expect on-board services that present high standards and producers, for their part, begin to implement more advanced telematic services.

As far as the diffusion of the Internet globally and effects on the connected mobility market are concerned, Statista data shows that availability of network access is very high in the United States and in Europe, while China still lies behind despite its recent rapid progress. Again according to Statista, broadband Internet access and connection speeds have experienced continual growth since 2016.

Internet penetration in 2018



Global fixed broadband subscriptions and average connection speed in 2018



The ecosystem relating to mobility infrastructures is delineated in a three-level architecture.

- The so-called "*field level*" or "*basic infrastructure*" comprises telecommunications network hubs, devices and the control points for the management of energy, water, public lighting and waste. As concerns connected mobility, all the devices scattered throughout the territory are grouped together - environmental sensors, road infrastructures, connected vehicles, wearable devices, smartphones - which can communicate with each other both in peer-2-peer mode (think of the V2X paradigm), and in the classic hierarchical mode of telecommunications networks to interact with related service platforms.
- The data generated by the basic infrastructure and by user behaviour are collected by connected objects and devices, becoming the starting point for the provision of "smart services". In the "*network level*", the operator's mobile and fixed infrastructure makes it possible to offer innova-

tive functions through IoT platforms for collecting and systematizing data, edge computing environments and systems for the management of the various modes of communication.

- The "*cloud level*" concerns the service platforms employed for the management and analysis of the Big Data generated in the previous levels, with the objective of providing users with useful, real-time information. Mobility applications and services based on geolocation are the contact point with end users.

Internet of Things on connected infrastructures

In the so-called *road* or *field level*, we have the development of the Internet of Things (IoT), a neologism referring to a group of technologies allowing connected devices to detect data in real time, to interconnect "objects", to transfer information and to act accordingly, making it possible for companies and public administrations to create new products and services.

Through this innovation devices can be managed remotely and are capable of gathering and transmitting data continually, providing useful information about their functioning and about user interaction with the same.

Among the most important issues relating to the IoT are the definition of a shared architecture and the standardization of technology, as well as risk management for security and data privacy. These solutions can undoubtedly bring broad social benefits, but they also require responsible governance.

According to a research study conducted by GSMA, the world association of mobile operators, it is estimated that turnovers connected to Mobile IoT technologies and services will reach 1,800 billion dollars over the next decade. Observing trends sector by sector, the connected car field places third among those that will grow the most.

With regard to research, development and testing of IoT connectivity technologies - such as NB-IoT, LTE-M and 5G – numerous players are interested in developing a favourable environment for ecosystem growth and for the implementation of new services. These include telecommunications companies, companies that develop and integrate IoT applications, as well as governments and regulators around the world. Overall, a rapid spread of the IoT is occurring despite the challenges related to the costs for the creation of new infrastructures, to compatibility and the lack of standards and to regulation of different aspects of the same technology.

Architectures and protocols in the Internet of Things

The Internet of Things requires scalable architectural choices, both in terms of observation of data by sensors or in the transmission thereof, and in terms of the processing or realization of the connected systems. The complexity resides in the identification of device requirements, which vary according to the contexts of use, but also in the continual evolution of connectivity protocols.

From 2G to 3G, and up to the now predominant Low Power (LPWAN) - including NB-IoT and LTE-M - and the most recent 5G technologies, all have been competing in the connectivity landscape to establish themselves as a standard.

The cost component represents a key factor in offering value added services without incurring excessive costs or high initial investments. For this reason, suppliers of sensors and network solutions are ever more oriented towards low consumption and long-range solutions.

Some devices are capable of communicating directly with one another ("device-to-device") through the short-range transmission of small packets of data and a communication protocol (for example Bluetooth, Z-Wave, cellular, ZigBee) with extremely low latency. Where, in contrast, communication between devices is envisaged through a gateway ("device-to-gateway") - a sort of "intermediary" device for connecting a number of devices simultaneously, physically close to the cloud - the latter is in the form of a software *layer* capable of increasing transmission security and translating raw data into a format that makes its subsequent processing possible. A further communication model, instead, allows "objects" to communicate directly with the cloud ("device-to-cloud") without using a gateway; in this case the communication uses Ethernet, cellular or Wi-Fi protocols and can provide direct access to the devices themselves.

Considering the exponential increase in connected devices that will take place over the next few years, the existing connection options (Bluetooth, cellular connectivity) will no longer be practicable due to increasing costs, limits linked to power (understood as the number of connections supported and band capacity) and of energy consumption. By way of example, 2G and 3G are not capable of guaranteeing adequate connection speeds; WiFi has high costs, needs the right hardware and software configurations and presents high consumption; Bluetooth guarantees exclusively short-range communication and is capable of connecting no more than 7 devices at once; Z-Wave is cheaper and simpler to implement than Bluetooth and Wi-Fi, but is devised exclusively for short-range communications (from 10 to 100 mt) and is not really suitable for the development of IoT applications for mobility and transport.

In general, amongst the network technologies for the IoT, connectivity through 5G, LTE-M, NB-IoT, satellite connectivity, Sigfox, LoRaWAN are all undergoing experimentation. Here below are outlined the characteristics and possible applications of the two best-established standards in the sector, NB-IoT and LTE-M:

Narrowband Internet of Things (NB-IoT)

↳ GSMA – Narrowband – Internet of Things (NB-IoT)

The NB-IoT is an open technological standard for LPWAN (Low Power Wide Area Network) radio communications developed by the organization 3GPP (for the standardization of mobile cellular communications). It is intended principally for low-cost coverage in situations of high-density connections for extensive areas of coverage; it uses, moreover, a portion of the LTE spectrum. The long duration of batteries, which can exceed 10 years - above all if used at low data transmission speeds -, the low latency of transmission, the large number of connections supported – up to 50 thousand connections per cell - and the possibility to exploit the licensed frequencies improve the reliability and security of communications as well as quality of service. The possibility of connecting objects and sensors positioned even within sites that are difficult to reach through cellular connectivity and electrical power supply makes NB-IoT the ideal choice for structural monitoring services for bridges, damns and viaducts. The first implementations were carried out in Europe and almost all NB-IoT devices available commercially today can be updated in their firmware to support 5G functions, making Narrowband IoT the ideal choice for companies that wish to protect their own investments in smart technologies.

LTE-M

↳ GSMA – Long Term Evolution for Machines: LTE-M

This is a technological standard for the LPWAN (low-power wide-area-network) radio communications, also developed by 3GPP. It relies on the LTE network and ensures the connection of a vast range of cellular devices and services, in particular for machine-to-machine (M2M) and IoT applications. It makes it possible for devices to connect to 4G directly, without a gateway, and presents a data rate of about 384 kbits/s. The advantage of LTE-M over NB-IoT is its greater data speeds, as well as its voice transmission "over IP" and its possibility to be used in mobility; on the other hand, it requires more bandwidth and has higher costs. The use of a dedicated and licensed bandwidth spectrum, together with scalability, ensure good performance with low interference. A further advantage is represented by batteries: since IoT devices can use the Power Savings Mode (PSM) when not connected, it is possible to ensure low consumption and a duration of up to 10 years. In general, it provides long-range applications and good coverage (up to 7 times higher than that of the most popular cellular networks) even for sensors and devices positioned in closed spaces or even underground. It was initially adopted in North America, but some large operators such as AT&T are working on expanding coverage globally for applications in various sectors, including retail, energy, utilities, healthcare.

Convergence of 5G and IoT for connected mobility and self-driving vehicles

IoT connectivity for connected mobility guarantees users complete and fluid experiences through the use of services of infotainment, cloud connectivity, vehicle tracking and reception of real-time information. These applications allow interaction with the outside world, supporting both navigation and remote diagnostics and, lastly, improving security.

In order to enable these services, connectivity requires interoperability as a prerequisite. In addition, it requires that sensors and applications be connected in *embedded* mode or by *tethering* (thus allowing direct access to the web). In *embedded* mode, in which sensors transfer data automatically through the Internet of Things and Vehicle-to-Everything, the sensors themselves are predominantly used for location or security applications, while in *tethering* mode, which includes cellular, Wi-Fi and Bluetooth connectivity, these are used primarily for entertainment.

Also with regard to self-driving vehicles, in addition to advanced technologies for data analysis, artificial intelligence and the integration of complex hardware and software, there are requirements related to connectivity. To improve the reliability of self-driving vehicles, in fact, it is necessary to have various types of connectivity converge and move fluidly from one network to another, ensuring continuity in communications and increasing the efficiency thereof with other cars and other devices. The network infrastructure must also support low latency, meet the needs of both narrowband and broadband and guarantee little interference, also through the use of licensed portions of spectrum. Finally, cellular communication infrastructures must provide continuous data backup, redundancy for emergency situations and ensure high security standards.

4G wireless technology is capable of handling some IoT applications but suffers from latency and lack of bandwidth. By 2030, it is expected that 5G will allow IoT devices to transmit large quantities of data between perimeter sensors, data centres and a variety of other processing resources distributed in almost real time.

IoT technology combined with the speed and bandwidth of 5G will be of benefit to numerous sectors, including that of transport, facilitating data transmission for systems of advanced navigation, satellite radio and roadside assistance, as well as helping autonomous vehicles to take decisions in real time. It will also allow communication with the infrastructure and traffic systems enabled to transmit data bidirectionally with surrounding sensors.

Despite the costs, the high energy consumption and the low scalability - the satellites are not able to support the connection of millions of devices - satellite communication is also exploited in the area of Smart Mobility, in particular to cover dark areas where common cellular coverage performs poorly. Operators in the sector are also working to make satellite networks interoperable and integrated with other types of connectivity, such as the cellular network. The industrial sectors that will potentially see a massive use of satellite connectivity include logistics (in particular fleet management and asset tracking), oil & gas and the military sector.

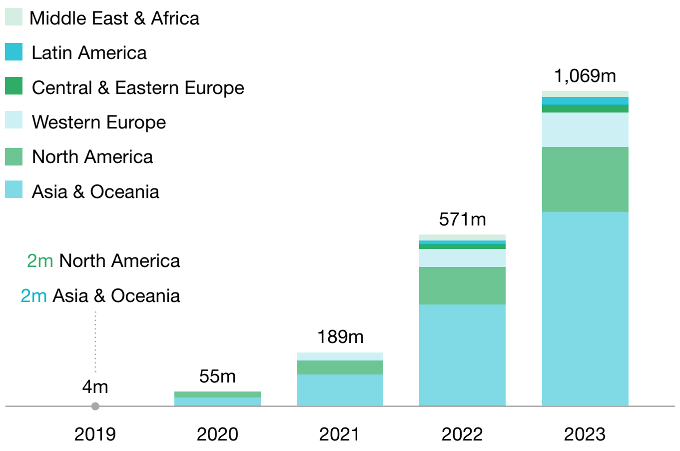
Impact of 5G on the future of transport

↳ Everything you need to know about 5G

The next generation of 5G network will offer mobility services new features, which will go beyond simply achieving better operating performance. In addition to providing higher speeds and significantly reduced latency, a key aspect is, in fact, subdivision into networks, that is to say, the ability to define sub-networks with a specific quality of service for a dedicated use. This allows the creation of new complete logical networks that can be dedicated to the management of specific areas such as road infrastructures.

Global 5G breakthrough is imminent

Estimated number of 5G mobile connections



As of June 2018. Source: Statista

The *Ericsson Mobility Report of 2018*, cited by Statista, records in 2019 only 4 million 5G mobile connections worldwide. Estimates, however, forecast its exponential growth, with a billion connections being reached by 2023, of which 118 million will be in Western Europe. The same source estimates that by the end of 2024 5G subscriptions will reach 1.9 billion units, with 35% of data traffic conveyed by 5G networks and 65% of the world population covered by the technology.

Focusing on market forecasts linked to the diffusion of 5G, according to the World Economic Forum the fast

and smart Internet connectivity enabled by 5G technology will generate 12 trillion dollars in global economic value within the next two decades, as a return on huge investments.

While several countries have already clearly planned a schedule for the implementation of 5G, others lag behind. In fact the investments necessary for the adaptation or 'ex novo' creation of infrastructures are significant; moreover, there is a lack of strategic alignment between the visions of political figures, of the regulators and of the private sector. China, South Korea, United States, Japan and some Scandinavian countries are leading the way to 5G. In Italy, bureaucracy and strict limits on electromagnetic emissions linked to fears about health block the road to the diffusion and development across the territory of technology and of complementary smart solutions.

In general, one of the main challenges that 5G will have to overcome in order to adequately support connected and autonomous mobility is the achievement of complete coverage across the territory. To ensure that cars move autonomously but also safely, it is not in fact possible to have roads or places without connectivity.

As regards instead the security of the ecosystem, this can be improved through the application of mechanisms of *trusted identity, trusted data* and *trusted infrastructure*, with the aim then of making the devices and infrastructures protected from any tampering or cyber attacks. Finally, it is necessary to implement high-precision spatial location algorithms more suitable for the management of mobility hubs.

↳ 5G for traffic management

5G has enormous potential to transform current transport systems into intelligent systems for connected and autonomous mobility, harnessing standard network protocols, communication optimized for mobility and interconnected systems for digital identity management:

- **Vehicle-to-vehicle (V2V)**: 5G will allow direct vehicle-to-vehicle communication, without going through the network, to prevent traffic congestion and delays. In the sphere of autonomous mobility, “self-driving” vehicles will be capable of alerting other vehicles in movement when a change in road conditions occurs (collisions, adverse weather conditions, slowdowns due to roadworks). This will allow autonomous vehicles to bunch together in what are called "platoons" - a group of vehicles going in the same direction at a specific moment -, optimizing, in this way, the traffic and at the same time improving road safety.

- **Vehicle-to-infrastructure (V2I)**: 5G will allow communication between the vehicle and infrastructures (for example, sensors, traffic lights, video cameras, drones). If it is indeed true that the current wireless technologies are fragmented, 5G will not only unify communications and provide direct low latency, but it will also permit the implementation of smart applications up to now unimaginable that can bring about a huge reduction in travel times together with safer journeys.

- **Multimodal transport**: this form of transport provides for the switching between one form of transport and another in a seamless interaction. Application services and connectivity based on 5G can ensure that user recognition and payment features are as simple and safe as possible. This requires an integrated management of digital identities among the various systems and providers, which is currently handled separately, and security and privacy for end users.

Globally, to fully realize the potential of the opportunities offered by 5G, the subjects in the whole value chain will have to understand in good time the changes brought about by each phase of 5G development in such a way as to be ready to capitalize on the latest features released and to adapt one's own business models in a dynamic way.

Focus – The Smart Road decree and experimentation in Italy

In Italy, the "Smart Road" ministerial decree, approved in 2018, authorizes the testing of technological solutions to adapt the Italian infrastructure network to new smart services and autonomous mobility.

The decree provides for the realization of interventions for the diffusion of connectivity for smart traffic management, to be implemented by 2025 on the infrastructures belonging to the TEN-T (Trans European Network - Transport) network and on the entire motorway network. The same decree also provided for the possibility for the Ministry of Infrastructure and Transport to authorize on-road testing of self-driving vehicles.

The aim is to improve the national road network through its gradual digital transformation, making it suitable for dialogue with the new generation connected vehicles and exploiting the most advanced levels of automatic driving assistance, as well as improving and streamlining traffic and reducing the risk of road accidents.

The decree provides, in particular, for interventions necessary for the communication of high bit-rate data, the coverage of all road infrastructure with connection services to the data communication network (V2X, 5G, connection services for IoT), the presence of a WiFi hot-spot system for the connectivity of personal devices of users in transit, a system to observe traffic and weather conditions and to provide medium-short term forecasts and estimated weather forecasts for subsequent periods. On the basis of the data collected, the system will also offer content for advanced real-time information services to support travellers. By 2030 the "Smart Road" decree establishes that "additional services are to be activated: diversion of flows, intervention on average speeds to avoid congestion, suggestion of routes, dynamic management of accesses, car parks and refuelling, including electric charging". The installation of devices for structural monitoring of the status of road works is also envisaged.

In Italy there are many initiatives already underway as well as trials in progress. In 2019 Anas signed an agreement with Open Fiber for the creation of infrastructures for a fibre optic network, with the objective of reducing the digital divide. The Anas programme envisages a first stage of laying the optical fibre (off) to create a network about 3,000 km long. It has also earmarked 140 million euro for infomobility and safety along roughly 2,500 km of Anas roads stretching across the whole country.

Regarding 5G trials directly connected to smart mobility, these are underway, for example, in Milan and Bari. Milan and its metropolitan area have, since the beginning 2018, played host to the 5G experimentation supported by MISE (the Italian Ministry for Economic Development), and with the involvement of 28 partners, with Vodafone as leader, and of local authorities. The focus of the experimentation is IoT and the development of smart applications in 7 different intervention areas for 41 use cases in total. One of these is the connected ambulance, the aim of which is to start medical treatment already in the ambulance, with tests and diagnostic imaging. This project sees the collaboration of the San Raffaele Hospital, Nokia, Qualcomm, Lombardy Regional Government, the Red Cross. As regards mobility and transport, one of the experimental projects is called "Cooperative Urban Cross Traffic" and is based on the possibility of exchanging information on traffic conditions and the state of the roads, using for example sensors fitted on tyres. Project partners include Politecnico di Milano, FCA, Magneti Marelli, Pirelli, Altran, Vodafone Automotive, and ACI, ATAM, Lombardy Regional Government.

Remaining within the scope of the MISE call, another Italian 5G trial concerns Bari, chosen for its strategic position to be one of the first ports in which to implement the IoT: here 5G will be used predominantly to test advanced services related to security and to the control of goods and access.

The European 5G-CARMEN project plans to implement 5G antennas on the Brenner motorway to allow connected cars to interact with the infrastructure along the route. The initiative envisages a first series of large-scale test corridors for the development of 5G technologies that allow, among other things, the automated driving of heavy transport vehicles and is part of the broader development framework of trans-European transport networks (TEN-T), of motorway networks and of the major European cities that, between 2018 and 2025, will involve the main urban centres and the most important transport arteries in the European Union.

Cybersecurity for critical infrastructures

By increasing connections in the digital world, infrastructure managers and operators cannot be indifferent to the evolution of cyber threats: it becomes necessary to consider and structure adequate security systems through the implementation of solutions for cyber defence. The number and severity of cyber threats continues to grow exponentially as the world becomes ever more connected.

> Critical infrastructures include physical and IT systems, as well as the resources essential for individual states; by way of example, national electricity systems, technological systems for connectivity, defence, emergency management services, etc. Failure, destruction or tampering with critical infrastructure by hackers or attackers can have a devastating impact on a State's physical and economic security and on public health.

According to Gartner, by 2020 as many as 20.4 billion devices will be connected to the internet. This proliferation creates an increase in productivity and efficiency, while exposing the attackable surface of existing infrastructures to potential threats and hacker attacks.

The growth of the “attack surface” for intrusions and cyber attacks in the context of public and private mobility is due to the introduction of new points of potential vulnerability, such as connected and self-driving cars, smart traffic lights, smart charging points and roadside sensors, which are potential “entry points” for the ill-intentioned.

New technologies in the transport system modify the basic nature of the vehicles used. For example, a bus is no longer just a public vehicle but also a system for collecting and recording data, an asset that facilitates the dissemination of various kinds of information, a mobile WiFi hub and a source of real-time information that makes it possible to develop strategies for the optimization of the transport network. In this context, the gap between what is physical and what is cyber disappears.

Potential applications of technology developments in cybersecurity for the mobility sector include advanced cryptography techniques, advanced threat detection and high-security wireless communications.

The start-up NanoLock Security is developing systems of IT security for IoT devices, for protect diverse parti of the IT systems - including firmware -, aspect particularly important for edge computing in connected cars given the greater vulnerability of IoT devices. In February 2019 the start-up announced a partnership with a listed semiconductor company to develop jointly solutions based on flash that boost the device security in the automotive sectors. The collaboration will develop solutions to allow for the creation of a reliable platform, to permit secure updates for the electronic units of autonomous and connected vehicles.

NANOLOCK SECURITY

NanoLock Security is a secure platform that protects firmware and sensitive information stored on connected and IoT devices and prevents attack attempts ranging from ransomware to malicious manipulation of stored data. The company offers safety solutions for autonomous and connected cars and for the market sector of industrial controllers.

Total Funding
$4.5 mln

Last Round
Sep 2018
Incubator/Accelerator

Country
United States

nanolocksecurity.com

In general, intentional and/or accidental threats to infrastructure security have serious consequences according to the maturity of the integrated system. In Smart Cities, a hacker attack can increase urban congestion by affecting the traffic light system and its sequencing, connected traffic signs and the speed control system.

The start-up Cynamics has recently created a machine-learning solution to holistically monitor network traffic without the need for any device and on a large scale. This approach to security, designed to guarantee network performance, allows smart cities and governments to have broad network visibility and to dispose of early attack prediction long before large-scale damage can occur.

Analysis of transport management systems demonstrates that the attacks with the greatest impacts occur in the area of air traffic and on rail control systems. In particular, as regards, the defence of rail systems against external attacks, transit security is closely connected to the security of train communication networks, wireless communications, signalling systems and station automation systems.

CYNAMICS

Cynamics is a network monitoring solution built for smart city, public safety, and critical infrastructure networks.

Total Funding
-

Last Round
Aug 2019 Undisclosed Investors

Country
United States

cynamics.ai

In 2014, the Chinese domestic train booking system was targeted by hackers who stole customers' personal data. In 2015, the Polish national airline LOT had to cancel ten flights due to a cyber attack on the airline's IT system at a local airport. In 2017 the German rail operator Deutsche Bahn was forced to close stations when it was struck by the WannaCry ransomware. In the same year, twenty ships in the Black Sea lost the ability to sail safely due to counterfeit transmissions that mimicked GPS signals. In 2018, Maersk, a company with activities in the sectors of transport and maritime logistics, suffered damage to its IT system of approximately 300 million dollars.

Cylus helps the main rail companies to avoid accidents and disruptions in service caused by cyber attacks. The company offers solutions specifically designed to meet the specific needs of the rail transport sector: the Cylus team in fact combines great experience in the areas of cybersecurity and rail security.

CYLUS

Cylus develops cybersecurity solutions for railways and metros. Cylus provides a platform that enables rail companies to maintain safety and avoid service disruption by detecting cyber-threats in their signaling and control networks before harm occurs.

Total Funding
$16.94 mln

Last Round
Aug 2019
Incubator/Accelerator

Country
Israel

The European Agency for Cybersecurity (ENISA) has classified functions and assets, by degree of criticality and vulnerability, and threats in the sphere of the public transport.

According to the consulting firm ABI Research, in 2024 44% of the global IT security expenditure of $ 100 billion will go to the energy, healthcare, public safety, transportation, water and waste sectors. Despite the considerable resources made available, the aforementioned analysts do not consider the effort sufficient to guarantee an adequate level of protection from hacker attacks on critical infrastructures.

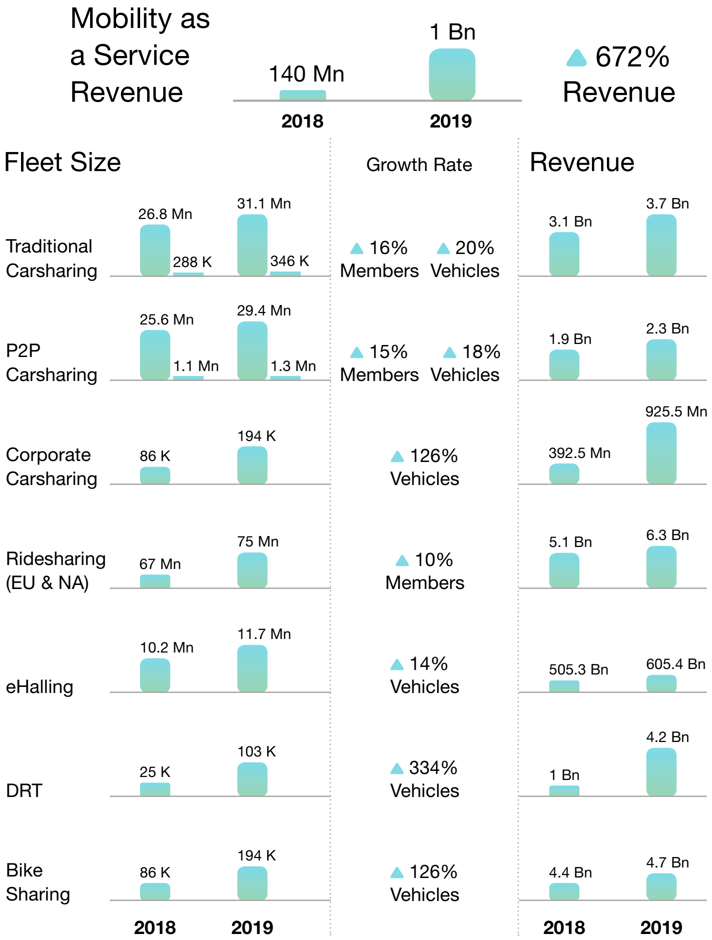
CRITICAL ASSETS	• System of payments • Internet and communication system • Operation control centres • Physical infrastructures • Security systems for sector and passengers • Data collection and privacy systems • Integrity and availability of data and communications • Reputation, public communications and social media • Financial profitability • Social engineering
POTENTIAL CRITICAL THREATS	• DdoS (Distributed Denial of Service) attacks • Tampering with hardware and/or software • Interruptions in the electricity grid • Terrorist attacks • Natural and environmental disasters • Malware and viruses • Unauthorized access • Loss and alteration of sensitive data • Operator errors • Strikes

Impact of infrastructures on business models

Digital progress underlies the development of new forms of transport and the success of innovative mobility services focused on the optimization of the customer experience. For this reason, the industrial sectors of transport and mobility will have to adapt their business models if they wish to fully exploit the technological potential of 5G.

The development and diffusion of new business models, such as ridehailing, car sharing, e-hailing, ridesharing, micromobility and multimodal service platforms testify to the transformation in progress.

According to Frost&Sullivan's estimates, by 2030 these innovative business models will manage to generate a market value of $ 2.2 trillion.
One of the main reasons for the success of new business models is certainly the growing sensitivity towards environmental issues, which channel virtuous choices such as, for example, energy saving and increased use of sustainable means of transport. Other factors can be identified in the increasing congestion due to the increase in traffic and in the policies incentivizing the use of alternative means of transport in the urban environment.
In this scenario, the mobility market is progressively moving towards multimodal and collaborative solutions, capable of guaranteeing greater flexibility and effectiveness in transport.



Source: Frost & Sullivan

Data Monetization

Data monetization strategies allow automotive companies to enhance their own offerings of products, from input to design; by exploiting the huge volumes of data it becomes possible to improve the customer experience, optimize the costs of production, offer new services and increase the levels of security of the vehicles.

By 2025 data monetization opportunities in the automotive sector will generate revenues of $ 33 billion for car makers and OEM's, thanks to shared mobility platforms and to services linked to vehicle connectivity.

Connectivity in the electric vehicle market represents a further interesting potential for the generation of data and, in the near future, for the monetization thereof: Hyundai Ioniq and of Kia Niro EV's new telematic systems are capable of providing great volumes of information concerning the charging of the vehicles, the position of charging stations, the availability of chargers and the compatibility of connections for the charging itself. These data will be able to be harnessed in the future for multiple solutions. Although the forecasts confirm the great potential in the market, the gap between the potential value of data monetization and actual incomes (or savings) generated by sector players remains substantial.

Key Enablers of DM

- Growing Data
- Big Data, AI, Cloud & Analytics
- Transforming Business Segments
- GDPR

Key Barriers for DM

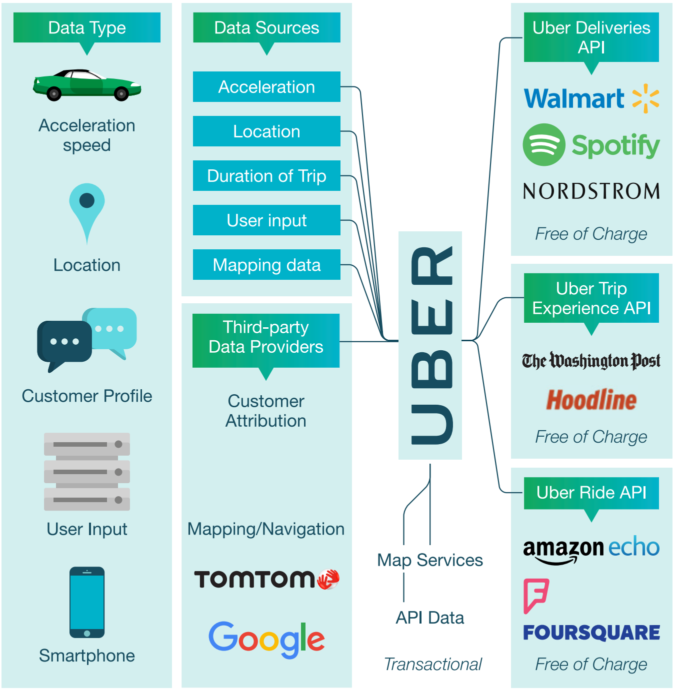
- Zero Data Sharing
- Lack of Skilled Manpower
- Data Ownership Issues
- GDPR

In this regard, McKinsey interviewed more than 60 leaders from the automotive sector in order to gauge attitudes towards data monetization and the state of progress of initiatives in this direction. The results demonstrate that the greatest obstacles to the success of the technology are, on the one hand, the reluctance of consumers to share personal data (84% of the interviewees share a sense of the difficulty of conveying the potential benefits that consumers would have and the guarantee of a responsible use of the information obtained), and on the other, the need for companies to undertake internal reorganization, dictated by the processes of digital and structural transformation necessary to develop new services and business models (69% of executives believe that their companies require a less rigid organizational model, without, however, having a clear vision of the ideal structure). A final factor observed in the survey identifies the establishment of partnerships as key to a correct functioning of this digital ecosystem, involving the various players of the same. In this regard, it emerges that the players that are most difficult to involve are OEM's and companies characterized by broad organizations, unlike start-ups or the tech players that view collaboration more favourably.

One good example of the efficient use of data is to be observed at Toyota: the company uses the data from its cars to produce local traffic forecasts. This information is, in turn, sold to town councils and logistics companies, with the purpose of understanding and improving urban infrastructures and optimizing travel routes.
In the insurance field, too, data monetization helps to align product supply with customer expectations, guaranteeing the customization of the service.

Uber distinguishes itself as a virtuous model in the sphere of technological innovation. Through its digital platform, thanks to the processing of data from over five billion journeys in six hundred different cities, the company anticipates using the huge volume of information available to provide various innovative services such as route optimization, HD mapping of cities, the study of driving behaviours, the analysis of traffic congestion, and urban planning.

Uber Data Monetization Model, Global, 2018



Source: Frost & Sullivan

The creation of Uber's data monetization model necessitated the signing of partnerships with external organizations (for example, technology suppliers and infrastructure operators) intended to acquire further data from third parties (such as TomTom and HERE). Furthermore, the company has signed agreements with the public authorities for the control of traffic congestion.

Other instances of new opportunities arising from the process of Data Monetization in the automotive field concern Tesla. The company is developing self-diagnosis systems for its own cars with the aim of offering insurance products through companies in the group.

Mobility-as-a-Service (MaaS)

The result of the progressive transformation of mobility into a genuine service is expressed to good effect in the acronym MaaS (Mobility-as-a-Service), which describes a new business model based on the provision of multimodal transport services.

The aim is to offer the user a unified and connected service capable of planning routes to be taken taking into account all the means of transport available, whether public (trains, buses, car sharing and bike sharing) or private (own car, bicycle, motorcycle). The service is managed through a single platform capable of processing and sharing the data flows with all the players involved.

> The model of mobility offered by MaaS intends to combine the multiple transport options available and to provide new customized solutions.
> The idea of multimodal services replaces and, at the same time, integrates the use of the various platforms active in today's market and of differentiated payments, implementing it all in a single application.

Mobility-as-a-Service allows the user to optimize travel times and to reduce costs. The possibility to add variables linked to the route is also envisaged; this includes personal travel preferences and weather conditions.

The system is capable of booking the means of transport necessary autonomously and of proceeding to payment by applying various types of fares, from "all inclusive" season tickets to "pay-as-you-go" formulas. *Maas* solutions constitute an effective solution for the private user, bringing significant positive externalities also for public transport companies.

The long-term goal is to extend the service to a corporate clientele and to the transporting of goods.

A classification of the degree of integration of the various options for the services offered by MaaS is helpful to provide an understanding of its potential level of evolution.

Some operators in the MaaS sector make it possible to extend the service to a corporate clientele and to the transporting of goods.

0	**No integration** Each service develops its own individual platform
1	**Integration of information** Search for travel solutions, multimodality
2	**Integration of booking and payment** Single journey – search, book, pay functions
3	**Integration of the services offered** Pay-for-use, Season tickets, Bundle, etc.
4	**Integration of social goals** Policies, Incentivization, Sustainability, etc.

The basic idea is that the mobility of the future is destined to offer a user experience that is so efficient and advantageous in both economic and practical terms that it can replace private transport.

In Europe in 2017 there were almost 252 million private vehicles. The statistics highlight how, generally, cars remain unused for about 90% of the time, with an average occupation rate of 1.6 people per vehicle (when used). In this context, the new mobility technologies and end-to-end platforms display immense potential for the optimization of the use of private vehicles.

The MaaS Market

According to F&S estimates, the global revenues from the MaaS market will grow exponentially, going from $ 61.3 million in 2018 to $ 34.53 billion in 2030, with an average annual growth of 69.5%. This growth will be led predominantly by the European and North American markets.

According to the same forecasts North America will constitute the largest portion of the market, exceeding $ 9 billion in value in 2030.

The greatest percentage increase, nonetheless, is anticipated in China, where the average annual growth will be of 109% in the 2018-2030 period. The players in the *Maas* sector are primarily concentrated in Europe owing to the quality of public transport there and to the presence of efficient infrastructures that make Germany, Finland and France leading countries in this field. By 2030 these operators are expected to have expanded towards other continents, especially North America and APAC. Among *Maas* sectors, the most significant growth is predicted in the sphere of DRT (Demand-Responsive Transit) services, the modes of transport in which vehicle routes are defined on the basis of individual travel needs, without then having predetermined routes or fixed timetables. Between 2013 and 2017 more than $ 60 million were invested in these solutions.

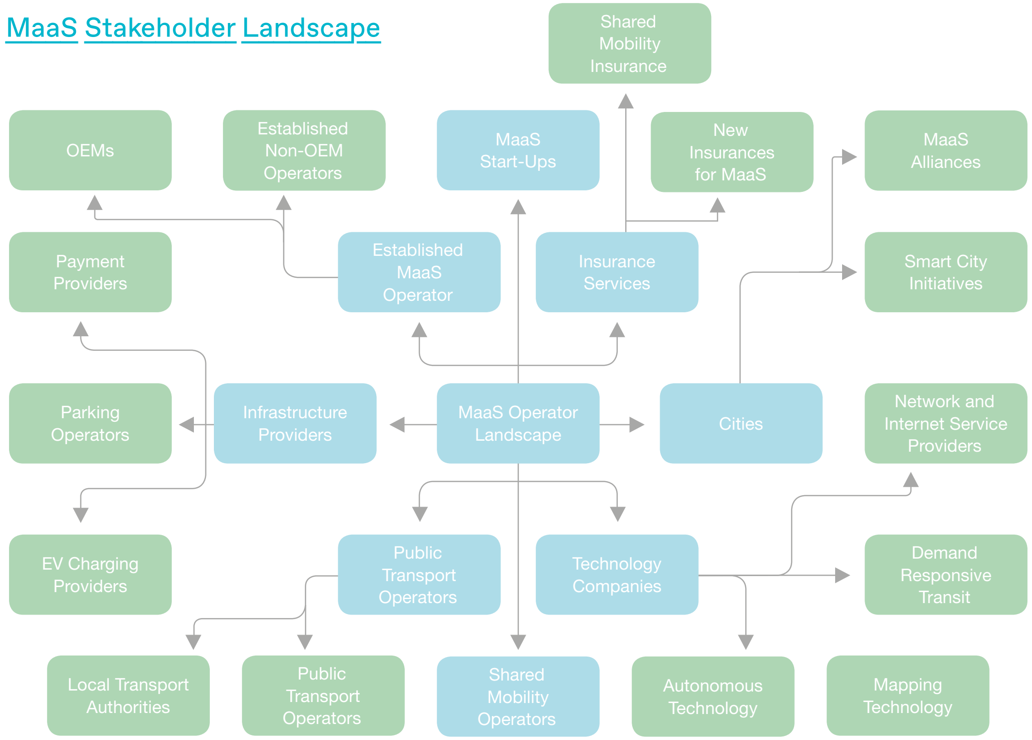
In 2019 there are, in total, 20 cities around the world in which active MaaS platforms are present.

The Mobility-as-a-Service ecosystem

The high level of interoperability and cooperation among the various players represents the principle underlying Mobility-as-a-Service, which involves all parties concerned including consumers, transport authorities, private players, suppliers of infrastructure and suppliers of software.

The constant increase in investments in the various services of shared mobility has contributed to the evolution of the ecosystem and to the emergence of new MaaS platforms. As of 2019 there were indeed multiple start-ups in this sector, often supported by government bodies, research institutes and universities, as well as partnerships involving public transport companies.

MaaS Stakeholder Landscape



Source: Frost & Sullivan

In the field of MaaS operators, among those operators supported by public transport authorities we see, for example, MetroTransit, Ladot, Moot, while among the operators that present themselves as private companies we find Moovel, Moovit and Whim. The latter segment includes both companies and start-ups already operational in the provision of specific services for mobility that broaden and integrate the existing offerings, and new companies established specifically to provide MaaS services.

OEM's, too, and tech giants have set themselves the target of bridging the gap between operators in the public and private systems, seeking to integrate and expand the current ecosystem with MaaS services.
With the diffusion of integrated platforms the major players in the sector will be able to dispose of an enormous

quantity of data and relevant information, on the basis of which strategies can be optimized and new business opportunities identified.

The sharing of data relating to mobility by operators represents a core element and a challenge for the scalability of multi-modal services, since players are generally reluctant to allow, in the public sector too, access to their own databases. The situation is, however, changing slowly and the boundary between public and private forms of urban transport seems to be becoming less and less marked. For consumers too, consent for the sharing of personal data with service providers is no longer a critical issue, but is incentivized by the provision, for example, of additional services and benefits (discounts, coupons).

MOOVIT

Moovit, formerly Tranzmate, is a transit data and analytics company that simplifies urban mobility around the world, making transportation easier and more convenient. By combining information from public transit operators and authorities with live information from the user community, Moovit offers travelers a real-time picture, including the best route for the journey.

Total Funding
$131.5 mln

Last Round
Feb 2018 Series D
$50 mln

Country
Israel

moovitapp.com

Mobility-as-a-service market: MaaS value proposition, global, 2018

Vendors (Technology)

- Gateway to enter one of the fastest growing markets - the transportation service market
- Opportunity for innovating
- Alternate streams of revenue

Transport Operators (Public & Private)

- Opportunity to improve the local transport network - improving first and last mile connectivity
- Possible reduction in car ownership rates, with positive impact on traffic, enviroment and congestion
- Help plan cities better using the data collected by MaaS operators

Government and Cities

- Opportunity to cater to wider group of customers
- Can help improve demand during off-peak hours
- Drives innovations in the travel market, (improved booking, payment and informations tools, data-sharing)

End Customers

- Wider range of transport options to choose from
- Personal mobility packages which could help reduce the cost of transport
- Particularly attractive in dense urban areas with a number of mobility options; furthermore, users can worry less about traffic and parking

Source: Frost & Sullivan

Through the MaaS model operators of infrastructures, such as, for example, motorways, will be able to establish modular solutions and prices on the basis of the intensity of use, of times of day and of other parameters. Furthermore, Maas solutions can also contribute to the creation of value for transport service providers, by offering the opportunity to meet customer demand not previously exploited through the simple and intuitive use of digital interfaces and of payments, as well as through richer data on models and on the dynamics of demand for mobility.

Also for autonomous vehicles, MaaS solutions will be increasingly crucial: it is predicted that access to autonomous vehicles will be made specifically through Mobility-as-a-Service platforms, rather than through private purchase. In these cases shared and autonomous mobility service providers will have considerably lower operating costs than traditional ones since, with the elimination of the human element, supply will become more efficient and more competitive.

In the field of investments, among the exemplary cases in this area there emerges Toyota, which has invested $ 500 million and $ 1 billion respectively in Uber and Grab in order to increase its activities in the ride-hailing of self-driving cars by 2021. Daimler and Bosch are planning to launch self-driving taxis by 2019, while Google has invested 11 billion in Waymo to integrate self-driving vehicles into an “as-a-Service” model by 2021.

Focus – Overview of active MaaS platforms

Among the transport solutions active in the market in 2019, the collaboration of BMW Group and Daimler AG has attracted general attention with the investment of a billion euro concluded in early 2019. The two giants announced the creation of five joint ventures for urban mobility services: ReachNow, ChargeNow, Freenow, ParkNow, ShareNow.

In the sphere of multimodal and on-demand services, the Moovel platform will soon be replaced by ReachNow, soon to become a reference point for the global market with its multimodal transport solutions designed to optimize the traffic flows in cities and to make journeys in the city more efficient.

According to data from 2019, the platform active in the German cities of Düsseldorf, Hamburg, Karlsruhe and Stuttgart has reached 6.5 million users, with an annual growth rate of 69% and with one transaction being recorded every 1.1 seconds on its platform.

The tool enables a completely “on-demand” service integrating services of shared mobility (car-sharing, bike-sharing, other), parking, charging infrastructure networks, taxis and public transport, making it possible to book the specific means of transport and to pay for the tickets directly from the app. Since 2018, the platform has also included the service of “on-demand” ridesharing already established in the cities of Stuttgart and Los Angeles.

In the North American market, thanks to 18 collaborations with transport agencies, Moovel is the main provider of mobile ticketing services for transport operators.

Also the well-known mobility services provider Lyft is currently collaborating with other mobility operators to transform its application into a multimodal transport tool in various cities in the United States. In 2018 it concluded its acquisition of bike-sharing company Motivate, launched its scooter-sharing activities, and initiated monitoring of public transport (local buses and underground) for the purpose of suggesting different and optimal trip tips to users.

With many years of experience in the sector, the Here Mobility platform offers, both to companies and individuals, mobility solutions harnessing the different transport options available (public transport, taxis, shared services and others). The platform seeks to offer customized transport solutions to optimize the customer's experience.

↳ The easiest public transport ticket across Switzerland

Switzerland boasts the world record for the introduction of an innovative system of “Post-Price-Ticketing” for the whole country's public transport systems. The “Fairtiq” application allows users to employ different means of transport (train, bus, tram, boat) without the need to purchase the individual tickets in advance, by harnessing passenger geolocation to calculate the price of the journeys made. Through the Check-in and Check-out functions, respectively at the beginning of the trip and at the end, the user transmits his/her position to the system throughout the whole journey. At the end of the day, the system calculates the overall price of the journeys made and debits the sum automatically.

HELSINKI

The city of Helsinki represents a cutting-edge model for urban mobility, thanks to its efficient public transport network and to the shared mobility schemes promoted. Among the Finnish capital's main aims is that of rendering it ever less necessary for citizens to own a car by 2025, by promoting the idea of transport as an ecosystem rather than a network of suppliers of individual and independent services.

In this scenario, the Whim platform, launched in October 2016 by the Maas Global start-up, represents one of the major European successes in the MaaS sphere. The application is an intermodal transport solution that allows users to plan journeys using public transport (Helsinki Region Transport), bike sharing, taxi (Lähitaksi) and car sharing (Sixt).

The tool also makes it possible to book the means of transport necessary (or to book taxis) and to make payment for the same through the pay-as-you-go formula. The possibility to take out monthly/annual subscriptions represents a further added value in the service, capable of broadening the offering with different customized packages.

Confirming the success of the service, in the month of January 2019 the tool's adoption rates reached the milestone of three million journeys booked and an average of 60,000 active users a month.
This milestone was reached thanks to government support and to the collaboration of local government organizations and of local operators. Free access to public transport on the part of the various operators and the implementation of paper-less ticket offices have played a decisive role in the platform's evolution and diffusion.

Payment services: automatic transactions and Car e-Wallet

The progressive diffusion of connected vehicles is attracting the attention of financial institutions, keen to broaden the market of online payments made directly from a vehicle.

On-board-vehicle payment will allow users, for example, to purchase foodstuffs during the journey and to settle the related payments directly from the car's dashboard. In the same way, it will be possible to pay for fuel at service stations, to pay motorway tolls, and to pay for parking and other services.

The new platforms will guarantee an increase in the volume of online payments; from this all players in the ecosystem will be able to draw advantage, from vehicle producers, to tech companies, to infotainment service providers of and providers of traditional payment services.

An interesting case of innovation in digital payment channels is represented by Visa, which as early as 2015 was working on the development of Visa Checkout, in collaboration with technological services provider Accenture. The system aims to enable the user to perform financial transactions inside a vehicle, by memorizing the personal credentials and using the "one-touch" option. The project also envisages technologies for automatic learning for the identification of models of behaviour and passenger routines, providing suggestions on the basis of position and of the history of their purchases. The payment process is facilitated by voice recognition, by interactive control and by other biometric technologies. Visa has signed partnerships and collaborations with various players with the aim of constantly improving the user experience and so that solutions are compliant with the financial security regulations, with the laws and standards of the automotive sector. Among the customer loyalty strategies provides for the possibility to make offers, point collections or prizes to incentivize commercial initiatives.

↳ A vision for in-car payments

Honda has launched a collaboration with Visa for the creation of the Honda Dream Drive app for facilitating convenient and safe on-board-vehicle payments. This represents one of the first initiatives in the field of infotainment both for drivers and passengers, offering a vast range of services and entertainment options. Among these is the capability of indicating a fuel station in the vicinity and of paying for the refuelling, as well as of booking and paying for parking thanks to the eParking function. Among upcoming developments in this solution is the signing of new partnerships to allow diffusion of the service also in electric charging infrastructures, in such a way as to also integrate the entirety of those services dedicated to such vehicles. No less important is the Visa Token Service for the protection of consumers' sensitive information, which by means of cryptography safeguards the owner's data in the event of theft or fraud.

Another interesting initiative is that of the Car eWallet start-up of automotive service provider ZF Friedrichshafen, in collaboration with Ubs and IBM: the project consists of a platform enabling payments of various types to be effected, making cars autonomous commercial entities. Thanks to blockchain technology, the start-up offers a payment system based on tokens capable of automizing different types of transactions, from tolls, to refuelling, insurance policies, not to mention electric charging and car washing. The first market tests of the system are expected in late 2019.

Insurance models linked to mobility

The success of new types of transport enabled by new technologies, such as shared mobility and transport in autonomous and connected vehicles, is opening up new opportunities for insurance companies, which will, however, be accompanied by a contraction in the demand for classic insurance products. In order to take advantage of these changes, sector operators must reconsider their own roles within the ecosystem, as well as their relations with mobility users and players.

Evolution of insurance in the automotive sector

Despite the policies adopted by insurance companies for the modulation of premiums, Deloitte forecasts that the insurance market linked to car mobility will reach a peak between 2025 and 2030, before experiencing a structural contraction bringing about levels 30% lower than current ones.

The same source predicts that this contraction in the insurance market may be particularly acute for mature markets, for two principal reasons:

- the reduction in the frequency of accidents.
- the greater efficiency in the use of vehicles generated by sharing.

It is thought, in fact, that the circulation of vehicles equipped with ever more safety features may result in the containment of accidents or mitigate their seriousness.

The progressive increase in the number of self-driving vehicles will also significantly reduce accidents, since the human variable, considered to be the main cause of road accidents, will be eliminated progressively. According to Volvo Trucks, 90% of accidents involving trucks are entirely or partially dependent on human factors; the US Department of Transportation reports, too, that, between 2005 and 2007, 94% of road accidents in the USA were caused by human factors.

It is thought that the advent and diffusion of self-driving vehicles may also generate a new specific segment for the insurance market. In fact, as it is more complicated to attribute blame for any accident to a private vehicle owner, liability could fall onto the constructor of the driving system.

The "transfer" of the risk towards the driving system constructor companies will entail the need for insurers to reorient their own offerings no longer towards an end consumer, but towards an intermediary corporate entity. While this scenario will bring about an absolute revolution in the insurance market, its real impact is not predicted to be felt before 2030, and a mature change is only anticipated on the mass diffusion of self-driving cars forecast for around 2045.

MDGO

MDGO develops a trauma analysis system for vehicles by utilizing existing sensors and connectivity applications (dongle, telematics, e-call). In case of a car crash, the system creates a medical report regarding the type and severity of the passenger's injuries and delivers it automatically to responders and relevant hospitals.

Total Funding
$1 mln

Last Round
Jul 2019 Series A

Country
Israel

mdgo.io

One phenomenon, the considerable impact of which will already be seen around 2025, is that of insurance for connected cars, in particular in the most industrialized areas. Car connectivity will not be exclusive to high-end cars, but will also become a standard for mid-range vehicles, enabling a number of innovative services linked to insurance cover.

The Israeli company MDGO makes use of the data gathered by car sensors to extract the information necessary for medical personnel to be able to provide the most appropriate assistance to persons injured in an accident. MDGO's algorithms analyze the vehicle sensor data relating to the deceleration in order to generate models capable of defining what type of crash has occurred and the injuries sustained

by driver and passengers. In this way, the most suitable emergency team can be sent to the site of the accident and specialist healthcare facilities can be alerted. In addition, it becomes possible for insurance operators to drastically limit insurance fraud, as well as to facilitate the process of paying premiums. The system has already attracted the interest of auto makers Hyundai and Volvo.

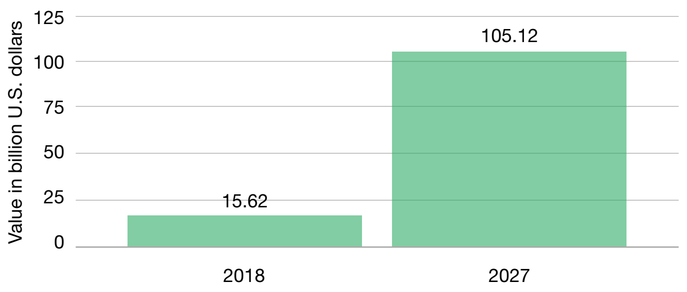
The use of vehicle data will thus permit greater customization, modularity of service, and also immediate availability of dedicated insurance products, opening up the way to revolutionary methods of risk calculation, based on a very large quantities of information, of which companies traditionally do not dispose.

Usage-Based Insurance (UBI)

Usage-Based Insurance (UBI) is a type of car insurance that keeps track of journeys and driver behaviour.

The idea behind UBI is that of keeping under control the quality and prudence of an individual's driving, allowing insurance companies a greater alignment between the premium charged and the risk incurred. Through vehicle data - for example where, when and how the vehicle is driven -, the insuree may enjoy of a customized offering, paying a premium calculated according to the personal style of driving rather than calibrated on an average estimated risk. Furthermore, UBI might incentivize a more prudent behaviour behind the wheel as this would produce a direct reduction in the premium to be paid by the insuree.

Market size of automotive usage based insurance market worldwide in 2018 and 2027



Source: Stastista

The principal factor determining this growth in the market is the wider diffusion of vehicles integrated with telematics or with the use of location systems for the acquisition of data on the vehicle and on driver behaviour; among these, the growing use of smartphones connected to on-board devices, permitting the sharing of data relating to driving. This has permitted many "insurtech" start-ups – that is, those working on technology and on innovation in business applied to the insurance field - to have immediate access to the UBI market for the automotive sector.

FRIDAY

Friday offers digital car insurance with features including kilometer accurate billing, monthly terminability, and completely paperless administration.

Total Funding
$84.25 mln

Last Round
Mar 2019 Series A
$84.25 mln

Country
Germany

friday.de

Friday is a German start-up that has created an insurance platform for car owners, based on vehicle usage. It offers premiums calibrated to distances travelled, as well as various other flexible policies, capable of generating savings for the customer. Through this policy customers can purchase insurance cover from 1 eurocent per kilometre. This offering is aimed at drivers who use a car only occasionally, or at drivers who own a second car and, in general, at those drivers who prefer flexible insurance.

Within the UBI market, it is possible to identify two further segments that help to better delineate the potential of the phenomenon:

- The "pay how you drive" (PHYD) segment
- The "pay-as-you-drive" (PAYD) segment

The PHYD segment assesses the quality of driving through analysis of data recorded by the telematic devices installed in vehicles and calibrates the insurance premium on the basis of such an assessment. The more careful the driving is, the lower the risk of accident, with an ensuing reduction in the insurance premium charged. With this system it becomes possible to vary the premium on the basis of driver behaviour, considering negatively, for example, driving for too long without a break, telephone use while driving or breaking speed limits. In 2017 this segment accounted for 70% of the UBI market.

The PAYD segment is, instead, targeted above all at those who use a car only occasionally. This type of policy offers an insurance premium calculated on the basis of the distance covered: the less the vehicle is used, the lower the insurance premium to be paid.

Alternative and multimodal mobility, a focus on the individual

New styles of mobility envisage the possibility to use combinations of different means of transport, including electric and/or shared ones, chosen on the basis of the user's immediate needs. A progressive disaffection with the physical good is thus becoming manifest, in particular among the new generations Y and Z. This fact imposes on the insurance world a gradual transition towards a variation in the object insured, from the vehicle to the individual.

Insurers will exploit the data generated by the person in movement within the whole mobility ecosystem in the interests of providing an insurance offering focused on the individual. Using the data collected, in fact, it will be possible to identify new methods for the calculation of insurance premiums evolving from current models.

Together with other qualitative inputs, profiles of consumer mobility behaviour are used by Uber to quantify the mobility risk through the assignment of scores, useful both for the signing up to, and for the identification of customized insurance and of other product needs. By exploiting machine learning algorithms, Uber actually identifies a set of assessment variables, such as current traffic, weather conditions, time of day, any news on mobility and festivities in progress, integrating this data into its own risk calculation models.

It is anticipated then that policies oriented vertically on an individual vehicle will be supplanted, through the use of integrated mobility data, by the possibility to offer in a single solution insurance cover for the individual, who will be protected for any means of transport chosen at any moment.

Among the investors of the aforementioned Whim start-up, we also find the insurance company Aioi Nissay Dowa Insurance, which defines its investment as strategic, and which might be interested in developing its own insurance services linked to multimodal mobility through the same platform.

New players in the insurance ecosystem

McKinsey analysts assert that current technological revolutions in the sphere of mobility may create a situation favourable for the entry of new organizations into the insurance services market.

Specifically, for the car insurance services segment, the progressive diffusion of self-driving technology will change the current sector paradigm, obliging car manufacturers and OEM’s to insure their own products. The latter, moreover, could decide to bypass insurers, by harnessing the data at their disposal via telematics and contact with customers, in order to offer their own insurance services.

↳ Tesla Insurance

In August 2019 Tesla launched its own insurance branch named Tesla Insurance. This initiative arises in response to the high prices applied by insurance companies to the owners of cars of this brand, despite the high-level safety standards offered. The overly high cost of insurance premiums, besides discouraging consumers from purchasing vehicles, have been deemed harmful to the image of the brand of the manufacturer, which, in contrast, has been focusing on sophisticated safety features for its system of assisted driving.

Tesla’s car insurance was initially trialled in Hong Kong and Australia in 2016, while in 2017 it reached North America. This solution replaces the traditional collaboration with two important insurance players such as Liberty Mutual and Aviva, respectively in the United States and Canada, whose insurance premiums were not considered to be appropriate. It is forecast that insuring through Tesla Insurance may bring savings of up to 20%-30% in the premiums currently paid by car owners of the brand.

As regards mobility in general, the owners of shared mobility fleets and other players such as technology giants, OEM’s and telecoms companies are already proposing new business models and are able, through the harnessing of their assets such as proprietary data, sophisticated and accurate analyses of customer needs and the capacity to exploit communication channels, to enter the market with a strong competitive edge over traditional insurance operators.

If companies wish to defend their positions of strength in the mobility ecosystem and rebuff external players seeking to enter the insurance market, they will have to develop competencies in a series of technological areas, such as the Internet of Things, data analysis and the development of customer interfaces.

Furthermore, collaborative projects between insurance companies and the highest OEM’s in the value chain, for the purpose of developing new products and new competencies, have already been set up. Partnerships with OEM’s and with big tech companies could allow insurers to assimilate the risk in existing offers, strategically overseeing the various segments.

Assicurazioni Generali and Fiat Chrysler Automobiles have signed an agreement for the development and provision, in Italy, of innovative services for the connected vehicles. The collaboration will permit the user to share information on his/her style of driving, in order to receive offers of customized insurance policies, the premiums for which are calculated on the basis of the user's specific risk profile, considering coverage that responds to the real data on car use. Furthermore, the agreement between the two companies has the ambition to develop further innovative solutions in the sphere of car insurance. Among the possible implementations is “Real Time Coaching”, a virtual assistant that records driving behaviours and is capable of preventing hazardous situations.

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The intelligent transport system meets the smart city

7

The intelligent transport system meets the smart city

In 2016 the global number of vehicles in circulation - cars, trucks and buses – stood at approximately

1.4 Billion units

A phenomenon of mass urbanization is well under way, and as a result of this the number of megalopolises in the world is constantly increasing

By the middle of the century the percentage will rise to only slightly less than 70%

Private vehicles are currently unused 95% of the time, on average

95%

25 m² required to park an automobile

Managing mobility in a "smart" way means having a significant effect on the critical issues which have emerged. Experiments under way in various European countries and in the United States have demonstrated that the application of the "Intelligent Transport System" (ITS) reduces travel times by an order of 20% and increases the network's capacity from 5 to 10%

-20%

+5/10%

ITS cuts the number of accidents by 10-15%, traffic jams by 15%, polluting emissions by 10% and energy consumption by 12%

Drivers in Rome spend 254 hours a year stuck in traffic, thereby earning the European record

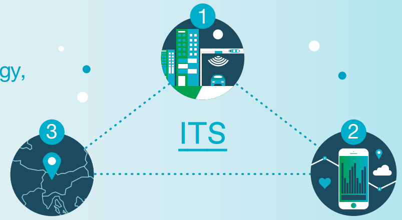
1.33 Italy

1.7 Europe

Italian cities see a daily circulation of 1.9 million motor vehicles transporting 2.5 million people, with an average of 1.33 persons per automobile (1.7 EU average)

ITS - Intelligent Transport System

Intelligent Transport Systems, grounded in the interaction between information technology, telecommunications and multimedia, allow public and private mobility problems to be tackled in an innovative way, by developing organically and functionally solutions based on safety, efficiency, efficacy, affordability while fully respecting the environment

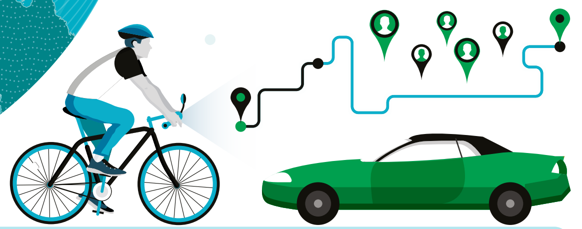


1. Connectivity technologies
Various standards for long-range and short-range wireless communication, are used for the implementation of "smart" services linked to mobility

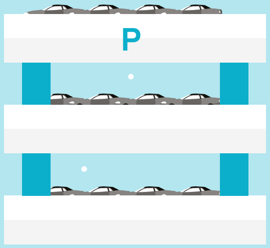
2. Physical connected devices and the Internet of Things (IoT)
Cloud-based IoT applications, which can receive, analyze, manage and transmit data regarding traffic

3. Territorial information systems for the georeferencing of objects and users (GIS)
Smart cities make use of GIS for purposes of planning and mapping, as well as of artificial intelligence for optimizing traffic flows and public transport fleets

Globally there has been an emerging interest on the part of many cities in testing "pioneering" solutions based on data collected from vehicles and users on the move and on a subsequent reprocessing of the same with the aid of artificial intelligence

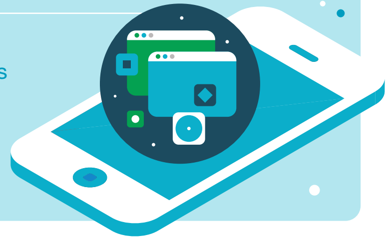


Smart parking



The search for a free space in city car parks undertaken by many vehicles at the same time, aside from generating driver stress, is a cause of traffic congestion and atmospheric pollution. Technology can reduce this problem, because, thanks to the installation of sensors on the road surface, it is possible to know which spaces are available and which occupied

A Smart City must be able to facilitate its own citizens movements and simplify all operations connected thereto, including the search for parking, the management of sharing services, the recharging of electric vehicles etc., but also payment procedures for those services which it makes available



How the mobility of the future changes cities

According to WardsAuto estimates, in 2016 the global number of vehicles in circulation - cars, trucks and buses – stood at approximately 1.4 billion units. If growth in vehicle numbers remains stable at +200% on a twenty-year basis, by the mid-2030's almost 3 billion vehicles will be in circulation around the world.

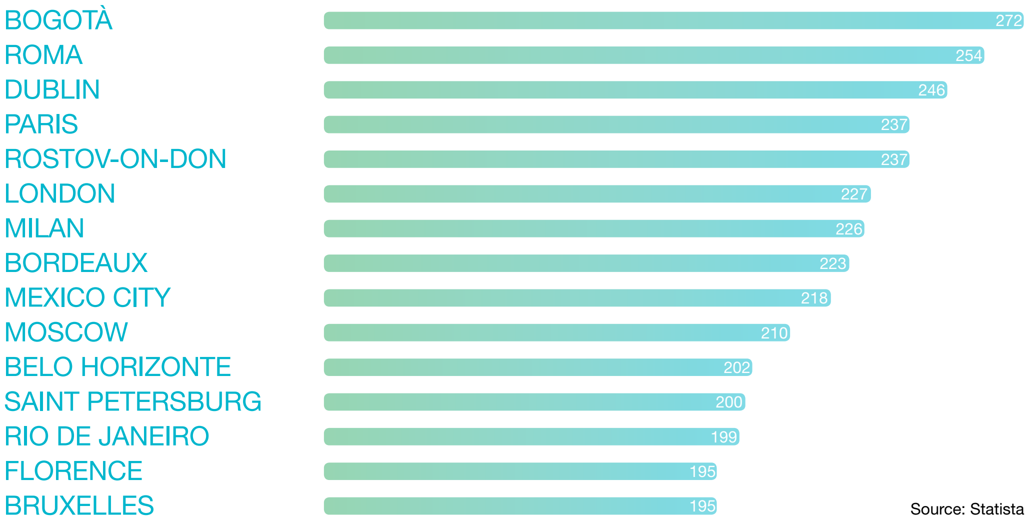
In parallel, a phenomenon of mass urbanization is well under way, and as a result of this the number of megalopolises in the world is constantly increasing: if, as of today, roughly half of the world's population resides in urban areas, OECD forecasts estimate that by the middle of the century the percentage will rise to only slightly less than 70%. In this context, public and private mobility which leaves behind current inefficiencies will be able to make a significant impact on improvement of quality of life and optimal use of economic resources.

To understand how much work needs to be done, it is sufficient to consider that private vehicles are currently unused 95% of the time, on average. This fact, when viewed in the light of the 25 square meters required to park an automobile, and of the billion and half of vehicles in circulation, paints a picture of extreme inefficiency in terms of use and optimization of urban spaces and of vehicles themselves.

According to research conducted by Anci concerning home-work and home-study journeys, Italian cities see a daily circulation of 1.9 million motor vehicles transporting 2.5 million people, with an average of 1.33 persons per automobile (1.7 EU average). If every car transported two people, there would be 628 thousand fewer vehicles in circulation and each year €360 million euros would be saved in fuel costs and 660 thousand tonnes of CO2 emissions would be eliminated in Italy alone.

The cities with the biggest traffic jams

Major world cities where the average commuter spent the most hours in congestion in 2018



Source: Statista

The inefficiencies associated with mobility in urban areas, such as the limited per-vehicle use of parking spaces, the excessive allocation of urban lots for car parking (albeit limited in relation to the demand), and the capacity of road infrastructures, which struggle to keep up with the increase in numbers of cars in circulation, are, in turn, causing one of the greatest problems for urban centers: traffic congestion. According to the INRIX 2018 Global Traffic Scorecard, drivers in Rome spend 254 hours a year stuck in traffic, thereby earning the European record.

Managing mobility in a "smart" way means having a significant effect on the critical issues which have emerged. Experiments under way in various European countries and in the United States have demonstrated that the application of the "Intelligent Transport System" (ITS) reduces travel times by an order of 20% and increases the network's capacity from 5 to 10%; lastly it cuts the number of accidents by 10-15%, traffic jams by 15%, polluting emissions by 10% and energy consumption by 12%.

ITS and technologies for the mobility of the future

By ITS, or Intelligent Transport System, is meant a technology, application, advanced platform or set of tools for the management of transport networks and of services for travellers, developed to improve traffic management and mobility (both public and private), road safety, management of the transportation of goods and automatic payments. ITS is based on processes of acquisition, processing and integration of data and manages the information chain to be provided to transport system users.

Such systems thus permit the enabling of added value services in the management of urban mobility: they can, for example, provide users with information concerning traffic and local transport in real time, concerning the availability of spaces in car parks and seats on public transport, with the objective, for example, of reducing commuters' journey times and of improving safety and comfort.

Although ITSs may refer to all modes of transport, the European Union's 2010/40/EU directive, defined ITSs as systems in which information and communication technologies are applied particularly to road transport.

> Intelligent Transport Systems, grounded in the interaction between information technology, telecommunications and multimedia, allow public and private mobility problems to be tackled in an innovative way, by developing organically and functionally solutions based on safety, efficiency, efficacy, affordability while fully respecting the environment.

ITSs acquire and process data by leveraging various technologies and infrastructures operating in synergy:

- Connectivity technologies
  Various standards for long-range and short-range wireless communication, from GSM to 802.11 protocols, right up to the more recent 5G are used for the implementation of "smart" services linked to mobility.

- Physical connected devices and the Internet of Things (IoT)
  Cloud-based IoT applications, which can receive, analyze, manage and transmit data regarding traffic, by exploiting connectivity technologies, can be used to provide information on the traffic in real time in a specific area of the city.

- Territorial information systems for the georeferencing of objects and users (GIS)
  Smart cities make use of GIS for purposes of planning and mapping, as well as of artificial intelligence for optimizing traffic flows and public transport fleets or for making the parking of private vehicles simpler and more efficient.

Among the other technologies used for the identification of vehicles and for data collection on the move, worthy of mention are: floating cellular data for the identification of public transport vehicles on the move and their speed; Vehicle-to-Vehicle networks, allowing dialogue between moving vehicles; and Vehicle-to-Infrastructure allowing dialogue between moving vehicles and fixed infrastructures.

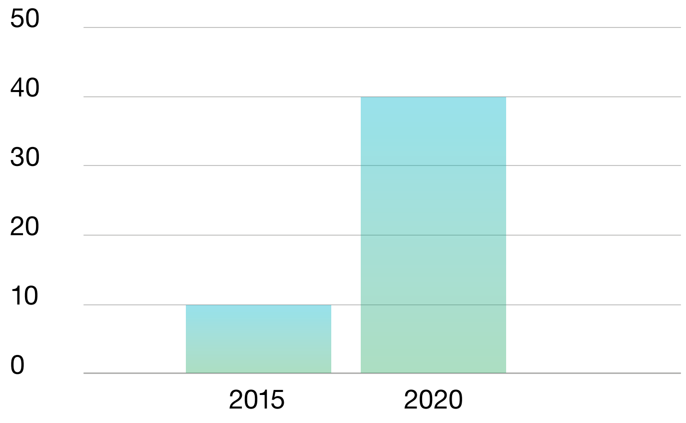
Last but not least we have sensors, installed on roads and physical infrastructures, devised, for example, for speed detection, but also for the enabling of connected mobility and autonomous mobility services. Roads may in fact be equipped with sensors able to trace vehicle transit data in order to extrapolate flow models of traffic, of road blocks, of road works, etc.

Furthermore, ample use is made of smart video cameras capable of, amongst their other functions, of recognizing moving vehicles and their number plates, but also driver behaviour, through advanced computer vision and artificial intelligence technologies.
For the observation of vehicles on specific roads or at dangerous crossings, inductive ring sensors are also used: the simplest detectors count the number of vehicles which pass over the circuit in a given unit of time, while more sophisticated sensors estimate speeds, lengths, types of vehicles and distances between them. Other types of sensors embedded in the road surface also make it possible to identify which parking spaces are available or occupied.

Many of the technologies for the enabling of “smart” services linked to mobility are housed on public transport and in vehicles for private transport. On-board electronics is indeed one of the main components of vehicles in circulation and these vehicles carry sensors, “embedded” smart platforms, operating systems and software applications of varying degrees of sophistication. These, taking advantage of the vehicles’ own computational capacities are able to process much of the information gathered in real time and send it to centralized data collection centres for further processing.

Many smart mobility systems are born, moreover, as instruments to aid decision making, by integrating predictive technologies for modelling and comparison with series of records relating to specific factors (traffic flows, meteorological data, public transport journey times at specific times of day, etc.).

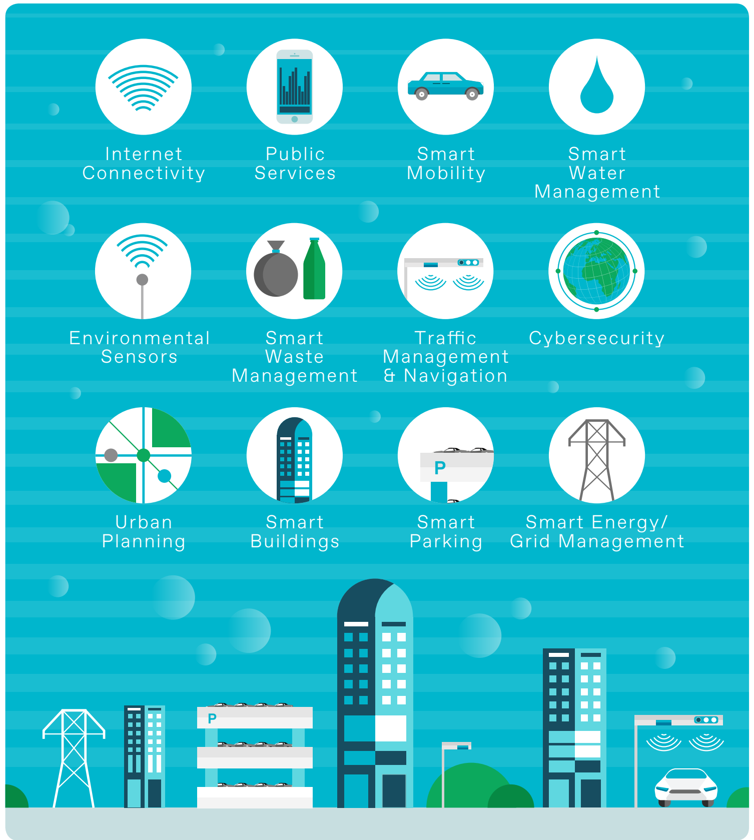
Global IoT transportation and logistics spending in 2015 and 2020 (in billion U.S. dollars)



Source: Statista

ITS applications for urban areas

Globally there has been an emerging interest on the part of many cities in testing "pioneering" solutions based on data collected from vehicles and users on the move and on a subsequent reprocessing of the same with the aid of artificial intelligence. Many cities have been transformed into authentic "test-beds" for testing and, where functioning, developing solutions on a large scale which involve the four dimensions of the mobility of the future – electric, connected, autonomous and shared.



Information management of public and private mobility data

The transmission of data and processing thereof in (practically) real time are the starting point from which to offer citizens and Public Administrations innovative services for urban mobility. A Smart City may indeed be defined as a "data-driven" city, where public administrators, decision-makers and citizens have an ever more detailed understanding of the conditions of mobility in the areas in which they live or work.

The agencies designated to optimize transport systems, whether public or private, are approaching the study of flows, of vehicles and of people, on the basis of a "smart" interpretation of data, and encountering, in the process, no few difficulties of management.

The data which fall within the extended perimeter of mobility are in fact fragmented and not very homogeneous and are managed by multiple parties who should ensure inter-operability for a transport system which is really inter-connected. In reality, however, most services are offered and managed by different entities using proprietary technological platforms which frequently do not communicate with each other. The market and technological management would require, in contrast, the presence of "aggregators" offering unified and more efficient services both to consumers, and to Public Administrations which must manage city mobility.

The technologies present on the market today, what is more, not only do not bring with them particular restrictions on aggregated data collection for a single individual, but rather they facilitate it: it is no longer necessary, in fact, as it was in the past, to "physically" collect data through the counting of cars in circulation or through the administering of interviews, it is, if anything, the cars themselves which communicate their own data and also those of their drivers, through insurance company black boxes, smartphones, IoT sensors, which communicate directly with a traffic management centre. Once the data have been processed, the latter provides users with updates on traffic conditions, journey times, delays, road traffic accidents, or on any road works.

By way of example, the city-state of Singapore has promoted the Smart Nation Sensor Platform (SNSP) initiative, that is to say, a sharing platform for aggregated data serving to guarantee efficient management of public services through the promotion of open data.

In Italy, one example of a company born to make mobility "smarter" is InfoBlu. Italian market leader in infomobility, it offers information on the road and traffic conditions of the major Italian highways, but also data on traffic in the main metropolitan areas, to the principal players in the sector: car manufacturers, navigation systems, television and radio broadcasters, telephone service providers, call centres and mobile applications, as well as public bodies and road network operators.

Once more in Italy, an interesting case of integration between information relating to private vehicles and traffic conditions, on the one hand, and real-time information about public transport, on the other, is the Milan City Council's Mobility Portal. The Lombard capital is in the vanguard in terms of the analysis of mobility data and of the use which it makes thereof, also for its long-term planning: the city has in fact been considered the "smartest" in Italy for years.Multimodal transport for

Multimodal transport for mobility on demand

The term Smart Mobility encapsulates concepts linked to technology, to infrastructures for mobility (car parks, recharging networks, road signs, roads and bridges, etc.), to solutions for an efficient, economical and sustainable management of mobility and lastly to models of consumer use of varying degrees of innovation. The integration of public and private transport, the sharing of the vehicles, "green" transport, are all aspects which combine to render urban mobility "smart", with the ultimate goal of cre-

ating flexible, integrated, safe, on-demand and cheap travel experiences.

The European Commission has, since 2010, supported - including financially – the creation of platforms capable of promoting intermodal travel solutions at a European, regional and local level, by integrating different modes of transport ranging from rail travel to bicycles, from public transport to car sharing.

An intermodal route planner uses digital maps, dynamic traffic data, timetables and vehicle positions in real time and an algorithm able to calculate the best routes. The objective of these planners is in fact, on the one hand, to provide citizens with a single information tool, thus facilitating "door-to-door" journeys (for example, home-work, home-school, etc.), and, on the other, to promote new models of Mobility-as-a-Service (MaaS) which envisage an all-inclusive, "on-demand" service customized according to the circumstances and allowing a single pass or book of tickets to be used for the payment of a bundle of of public and private transport services, accessible through a multi-mode mobility app.

By way of example, Be-Mobile's intermodal route planner is available to the citizens of Antwerp (Belgium): it is able to calculate up to 250 different transport solutions for each route, its algorithm filters the most relevant and presents users with the options from which to choose.
An app launched in Berlin in February 2019 allows travellers to access all forms of public and private transport in the city. The service, named Jelbi and created by the technology company Trafi for BVG - Berlin's transport company -, allows users to plan and purchase travel solutions with scooters, bicycles, taxi and car-sharing and ride-hailing services.

Across the ocean too, the city of Saskatoon (Canada) launched in August 2019 a "multimodal trip planner" allowing its citizens to combine different means of travel: those who move mostly by bicycle can cover the first or

TRAFI

Trafi is multi-platform and available on Android, iOS and Web using real time data to help users find the best possible way to commute from door to door either by public transport, taxi, cycling or even walking.

Total Funding
$14 mln

Last Round
Sep 2017 Series B $7 mln

Country
Lithuania

trafi.com

last mile on buses or else use ride-hailing services, in both cases transporting their personal bikes on public transport.

Smart parking

The search for a free space in city car parks undertaken by many vehicles at the same time, aside from generating driver stress, is a cause of traffic congestion and atmospheric pollution.

Technology can reduce this problem, because, thanks to the installation of sensors on the road surface, it is possible to know which spaces are available and which occupied. One of the possible applications of the ITS in the area of "smart parking" makes it possible to have these IoT sensors communicate in real time with a centralized cloud platform, which positions on a map available parking and then shows drivers the closest spaces through an app. These technologies also allow public officials to check in real time if a car is parked in points in the city in which parking is not permitted or if the parking ticket has expired, thus aiding the issuing of penalties, even remotely.

↳ "Automated valet parking"

Barcelona has integrated some technological solutions intended to monitor the traffic in certain areas and to design a new more efficient network of public transport. In particular, at El Prat airport it has exploited Sensefields technology to implement traffic control in the " express parking" areas for short stops, situated both outside the terminal, and in the taxi ranks, with the objective of collecting data over time on the number of vehicles in transit and stationary at each point monitored, of reducing traffic congestion and ensuring a constant availability of taxis in the areas involved.

In the area of self-driving vehicles, in July 2019 Bosch and Daimler obtained authorization from the relevant authorities in Baden-Württemberg for the first autonomous unsupervised car park. "Automated valet parking" will be provided at the Mercedes-Benz Museum in Stuttgart, where drivers may leave their own cars at the car park entrance and, through an app, instruct the car to park itself, moving around the museum car park and selecting a space without additional assistance.

Digital payments for Smart Mobility

A Smart City must be able to facilitate its own citizens movements and simplify all operations connected thereto, including the search for parking, the management of sharing services, the recharging of electric vehicles etc., but also payment procedures for those services which it makes available.

Technology helps to speed up and simplify mobile payments: in the area of Smart Mobility the trend is in fact to eliminate the need for the use of cash in favour of (predominantly contactless) safe and internationally-accepted payment services, which facilitate citizens' and tourists' access to trains, buses, ferries, public car parks, and make the use of systems of bike and car sharing and of chargers for the recharging of electric cars easy.

In many cities around the world "smart" services for mobile payment have been active for years now. In Shanghai, since 2018 and thanks to the collaboration of the public transport company and Alipay, it has been possible to pay to access the underground by using a cellphone and the reading of the QR Code on passing the turnstiles on entry and on exit. From 2020 the Hong Kong MTR will also provide the possibility to pay the underground fare with a QR Code through Alipay. WeChat took steps in 2018 to enable, in Beijing and in other Chinese cities, the smart ticketing and payment service for public transport through the use of NFC (Near Field Communication) smartphone technology.

The same NFC technology has also been used in Milan, where it is possible to use any credit card or PayPal to enter and exit the underground in an easy and contactless fashion.

Since May 2019 New York too has had an active collaboration with the Metropolitan Transportation Authority (MTA) and Apple Pay for the payment of subway fares through biometric facial recognition or iPhone or Apple Watch Touch ID.

In Europe, the aforementioned Be-Mobile, a Belgian operator providing advanced services for Smart Mobility in Belgium, Netherlands, France, Finland and in other countries, provides an integrated platform for mobile payments not only for the payment of public transport fares and car parks through apps or text messages, but also of recharging sessions for electric cars.

In Switzerland a single card – called SwissPass - is available and provided by the public transport authority, which makes it possible to get around (and pay) on all forms of transport, ranging from train journeys to car sharing. Besides being a public transport pass, it allows access to services offered by numerous partners: it can in fact be used to access and pay for the services of car sharing or of bike sharing, but also to open the turnstiles at ski stations or to experience certain self-driving bus routes.

↳ "Gabriele Benedetto (Telepass): la formula della smart mobility"

In Italy with Telepass Pay it is possible to pay to park in the on-road "blue lines" areas and in some car parks: in Milan this method of payment has been available since as early as 2015, but this service has now been activated in many other Italian cities too. Telepass Pay also makes it possible to pay for fuel, to pay the toll for Milan's Area C (an area in the city centre with specific restrictions for certain types of vehicles), for tickets for ships and ferries for the main maritime routes, for ski passes in some ski stations in Northern Italy, road tax, for carwashes – in collaboration with the startup WashOut -, for instant insurance which can be activated at the moment of departure, for scooter hire in some locations on the Romagna coast and in future for car, scooter and bike sharing, as well as for rail tickets.

Technology can also serve town councils for controls and sanctions, tackling fare dodging on the part of many users of public services. Since June 2019 Barcelona has been experimenting with an advanced solution exploiting artificial intelligence, and, in particular, "machine vision", by processing images from video cameras in train stations, asking to see tickets only of "suspect" users and thus speeding up controls.

Indicators for smart mobility and governance

Many urban areas are facing an increase in the population and an increase in the volumes of goods, with a consequent increase in traffic congestion, lower quality of life, a loss of economic potential and negative health outcomes. The boundaries of many cities have changed when compared to their initial configuration and to how they looked in the period in which the specific public transport systems were established, often decades before. Nonetheless, in many cases, the transport networks serving these areas have basically remained unchanged and inadequate for the great current volumes of traffic.

If one thinks, however, that transport plays a key role in the growth and economic prosperity of a city, it is easy to deduce that a not wholly effective management of mobility can lead to significant losses in economic and social terms.

New technologies, if well integrated, however, can aid the resolution of this problem and assist urban areas to face these challenges. With the emergence of autonomous and shared mobility, of connected infrastructures and of Smart City technologies, the possibility of creating a faster, cheaper, cleaner and safer intermodal urban transport ecosystem appears to be more realizable than ever.
To achieve this, however, an integrated long-term vision is necessary, which is not merely the sum of a series of initiatives and timely experimentations; it is then essential that there be a systemic intervention, capable of acting on governance and on the planning of interventions. This is possible through the identification of the right mix of

collaborations, which take into account and, if opportune, also involve the private sector.
To support authorities in the management of Smart Mobility, the BCG Henderson Institute has drafted some indications useful for the adoption of "good practices" and solutions serving to improve the management of urban mobility:

1. identifying indicators for "smart"mobility, that is to measure the validity of initiatives and to target policy: in order to understand what the advantages or disadvantages connected to the implementation of innovative solutions in the field of mobility can be, it is crucial to employ right measurement tools. The table here below contains a list of suggestions on the parameters to monitor and evaluate.

ECONOMIC PERFORMANCE	Traffic congestion	Busiest times and routes
	Reliability of public transport	% of delays, service continuity
	Safety	Number of accidents/victims linked to traffic
	Integration of technologies	Collection and use of open data
ENVIROMENT	Climate impact	CO_2 emissions, air quality
	Use of the asset	User-km and vehicle-km ratio
	Initiatives for environmental sustainability	Sustainability plans and incentives for electric transport
LEADERSHIP	Strategy	Number of collaborations and joint initiatives with the private sector and the academic world
	Investments	Percentage of budget allocated to the transport sector (as a proportion of local authorities / city total budget)
	Planning regulations	Ad hoc regulations for innovation in the mobility sector
SOCIAL IMPACT	Accessibility	Accessibility indices by area
	Inclusivity	% of inhabitants who do not travel, due to the lack of services
	Versatility	Presence of alternatives, connections among the various types of mobility
	Satisfaction	% of users satisfied, overall and by type of transport

2. Investing correctly and stimulating development. It is necessary to constantly remain up to date with the possible applications of technologies in the area of mobility and with the added value which these can bring, in such a way as allocate adequate investments during intervention planning. The planning of interventions will be all the more effective, the more this takes into account the peculiarities of the area and the needs of the community.

3. Regulating and rethinking policy, by valuing flexibility and public-private integration. Fragmented and rigid governance risks finding itself in difficulty when faced with current multiple and "multimodal" transport systems. Conversely, a compact and adaptive governance, focused on the user and able to have the public sector engage flexibly with the private sector, may be more appropriate in managing a multiform and heterogeneous situation. A number of analysts recommend adopting integrated policies operating with public interventions at specific stages in the value chain (as regards, for example, the sharing of data, parking and safety), preserving the flexibility of private operators (as regards, for example, the detailed structure of prices and user interfaces).

4. Learning and progressing "by experimenting". Experimentations represent a key driver for opening up to innovation, and innovation feeds on trial and of error. Adopting intermediate and "open" solutions, not necessarily final ones, and using these as moments for experimentation, makes it possible to progress albeit allowing for a certain margin of error. Cities have before them the opportunity to learn by experimenting, even if occasionally some experiments fail; and precisely through failure and the sharing of experiences with other cities and within public-private partnerships can trigger "good practices" and initiatives to be replicated on a giant scale.

The “Smarter London Together” plan and the partnership for smart mobility

↳ “Smarter London Together”

London, the largest city in western Europe, with around 9 million of inhabitants, possesses a system of transport which is recognized internationally as being effective, safe and integrated. Due to its size and to the number of its inhabitants, every day millions of vehicles clog its roads and, according to the Ford City Data Report, it is estimated that costs for the public and private sectors attributable to city traffic amount to € 10.8 billion.

In 2018, the Mayor of London announced an integrated strategic plan designed to make London the “smartest city in the world” and named “Smarter London Together”.

In collaboration with the districts of the capital, the programme’s objective is to enhance sustainability and improve the quality of life of citizens. Programme initiatives range from increased availability of public Wi-Fi to the distribution of “smart parks” which permit data collection on emissions and on the quality of the air.

The collection and enhancement of data represent key drivers for TfL – Transport for London – the company responsible for transport and for the maintenance of public vehicles-, which has implemented technological solutions ranging from the control of rail travel to road planning through the use of virtual reality. The data generated by moving vehicles merge into an open proprietary database, which the developers use to create innovative products and services to improve city mobility. The exploitation of the data extracted generates an annual economic benefit for the city of about € 147 million.

London is also home to the TRL, global centre for innovation in the sector of transport and mobility, which supports organizations in the creation of systems of safe, economic and efficient transport. The main areas of action concern ITS, sustainable mobility, vehicle safety and technological research in the area of Smart Mobility. Investments are directed towards connected, shared and autonomous mobility, the reduction of the emissions and, on the technology front, the exploitation of big data and artificial intelligence to improve traffic conditions.

In the context of partnerships, the Smart Mobility Living Lab (SMLL), launched in 2018 by TRL in collaboration with universities, with Cisco and with Transport for London, intends to create the most advanced connected test environment in the United Kingdom. The SMLL project, subdivided into various sub-projects of research focused on the four paradigms of mobility - electric, connected, autonomous and shared-, fosters collaboration among private firms for the testing of new types of service. Living Lab’s ultimate goal, achieved in June 2019, was to create specific city routes for the testing of self-driving cars. These are over 24 km of public roads equipped with technologies for the monitoring of moving vehicles and which can be customized according to the needs of the tester company.

In 2019 Bosch chose London as the location for the new innovation hub, London Connectory, born to meet the future technological needs of urban transport, to co-create and develop smart mobility solutions. The hub will host a network of start-ups, tutors, investors and developers in a space of co-innovation the objective of which is to devise smart solutions for mobility and to achieve the goals set by the “Smarter London Together” programme. Ford, too, through Ford Smart Mobility, its global organization which designs, develops and invests in Smart Mobility services and connectivity solutions for smart vehicles, supports “Smarter London Together”. The solutions implemented concern:

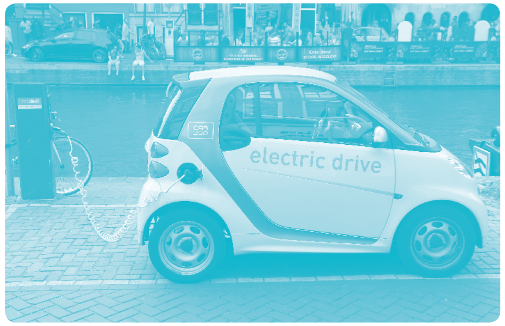
- the identification of the best locations and positions for recharging stations for electric vehicles EV;
- the identification of sensitive areas for road safety, encouraging citizens to avoid some stretches at particular times and helping urban planners during the planning stage;
- an app which shows which routes are more efficient if taken on public transport;

- a method for the calculation of the "social benefit" arising from the reduction of time spent on the road, considering the situation in which a higher percentage of vehicles is able to move at different moments of the day in order to avoid the rush hours.

The "Smart Mobility Amsterdam" programme

The old town of Amsterdam, characterized in its topography by narrow lanes and criss-crossed by canals, naturally presents a high risk of traffic congestion, and a very critical management of road safety.

It is no coincidence then that the city has developed a "historic" tradition in the study and implementation of policies linked to traffic management and to public transport, launching the first "smart" experimentations as early as the 70's for tackling the high mortality rate due to road accidents.



Digital technologies have entered by right into the definition of the support strategies for the city's smart mobility through the "Smart Mobility 2016-18" programme with a series of initiatives for the improvement of safety, accessibility, quality of the air and quality of life. The development issues identified are four in number: the Internet of Things, a smart use of space, mobility-as-a-service and self-driving cars.

Among these, ample space has been given to the development of ITS to monitor and optimize traffic flows: in 2017 on the N205 motorway in Noord-Holland, close to Amsterdam, smart traffic lights were installed which, via app, can "talk" to motorists in real time, providing information on the traffic and preventing congestion. Within the same programme, the city has installed a public network of beacons to monitor the public transport journey times, with the ultimate objective of providing travellers

with information with which to plan the best route in real time.

As further proof of the city's green and digital vocation, mobility policies have been reinforced once more by the "Smart Mobility Amsterdam"programme, which, for the years between 2019 and 2025, is promoting the designing and experimentation of new modes of shared and electric mobility and of traffic management both in real time, and predictively, in order to build an environmentally-friendly and smart city, free from traffic and with emissions of CO_2 reduced.

Since the beginning of 2019, the city council of Amsterdam has boosted the collection and management of data, working in close collaboration with research institutes and public and private companies: some data sets produced, for example, by the mobile application for mobility "Waze", are used to determine where accidents, closures and other disruption on the roads occurs. In the context of the mobility-as-a-service model, the eHUBS - Smart Shared Green Mobility Hubs have been created as dedicated places on the road, in which citizens can choose between various options of sustainable electric transport (e-bikes, e-cargo bikes, e-scooters or e-cars) for shared use.

As far as electric mobility is concerned, public policies have been so effective that the administration has calculated that to charge the ever-growing number of electric vehicles (17.000 in 2019), up to 23.000 recharging points might be required in the city by 2025. In this regard, experimentally, two Vehicle-to-Home systems have been installed- which fits in with the more general Vehicle to Grid (V2G), that is to say the technology which allows the electric vehicle to function not only as user, but also as an accumulator of energy, to be passed on to electric devices inside a building. The project, under way since March 2013, makes it possible to use the electric car as a backup charger during power cuts, thus providing storage solutions for renewable energy in the Netherlands. Since 2017 the experimentation has also included Vehicle-to-Office systems, similar to Vehicle-to-Home technology.

↳ "V2Xa Switch2SmartGrids Project: Overview"

In terms of the initiatives for the experimentation of "self-driving" vehicles, according to the Autonomous

Readiness Index drawn up by KPMG, the Netherlands is the country most ready to face the challenge of autonomous vehicles, thanks, above all, to the investments made in the IoT (Internet of Things) field. Amsterdam is in fact home to heterogeneous experimentations in self-driving vehicles, which involve different categories of vehicles (public transport, heavy goods and boats).

2018 also saw the first trials of autonomous boat prototypes, on a scale of 1:4, according to the directives provided by the Roboat project, which sees the collaboration of the Massachusetts Institute of Technology (MIT) and the Amsterdam Institute for Advanced Metropolitan Solutions (AMS Institute). Roboat intends to design and implement a fleet of autonomous city boats which will have different fields of application, among which the transportation of refuse and the distribution of food.

Singapore, the city-state of V2X communication

Singapore, the city-state populated by roughly 5.5 million inhabitants, is genuinely an "open-air laboratory" dedicated to digital and technological transformation, whose strength is represented by the perfect synergy between administration public, universities, enterprises and start-ups.

In the sector of mobility, research and innovation are focused on the development of "vehicle to everything" (V2X) systems and on the management of traffic flows, with significant investments directed towards the smart transformation of public transport.

In particular, under experimentation currently is communication:

- from vehicle to vehicle (V2V), to make possible, for example, communication between self-driving cars;
- between vehicle and infrastructures (V2I), to permit dialogue between the vehicle and, for example, the city's traffic light system.

The ultimate goal is to enhance road safety: the combination of the two technologies, in a hypothetical emergency situation, makes it possible, for example, to create openings in the traffic for emergency vehicles.

The development of Smart Mobility technologies is moreover devised for the settlement of payment of road use charges thanks to the support of analyses of the data extracted. Big Data are, in fact, also employed in the calculation of Singapore's road tolls. This calculation takes into consideration the route taken, the time of day of the journey and the level of traffic: knowing the position of the vehicle in real time makes it possible to collect accurate data for the calculation of the amounts. By 2020, Singapore will have become the first city in the world to introduce a system of road pricing via satellite.

Further analyses are carried out on the anonymous Open Data obtained from commuter passes and on the identification of hotspots for the management of public transport fleets. The Singapore transport authority (LTA – Land Transport Authority) is able to manage its public fleets efficiently, by providing services for the community which revolve around people.

The results of these analyses have permitted a 92% reduction in the number of overcrowded buses and have reduced the average commuter waiting time to four minutes.

Other projects on the mobility of the future, still being studied and not yet implemented in 2019, regard the creation of an air network with a series of routes and trajectories dedicated to journeys by drone-taxis.

2019 saw the beginning of the Lamppost-as-a-Platform (LaaP)experimentation, which is based on the installation of sensors on the city's lampposts. The LaaP programme will make it possible to obtain, in addition to real-time measurements of air quality and noise pollution, data relating to traffic flows: by using artificial intelligence algorithms, the data gathered will be analyzed for the purposes of improving the definition of urban policies and the provision of services for the citizen and for the territory's enterprises.

Thanks to the implementation of open data and to the sharing of geospatial data, several portals have been created which make it possible to support the urban mobility system.

- The MyTransport.org portal provides public transport users with information regarding bus lines and related stops in the main tourist spots and train stations;
- The Beeline platform makes it possible to book and purchase the tickets for public transport. The data which derive therefrom ensure monitoring of the lines of transport and, consequently, a more efficient service.

Dubai and futuristic modes of transport

Since 2005, which saw the birth of the Roads and Transport Authority (RTA), Dubai's urban mobility has registered rapid growth in terms of efficiency of the public service. The number of passengers using public transport has risen significantly, rising from 168 million in 2006 to over 588 million in 2018, with an increase of 11% in only 13 years. Such a significant milestone is the result of a series of targeted policies, which can be traced back to the Dubai Smart City programme, launched in 2014 with the objective, amongst other things, of increasing to 25%, by 2030, the respective shares of public transport and shared mobility.

The Dubai's Smart Autonomous Mobility Strategy also falls within this programme and places autonomous mobility at the centre of its attention, with the ambitious project of raising to 25%, by 2030, its share of journeys

in autonomous vehicles. This strategy should raise 22 billion AED in annual economic benefits (roughly 5.5 billion euros), thanks to the reduction in transport costs, and contribute to a saving of 1.5 billion AED a year, thanks to the reduction in environmental pollution by 12%, by 2030.

Transport company RTA, in keeping with Dubai's Smart Autonomous Mobility Strategy, is concentrating its resources on the research and development of futuristic modes of transport such as the autonomous transport capsules, automated air taxi and the Dubai Sky Pod, a high-speed cable transport system. For the latter RTA has signed an agreement with skyTran, a company which seeks to provide magnetic levitation transport systems, for the development of suspended transport systems.

The trials of the air taxi, first autonomous means of transport with completely electric vertical take-off began in 2017 following the agreement between the Dubai Roads and Transport Authority and the German company Volocopter.

Transport company RTA has also created its Enterprise Command & Control Centre (EC3) which processes Big Data on mobility on a daily basis, with records totalling 75 million, for the purposes of identifying the best strategies for regular and efficient mobility.

Big Data and artificial intelligence support all operations on Dubai's underground, from automated planning to the prevention of the risk of collisions. The result of this application is a 7% reduction in operating costs and a greater efficiency in terms of punctuality of 6.4%.

For the benefit of residents and tourists a route planning app was introduced which permitted an increase in user satisfaction of 11% in 2018.
Lastly, RTA's Innovation Lab has launched the installation

SKYTRAN

SkyTran is the developer of the patented, high-speed, elevated, levitating, energy-efficient skyTran Personal Rapid Transit (PRT) and Cargo Rapid Transit (CRT) system. skyTran consists of a network of computer-controlled, 2 and 4-person "jet-like" vehicles and cargo pods employing state-of-the-art, passive skyTran MagLev (STML) technology. skyTran systems will transport passengers and cargo alike in a fast, safe, green, and economical manner.

Total Funding
$51.7 mln

Last Round
Oct 2018 Series B
$5.9 mln

Country
United States

skytran.com

of Dynamic Messaging Signs (DMS), that is, interactive road signs, for the transmission of information on traffic conditions in real time. These installations are part of the ITS project, which in 2019 has reached a 65% completion point, with final total coverage of 60% of Dubai's roads. In the near future more than a hundred video cameras will be installed for traffic monitoring and data acquisition, alongside an equal number of systems for the surveying of traffic, and twenty or so systems of weather information for the roads. In addition, the fibre-optic network for communication between devices will be extended.

One of the key factors, which have contributed to stimulate Dubai's "smart" revolution, is without doubt, the upcoming Dubai Expo 2020. The government has planned to spend over 7 billion euros on projects relating to Expo infrastructures.

One of these is the futuristic Hyperloop: by 2020, it will be possible to cover the distance between Dubai and Abu Dhabi in 12 minutes (the current journey time by car is about an hour and a half). This revolutionary system of transport aims to use magnetic levitation to allow the transport capsules to reach a speed of up to 300 metres per second. The particularity of the Hyperloop TT supersonic capsule resides in the elevated containment tunnels: these will be covered with solar panels supplying all the electricity necessary to create the pneumatic vacuum within. The system will be self-sufficient in energy terms or may even produce more energy than it consumes.

HYPERLOOP ONE

Virgin Hyperloop One develops technology and hardware to create a system that puts passengers in pods hurtling through vacuum tubes.

Total Funding
$471.7 mln

Last Round
May 2019 Series C
$172.2 mln

Country
United States

hyperloop-one.com

Toronto and the communities of the future

The long-term strategies of the Toronto Transit Commission (TTC), already in place in 2019, are focused on the expansion of the transit networks to support the installation of smart transport systems.

Metrolinx, an Ontario government agency coordinating and integrating road and public transport, is an integral part of the regional transport plan (RTP) 2041. The programme seeks to connect the municipalities in the Greater Toronto Area through rapid transit corridors for express trains, light metro and fast buses. This programme represents a model for a system of multimodal regional transport, the focal point of which is centred on user needs. The particularity of RTP 2041 is to be found in its indirect advantages for companies such as, for example, support for employers in the fostering of teleworking amongst their employees, collaboration with civic organizations and schools to encourage the use of public transport.

One of these systems of "social" transport is represented by the "Smart Commute" programme, supporting users in the identification of alternative and smart travel options while reducing city traffic.

Innovative projects regard all the paradigms of mobility. Connected and autonomous vehicles will soon enter the market: by 2030 robo-taxis will represent 27% of vehicles used by passengers for the same types of journey.

In 2017 the company Sidewalk Labs, an Alphabet (Google) subsidiary, and the government of the city of Toronto announced a plan of technological regeneration based on Smart City concepts for a district of the city on the banks of Lake Ontario, with the objective of creating a community which "combines the best of urban design and the latest digital technologies". The possible new mobility initiatives, once implemented, should lead to the need to own a car being eliminated, thus permitting a family to save about 4,000 $/year, by providing valid electric and shared alternatives for use with travel passes.

The future developments for mobility in Toronto also concern the use of Big Data and machine learning for implementing a system of mobility management capable of processing data and information in real time and thus coordinating vehicle flows and the various road infrastructures. One such example is the traffic light system which gives priority to pedestrians who require more time to cross from one side to the other.

For the project managed by Sidewalk Lab, to be launched in 2022, 980 million dollars will be invested with the implementation of, amongst other things, smart traffic lights, dynamic footpaths, cycle paths and heated road surfaces for the bitter winter temperatures. In the Sidewalk Labs' vision of the future, since in the district of the future the need for parking spaces for private vehicles will be reduced thanks to the diffusion of autonomous or shared vehicles, car parks may be transformed into green spaces and shopping areas.

Notes

Innovation trend report – Smart mobility

Intesa Sanpaolo Innovation Center

Exploring the business models of the future to discover the new assets and skills needed to support the long-term competitiveness of its customers and of the Group as we become the driving force of the New Italian Economy, this is the mission of Intesa Sanpaolo Innovation Center which aims to create the assets and develop the necessary skills that guarantee the competitiveness of the group and its customers through the promotion of new technology use and the support of corporate transformation projects where responsible business models can reconnect business and society.

Intesa Sanpaolo Innovation Center supports the growth of start-ups in domestic and international markets through programs in acceleration and networking and has created laboratories and Competence Centers to generate know-how and develop new assets and businesses.

Intesa Sanpaolo Innovation Center invests in start-ups with its Corporate Venture Capital NEVA Finventures to encourage new business growth and to support the champions of tomorrow.

Intesa Sanpaolo Innovation Center: the country's driving force for future-proof change.