



How are startups shaping the future of road mobility?

ROAD MOBILITY STARTUPS ANALYSIS 2018

WAVESTONE



Startups can further enhance the mobility offer

Tesla, Uber, Blablacar. Most Europeans would acknowledge that these 3 startups have revolutionized the world of road passenger transport over the last 10 years.

By launching a company with global ambitions in this industry, the likes of which had not been seen since the creation of Honda in 1948, Tesla shook well-established car manufacturers. It opened the door to a new generation of cars: electric, connected, autonomous.

The world of taxis was halted, even blocked. By relying on smartphones, Uber dynamised the situation and somewhat satisfied - not without criticism - the shortage of affordable private driver services in some cities.

The sharing economy is simple (...on paper): exploit the over-capacity that one person has in order to make it available to all. What Airbnb has done for hotel business, Blablacar has succeeded

in doing for passenger transport, to the point of being now a leading alternative to buses, trains and short-haul aircraft.

Tesla, Uber and Blabacar - and their counterparts in other parts of the world - are no longer startups. Are there new startups that will herald market re-alignments of the magnitude of these 3 companies? If so, in which domains? How are they going to do it?

To answer these questions, we studied 421* startups associated with on-road mobility.

This study of 421 startups allowed us to highlight 3 major groups:

- / Startups that contribute to the emergence of a new generation of cars;
- / Those which conceive mobility not through means, but as a service;
- / Those that mix the future of the vehicle and new types of services to anticipate future market needs and technological advances.

*Source: These 421 startups are mainly extracted from the Dealroom database, which focuses on high-growth companies in Europe and beyond.

Designing the future of the vehicle

Electric, connected and autonomous. Tesla is no longer the only manufacturer - coming from nowhere - to aim for the emergence of a completely renewed car. Future Faraday, Byton, Lucid... attempts are multiplying, often supported by Chinese funding.

The startups that this analysis studied do not belong to this new-builder category. Nevertheless, they contribute to the development of the components of this new vision of automotive. Whether in embedded autonomous technologies, future car powers or the valorisation of car and driver data, they cover practically all fields of development.

These components are in addition to cybersecurity, which is a major variable that the connected vehicle will have to contend with.

Thinking in terms of services rather than means

One evolution is eminent and seems to accelerate: at least in Europe, cars are less and less a matter of property and owning a car is no longer an objective in itself, given that drivers' first concern is the lower cost of ownership. Given this crucial change, some startups are looking to accelerate the development of Car as a Service.

Uber and Blablacar have respectively solved the problem of ride-sharing (I drive you where you want to go) and carpooling (I share with you the ride I have planned to do). Accordingly, new startups are niche-specific in these areas. Conversely, car sharing (I rent my own car and you can drive it where you want) is still an ongoing issue; the service is far from being widely available and many startups are still looking for the jackpot.

Some startups go further and do not limit their service approach to cars only. It is therefore a question of thinking each trip as a multimodal journey that must be optimized. Cars, bikes, trains, buses... no matter how. But long is the road, and this simple idea might be at the end of the day much more complex than initially imagined.

Seeking one step further

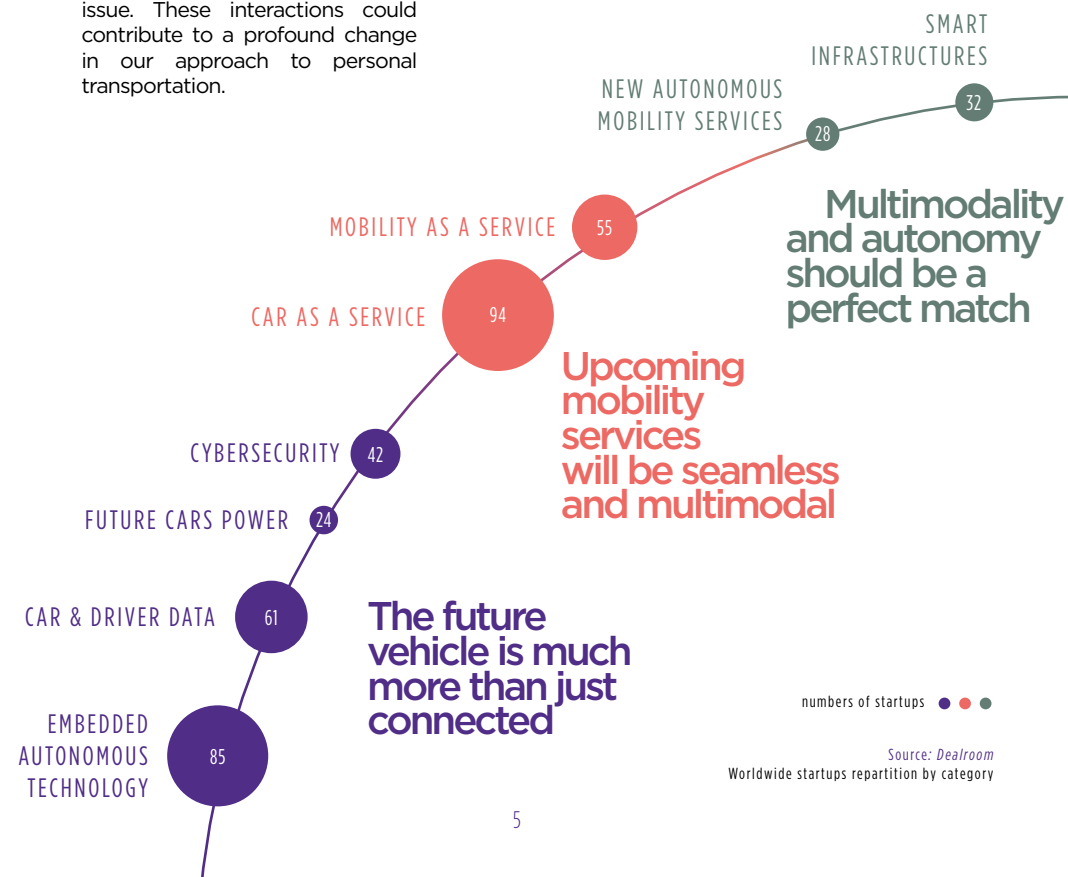
The previous two categories explore movements that have already started. Even more questions arise when it comes to looking further and thinking about mixing autonomy and services.

Only few startups are experimenting shuttles in partnership with transport operators. A few others already imagine an even farther future, coming out of the only question of transportation.

For this point of view, the way infrastructure will interact with cars is still a partially explored issue. These interactions could contribute to a profound change in our approach to personal transportation.

The game is wide open

Startups are no longer an epiphenomenon. That is especially true in transportation. Through partnerships, investments or acquisitions, traditional players of this sector are now getting even closer to those from which disruptions might occur. New powers, connected services, autonomous capacities and sources of change are numerous. The future of mobility will come from the combination of these elements.



The future vehicle is much more than just connected

EMBEDDED AUTONOMOUS TECHNOLOGY

CAR & DRIVER DATA

FUTURE CARS POWER

CYBERSECURITY

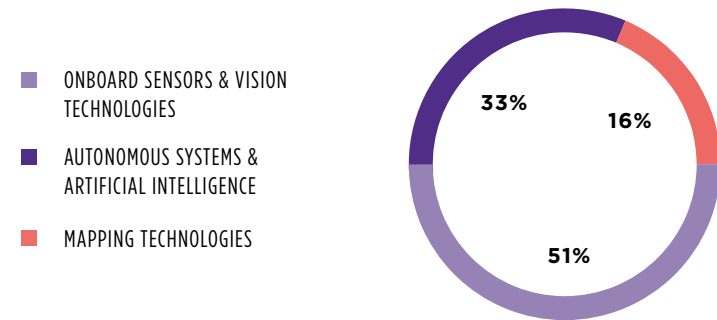


Startups are at the very heart of the autonomous technology evolution



The startup ecosystem for embedded self-driving technology has numerous facets. It does not just cover the Autonomous Systems & Artificial Intelligence aspects that operate the vehicle, but also the array of onboard sensors and vision technologies, as well as the more sophisticated mapping technologies.

On all these innovations, startups had the upper hand and are at the center of big players' attention as shown by recent acquisition and new funding records. Through them, traditional actors have the real opportunity to boost their technology push and speed-up their autonomous vehicle programs.



Source: Dealroom

Worldwide distribution of startups by type of embedded autonomous technology

Innoviz Technologies, flagship of Israeli technological innovation

Innoviz Technologies

Headquartered in Israel, Innoviz is one of the most funded self-driving technologies startup of 2017, mostly from leading auto industry suppliers Delphi Automotive and Magna International. In January 2018, the startup announced the release of InnovizPro, a solution that will enable their LiDAR sensor to come with significantly lower costs and smaller sizes than those already existing in the market.

Founders: Amit Steinberg, Omer David Keilaf, Oren Buskila, Oren Rosenzweig, Zohar Zlsapel
 Series B – Funds raised: \$82M
 Country: Israel

Investors are betting on startups developing improved onboard sensors and vision technologies

One of the hottest technologies among the Embedded Autonomous Technology field is onboard sensors and vision technologies with nearly \$1.7bn of total investments during 2017.

LiDAR “Light Detection And Ranging” startups represent strategic targets for investors and particularly carmakers with more than \$719m global funding. In 2017, GM and Ford-backed Argo AI acquired promising US LiDAR startups (Strobe and Princeton Lightwave) to accelerate their autonomous vehicle developments, reduce costs of production and also take control of their supply chain.

In addition to Radar and LiDAR-based solutions, autonomous vehicles require very good camera vision systems to reach full autonomy in natural unconstrained environments. Last year’s acquisition of Mobileye by Intel for \$15.3bn or the latest \$600m record for venture capital funding in the AI sector set by the Chinese SenseTime, specialized in camera-based image processing and valued at \$4.5bn, show how crucial those innovations are.

Key investors are recognizing the value of the startups that innovate on hardware components, and are moving their pawns forwards to lock down this technology for their own autonomous vehicle programs.

The new value chain requires AI expertise

28 startups, representing around \$2.3bn of total funding, are creating AI software for autonomous vehicles using deep learning technology.

4 well known startups - Argo AI, Nauto, Pony AI and Preferred Networks - have received more than \$1.4bn from carmakers since 2014. GM has acquired Cruise automation in 2016 for \$1bn and startups like Aurora Tech. or Nutonomy have already announced key partnerships with Volkswagen / Hyundai and PSA respectively.

The effervescence around those startups is due to the shift from equipment-first sector to software-first sector. Carmakers who truly take that shift into account and enter the new value chain will win the race and stay competitive... but transforming themselves into technology-first companies will not be easy.

Establishing partnerships with exciting and promising startups seem to be the royal road to achieve this transformation.

GM’s attitude towards tech. startups can be compared to Apple strategy. Both of them have decided to combine software and manufacturing to allow to capture the full added value of their product. This integrated approach is reflected by GM’s following moves on the market :

- Strobe – LiDar (Acquisition)
- Cruise Automation – IA system (Acquisition)
- Ushr – HD & 3D Map (Investment)

Baidu or Waymo are betting the opposite by focusing on the operating system and integrating into hardware provided by OEMs.

General Motors’ fully integrated approach



The development of autonomous vehicles is one of the main applications of machine-learning systems, biomimetics or interactions based on multi-agent systems which are already attracting significant investment from existing players.

It is often considered as a major commercial application of AI on a large scale. A 2017 study by the Brookings Institute estimated that more than \$80 billion has already been invested in the autonomous vehicle.

These figures reveal the technological race engaged in that purpose, between the big carmakers, but also featuring traditional and new actors from the advanced technologies industry.



FOR A MEANINGFUL ARTIFICIAL INTELLIGENCE, BY CÉDRIC VILLANI, MATHEMATICIAN AND MEMBER OF FRENCH PARLIAMENT - 2018

The fierce competition to map the world

The best AI software in the world will not be enough for a vehicle to be fully autonomous. It will need highly sophisticated, ultra precise maps updated in real time and augmenting the sensors to circulate on roads.

For this reason, carmakers have been investing for several years in cartography-specialized startups and firms. BMW, Daimler and Audi, for instance, acquired for €2.8bn the Here company in 2015.

These so called high definition or 3D maps go far beyond basic turn-by-turn directions

of currently embedded GPS’s and have become the sinews of the war. Carmakers are at work to ensure that they will not become dependent to the omnipresent actor Google and its well known Google Maps service.

Some startups like Civil Maps, DeepMap, Carmera, Momenta AI or Ushr still try to make a place in this highly competitive market, dominated by TomTom and Here.

But the game will prove very difficult, despite the fundraisings.

The data generated by connected cars will become more significant with the arrival of autonomy



In 2018, the penetration rate of connected vehicles in the world market is **28.8%**

Source: Statista, 2018

The exploitation of data from vehicles is one of the leading fields of investigation for the startups of our panel.

Currently, the majority of the car fleet still consists of unconnected vehicles, and many (87%) startups of this category only exist to overcome the lack of connectivity of current vehicles.

These startups embed hardware plugins or use sensors from passenger smartphones to collect data and offer all types of services based on the analysis of vehicle data.

CONNECTED SERVICES: 53 STARTUPS WITH \$980M OF TOTAL FUNDING



Source: Dealroom

Number of startups by type of connected services provided

Connectivity and openness are no longer options

Nowadays, carmakers tend to systematically produce connected vehicle by default, and regulators enforce manufacturers and mobility operators to expose their collected data through APIs in order to allow service providers to access data at various level of processing (raw data, pre-processed, enriched...).

Some carmakers have already started this transformation by opening part of their connected vehicle APIs and encouraging developers to innovate and build services around mobility.

This openness policy has to go hand in hand with a reflection on protection and use of the personal data of drivers and travelers.

On this specific point, the General Data Protection Regulation (GDPR) is a structuring element: from the car manufacturers' and mobility operators' point of view who will have to demonstrate that the data subject consented to the processing of his or her personal data, but also from the service providers' point of view who will have to ensure that personal data is processed in a lawful, fair and transparent way with regard to the data subject, collected for specified, explicit and legitimate purposes, and not be further processed in an incompatible way with these purposes.

Mastering the autonomous car's data-driven ecosystem

According to Intel CEO, Brian Krzanich, in 2020 the average autonomous car may process 4,000 gigabytes of data per day. Indeed, on-board AI systems, as well as other embedded technology like sensors and mapping which power self-driving, must be constantly producing data.

That's why carmakers are now searching for platforms which are capable of handling the huge amount of data generated by self-driving cars.

Applications for effective data storage and processing are numerous and we can divide them into two categories:

- / RUNNING AND IMPROVING THE AUTONOMOUS DRIVING SYSTEM
- / PROVIDING CRUCIAL SERVICES APPLICATIONS LIKE DIAGNOSTICS AND FLEET MANAGEMENT

In this race, very few startups position themselves on this market segment as it requires an access to new generation vehicles to test the future technologies and services. These startups are, for the most part, already linked to major players in the market.

ExVe Standard

To ensure secure access to vehicle data, off-loaded facilities are set up, from which service providers can access data, rather than having direct access to the vehicle in an uncontrolled way. The ISO 20077 standard (ExVe: Extended Vehicle) wants to define the rules for interoperability and protection of this data, thus facilitating access to vehicle data.

\$16M

BESTMILE
(Suisse, partnership Navya)

\$34M

VULOG
(France, backed by Bpifrance)

\$26M

RIDECELL
(USA, partnership Auro and backed by BMW i Ventures)

N/A

AUTONOMIC
(USA, acquired by Ford)

Source: Dealroom

Flagships startups offering autonomous mobility platform

To build their autonomous vehicle management platform and manipulate this growing flow of data, manufacturers adopt different strategies. They either:

/ Develop their own system from scratch to remain the sole owner and user (e.g Waymo)

/ Rely on interoperability standards to add technology or service layers by startup buyout/partnership (e.g GM, Ford, Zenuity)

/ Leverage cloud platforms developed by tech giants (Baidu, AWS) and benefit from their partnerships

BLOCKCHAIN

DOVU is an English startup shaping the blockchain model for the mobility ecosystem.

Backed by InMotion Ventures, the Jaguar Land Rover subsidiary investment fund, DOVU wants to become "the global marketplace for transport data". It means that owners of cars will also be owners of the data and that consumers of data will pay to get access to the data that the vehicle generates. Then, data owners can use the received tokens to buy other mobility services.

Founders: Arwen Smit, Irfon Watkins
Seed stage – Funds raised: \$6.2M
Country: United Kingdom

DOVU

Cars tend to be electric



It is the moment for ecology and major markets are already aiming to significantly reduce their pollution rate. One big challenge for tomorrow's vehicles is therefore for automakers and their suppliers to find innovative solutions to reduce the emissions and consumption of their ever smarter and energy-hungry cars.

Everything suggests that futures vehicles will be neither gasoline nor diesel, and research is therefore massively focused on alternative greener energies. For the time being, hybrids vehicle market is growing but appears to be more like a transition phase towards eco-friendly vehicles than a real sustainable alternative. Alternative fuel vehicles have particularly seen their sales increase by 39.7%* in 2017 in Europe, which shows the will of consumers to favor other energies over fuel. In addition, a significant number of countries shows their willingness to stop sales of gasoline and diesel vehicles.

The phasing out of fuel engine

* from The Electric Vehicle World Sales Database (evvolumes.com)

COUNTRIES HAVE FIXED TARGETS TO STOP SALES OF GASOLINE AND DIESEL VEHICLES



The chinese government has not yet given a precise date to stop the sales of gasoline and diesel vehicles but is preparing a plan to follow the above countries.

Electric under the spotlight

The hype surrounding electric vehicles is building and is setting new records with its worldwide sales rising by 58%* in 2017 (pure-electric & plug-in hybrid vehicles). Mandated to be a clean and eco-friendly energy, electric market managed to enticed as well consumers as automakers, who do not hesitate to invest massively in it.

This field has seen many startups flourish, representing nearly one billion dollars of investments in the last three years for our panel of around twenty startups specialized in batteries and next-gen components. Their purpose is to ensure the level of power and operating life required for electric vehicles of tomorrow, which happens to be one of their weaknesses right now.

The most skeptical ones are however wondering about the real impact of electric engines on ecology and exhibit its controversial production in nuclear power plants or coal plants. This is one of the main arguments, with the charging time of its batteries, of those who advocate another source of energy that claims also to be eco-friendly: hydrogen.

* from The Electric Vehicle World Sales Database (evvolumes.com)

Global carmakers will invest \$90 billion at least*

*Source: Reuters, 2018

« **Investments in electrified vehicles announced to date include at least \$19 billion by automakers in the United States, \$21 billion in China and \$52 billion in Germany.*** »

*Source: Reuters, 2018

Hydrogen can still come into play

Although it seems less popular than electric, hydrogen has not yet said its last word. Indeed, while automotive giants like GM and Tesla are all about electric cars and seem to have completely abandoned the latter option, other automakers do not hesitate to invest huge sums on it.

Toyota, Daimler and BMW are leading a group of 13 companies across the world:

the Hydrogen Council, that will invest \$10 billion over the next 10 years in developing hydrogen technology and infrastructure.

Even though there are a lot of investments, almost no startups exist in the field of hydrogen, and investments mainly concern heavy infrastructures for hydrogen storage and distribution. Moreover, as the current demand of hydrogen vehicles remains so low, similarly to the number of cars already on the roads, these are long-term investments that do not allow profits before a real democratization of such cars.

FUTURE POWERTRAIN

SolidEnergy

SolidEnergy Systems is an American startup which manufactures a new kind of battery.

The promise of this startup is to offer a battery based on lithium-metal technology that has an autonomy twice as large as the market references. It means that a battery could be half the size of a standard lithium-metal battery and hold the same amount of energy. The company is focusing for the moment on drones but will certainly extend its scope to other types of mobility.

Founders: Qichao Hu
Series C – Funds raised: \$54.5M
Country: USA

Carmakers are investing in startups

- GM invested in Sakti3, SolidEnergy, Tula Technology, Proterra, SiNode Systems
- Volkswagen invested in QuantumScape
- PSA invested in Nidec (Joint Venture - €220M)
- Daimler invested in StoreDot (\$60M), VantagePower



When cybersecurity comes into play



The automotive industry must now consider cybersecurity as an integral part of how cars are built, just as physical safety became a critical part of how cars were built in the late 20th century.

Many people in this field caught on leading to the creation of many startups on the topic. Today, no less than 20 startups try to provide solutions to face automotive cyber risks.

Cybersecurity, yes, but with a different approach

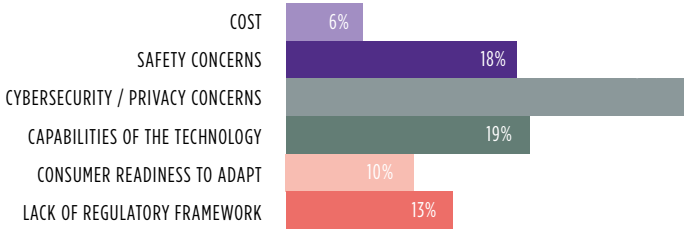
Those startups show that the challenges to be handled are almost the same as those usually encountered in other sectors but need to be addressed differently.

Due to the current specificities and constraints related to the automotive industry and connected car in particular, startups are having to adapt existing cybersecurity concepts and solutions while innovating including:

- / Manufacturing costs;
- / Proprietary and specific technologies for embedded materials, with little security originally integrated (e.g. CAN - Controller Area Network);
- / Systems with a long lifetime and complicated upgrade capacity;
- / Limited processing capacity;
- / Architecture complexity.

Cybersecurity is seen by automotive and technology executives as the biggest obstacle to the growth of connected cars

WHAT DO YOU SEE AS THE BIGGEST OBSTACLE TO THE GROWTH OF CONNECTED CARS?



Source: *Foley, 2017 Connected Cars & Autonomous Vehicles Survey (2017)*
Responses from 83 automotive and technology executives

4 MAIN CYBERSECURITY OBJECTIVES are addressed by startups in the field, through the products and services they propose:

- 1. PROTECTION OF HARDWARE, FIRMWARE AND SOFTWARE**, as well as related processed-data which is a true challenge especially when having to implement cryptography mechanisms requiring significant computational power
- 2. ENSURING ONLY LEGITIMATE COMMUNICATIONS** are allowed to ensuring no-one is able to take unauthorized control of a car, while protecting data in transit which is essential for privacy
- 3. DETECTING OF ABNORMAL EVENTS AND REACTING** accordingly in order to prevent any intrusion or cyber attacks on a car or a whole fleet
- 4. MANAGEMENT OF SYSTEMS LIFECYCLE**, particularly related-vulnerabilities is becoming a major concern all the more so when a car has a 15-to-20-year life year life.

It clearly appears that intrusion detection and threats prevention are two of the most covered topics as 70% of the automotive cybersecurity startups are offering related solutions. One can say that the market and car manufacturers kept in mind what happened to the Jeep Cherokee. However this figure may originates from the fact that is probably easier to provide security at the car boundary rather than to integrate

cybersecurity in the current constraints of in-vehicle architecture and components.

One another key point is that vehicles have a lot in commons and share, for some aspects, the same characteristics with the Internet Of Things. That's why it is not surprising to see startups like Prove&Run or IoT.BZH coming from this world and offering embedded software and hardware oriented security services and solutions to the automotive market.

Major actors invest in startups at an unprecedented pace

The ongoing creation of cybersecurity startups in the automotive industry over the past years highlights the fact that cybersecurity has become a top concern in the sector.

Established automotive companies, like car and equipment manufacturers, know this well.

Some focus on hiring new talents and/or developing technologies in-house but most of them are very aggressive in investing or buying startups at an unprecedented pace. Are they afraid of the potential competition? Are they unable to provide these innovations with their own R&D teams? Do they want to accelerate with the integration of new ways

of working and new teams? The answer is certainly a combination of these 3 factors as the connected and autonomous car represents a major shift in their organization and strategy.

This fast movement is clearly visible when looking at the list of the latest startups acquisitions below:

- / Founded in 2013, **ADVANCED TELEMATIC SYSTEMS** was acquired by HERE in 2018;
- / Founded in 2013, **ARGUS CYBER SECURITY** was acquired by Continental in 2017;
- / Founded in 2012, **TRUSTPOINT INNOVATION TECHNOLOGIES** was acquired by ETAS (Bosch) in 2017, which had already acquired the cybersecurity company Escript in 2012;
- / Founded in 2012, **TOWERSEC** was acquired by Harman in 2016, which was in turn acquired by Samsung in 2017;
- / Founded in 2010, **ARILLOU TECHNOLOGIES** was acquired by NNG in 2016.

In addition to these acquisitions, many actors also invest in startups and build partnerships with them, like Denso for example, which recently invested over \$2 Million in Dellfer, a startup that was founded in 2016.

Besides, startups are not the only ones to be concerned. Some established companies in the field are also concerned, highlighting

the market dynamism on the topic. For instance, Thales and Vector recently formed a joint-venture to work on addressing cybersecurity challenges related to the connected and autonomous car.

A new area of risk is rising

The arrival of autonomous cars is a new challenge for cybersecurity. Many new risk scenarios will have to be taken into account, mainly in the field of attacks on artificial intelligence, advanced sensors security and even automated response to cyber events.

To face this new challenge, solutions are only at a development phase and not particularly dedicated to the automotive sector. Many researchers like Nicolas Papernot or Ian Goodfellow are currently working on how to prevent Adversarial Attacks which aim at deceiving AI and which could lead, if applied to an autonomous car, to safety issues.

Breakthrough solutions are probably being developed by startups from the Zereth. AI accelerator, an Artificial Intelligence and Machine Learning focused startup accelerator.

Although they will undoubtedly provide bleeding edge solutions to these complex problems, no one has declared working on the automotive field yet.

Certainly, cybersecurity and safety will have to be addressed jointly to make autonomous vehicles a reality.

Cybersecurity startups anticipate future connected car architectures

Even if startups mainly offer solutions and services to secure existing systems and architectures within modern vehicles, there is a trend today showing that some of them are anticipating and building cybersecurity solutions for the forthcoming systems and architectures.

The startup Argus Cyber Security* is a good example. One of its first products was the "CAN firewall", to protect the historical CAN network which is still the reference protocol in current vehicles. The startup has since developed new solutions like the "In-Vehicle Network Protection Suite" to support a wide array of network protocols – CAN and CAN-FD, FlexRay, Ethernet (with SOME/IP, DoIP etc.),... – and thus defend current and future vehicle architectures.

Another example is Arilou Technologies*, which recently designed a new cybersecurity tool called the "Ethernet Security Hub" focused on for protecting future connected and autonomous vehicles equipped with Ethernet networks rather than CAN networks.

(* This startup has since been acquired. See the text above.



Upcoming mobility services will be seamless and multimodal

CAR AS A SERVICE

MOBILITY AS A SERVICE



Transforming cars into a platform of shared services



The rise of connectivity and sharing economy has opened a wide range of services around cars that are transforming the way we use and live them. Startups have disrupted and are, to this day, still boosting the car services market. There are 3 major types of services facing an increasing demand:

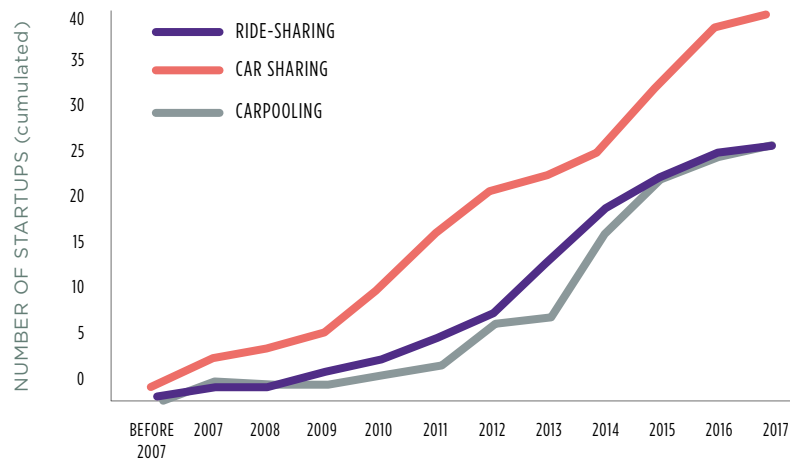
- / **RIDE-SHARING:** ride hailing and peer-to-peer platforms connecting on-demand drivers with travelers for a personalized itinerary such as Uber, Didi or Grab.
- / **CAR SHARING:** new generation of short term car renting solutions that can take two major forms:
 - / Professional fleets owned by companies such as Zipcar, DriveNow or Car2Go that can be accessible through free-floating or dedicated spaces in the streets.
 - / On-demand platforms connecting private owners with travelers such as, Drivy, Getaround or Turo. The idea is for people to rent their cars to others when they are not being used.
- / **CARPOOLING:** car owner sharing his ride with people, on the same journey. This

can also take two major forms:

- / Long distance and occasional travel such as Blablacar.
- / Short distance and daily commuting such as Klaxit, Flic or Luxi.

Beyond unicorn companies, what can be learned from the startups competing in this field?

Among these 3 categories, the ride-sharing services have been predominant in terms of fund raising and number of users over the last decade. Launched with Uber in 2009 and quickly followed by other companies (like DiDi, Grab or Ola), these former startups are nowadays big mature companies (7 years-old on average) and have raised alone about 50 billion dollars.



Source: Dealroom
Car sharing startups never stopped sparking new businesses

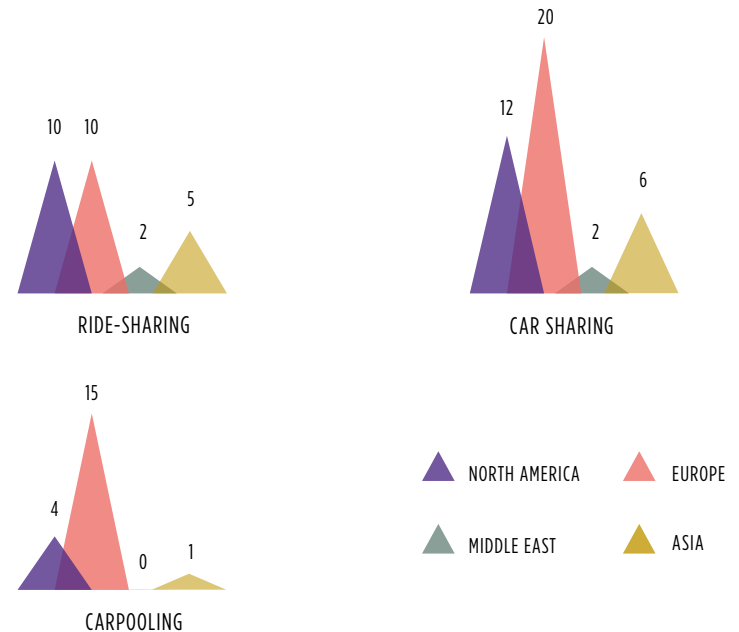
Once the major actors of ride-sharing are excluded from the scope, other trends emerge.

Carpooling is becoming more urban, with the multiplication of commuting startups encouraging people to share their ride while going to work, for short distances. This expands the original long distance service of older actors like Blablacar and boosts the ecosystem with investments and partnerships.

The car sharing category concentrates the greatest number of startups. Those providing peer-to-peer rental account for around 25%, while the remaining 75% of startups deal with car rentals from dedicated vehicle fleets. Though it may appear that there is no famous unicorn startup offering such services, users are numerous. In fact, 10.5 million people used them in 2017 (8 million for traditional car sharing & 2.5 million for peer-to-peer renting) according to Statista.

A distribution existing within geographic regions

Moreover, the distribution among different car services is also accurate by geographic region, with a prevalence of the car sharing category in both Europe and America.



Source: Dealroom
"Car As a Service" startups geographical distribution

Carmakers are also betting on Car as a Service

Ride-sharing, Carpooling and Car Sharing services could be seen as a threat to the traditional business model of carmakers: those services could reduce individual car ownership.

Major automakers have already understood that they have to be fully involved in this new ecosystem of mobility services. For this reason, most of them have already massively invested or acquired startups in that field. Through those moves, carmakers gain valuable knowledge and technologies, like fleet management, diverging from their current core business. It's essential to prepare for the arrival of autonomous vehicles.

General Motors acquired select assets and employees from the startup Sidecar and launched in 2016 its own car-sharing service called "Maven"

RCI Bank and Services, subsidiary of Renault Group, acquired 2 startups in 2017: Yuso, a global dispatch software solution for taxis, private hire and delivery services; Marcel, a VTC booking platform

The BMW Group and Daimler AG announced in March 2018 that they plan to combine and strategically expand their existing on-demand mobility offering in the area of Car as a Service (Car2Go and DriveNow for car sharing; mytaxi, Chauffeur Privé, Clever Taxi and Beat for ride-sharing).

Connecting key players and services to provide seamless journeys

People expect new adaptive and personalized ways of transportation. Mobility as a Service is about efficiently connecting car services, mass transit and smooth mobility to provide high quality journeys.

The need is obvious, but transforming it into reality is a real challenge regarding several issues:

- / **THE FIRST STEP IS ABOUT TECHNOLOGY.** Data need to be accessed and processed to be able to propose reliable transport solutions. Considering that the availability of some modes varies (bikes for example), that traffic impacts schedules (buses for instance) and that incidents can occur for all modes, real time access to information and quick analysis is key to offer efficient journeys.
- / **OFFERS NEED TO BE VARIOUS** in the aim to combine them into different

journeys that meet all customers' criteria: travel time, cost, gas emission, calories burned, accessibility for disabled persons for example. Besides, big companies such as car manufacturers, public transport operators or tech giants are aiming to broaden their scope by providing seamless multimodal door-to-door experiences through acquisitions, investments and partnerships. The key challenge is to provide a complete and seamless multimodal solution that combines different modes in function of the exact customer's need.

/ **MOBILITY AS A SERVICE IS ALSO STRONGLY TIED TO TERRITORIAL POLICIES.** A new balance is yet to be found among open data, regulated markets, traffic management and sidewalk occupation. Thereby, Mobility as a Service relies on the perfect match of regulators, traditional actors and new players.

« *In wider metropolitan areas, new types of shared services such as Shared Taxis or Taxi-Buses can serve as feeders to existing high-capacity public transport networks such as metro or rail lines. This facilitates the introduction of shared services and increases the use of those high-capacity services and the overall positive impacts in terms of congestion reduction, more equitable access and gains in public space.* »

INTERNATIONAL TRANSPORT FORUM PAPER (OECD)
“TRANSITION TO SHARED MOBILITY” – 2017

Startups are making a contribution towards multimodality

Numerous journey planning applications are aiming to provide smart route solutions, gathering different mobility services for a real-time specific journey.

Some are matching public transport and car services to provide adaptive routes like Citymapper or Moovit. Other platforms can also localize multiple car and two-wheels services on a single map like Free2move, which operates in big European cities.

Such services already improve the traveler

experience through adaptive itinerary and smart connections in personalized contexts, thanks to open and contextualized data.

The farthest step is combining all modes, including public transport, booking payment and mobile ticketing in a single app. Personal transportation (ones own bike for example) can potentially be considered. Such a service helps anticipating the journey while avoiding time-consuming physical payment and registration.

Some initiatives reveal that multimodality and integrated solutions are an underlying trend

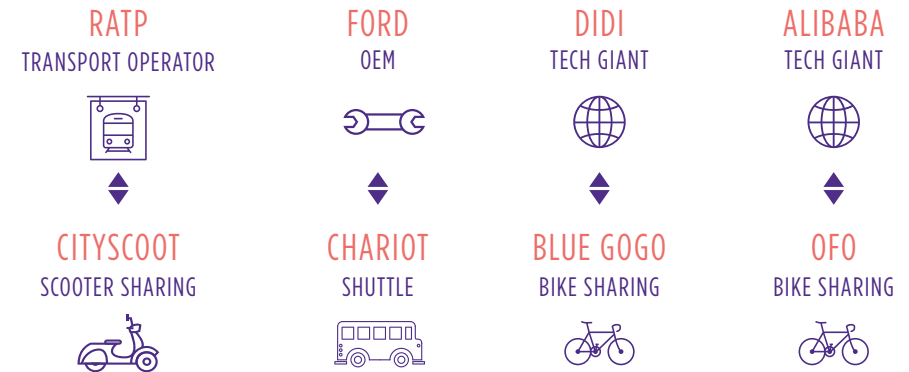
Though multimodal and seamless services face major challenges and require sustained political commitment, some initiatives are worth analyzing since they are opening the road of dreamed mobility services.

This multi-player field is connecting traditional actors as well as unicorns with startups that provide new mobility services.

Each player fulfills its own strategy by acting on its mobility suite and improving its customer relationship.

For example, Transport Operators can consolidate their offer by adding complementary mobility, OEMs can exploit their own products or tech giants can extend the scope of their digital applications.

4 EXAMPLES OF STRATEGIC INVESTMENTS & ACQUISITIONS



MaaS Global

In 2016, MaaS Global launched an application called Whim to carry out this advanced integration in Helsinki and beyond.

Whim can combine mass transit, bike, taxi and rental services through different subscription plans. Companies like Transdev, Toyota and Denso have already invested.

Founders: Kaj Pyyhtia, Sampo Hietanen
Early VC – Funds raised: \$20.5M
Country: Finland

INTEGRATED MOBILITY

Two-wheels services and parking solutions complement transportation offers



Two-wheels sharing services (bikes & scooters) have been rising since 2015 and are booming in large cities. Startups in this field have raised more than 400 million dollars, some of which, such as Mobike and Ofo (free floating bikes), have already become unicorns (not included in our study). They notably help dealing with the first or last mile of a journey. Furthermore, these services support the evolution of cities towards green and non-polluted areas. 100% of scooter sharing startups studied are electric.




Parking solutions are also addressing specific urban needs and drastically diminishing the time to find a place. Some startups are leading the way, such as Parkbee and GottaPark.

2 European projects

1. EIT Digital is launching Easy2go, a Pay-as-you-go solution that combines public transport and carpooling in one application while providing a single ticket. Customers will only pay their effective use of the service. It will be integrated with multimodal applications in several countries by 2019.
2. European Union's Horizon 2020's IMOVE is about providing a better connectivity among MaaS solutions over Europe and creating a sort of "roaming" as in telecommunications to facilitate transnational services.



An aerial, long-exposure photograph of a complex highway interchange at night. The image is dominated by vibrant, glowing light trails in shades of purple, blue, and orange, which trace the paths of vehicles moving through the multiple levels and curves of the interchange. The perspective is from a high angle, looking down on the intricate network of roads and overpasses.

Multimodality and autonomy should be a perfect match

**But several issues still
need to be explored**

NEW AUTONOMOUS MOBILITY SERVICES

SMART INFRASTRUCTURES

Some startups are already shaping next generations' mobility services



Current transportation modes are already becoming autonomous

American and European startups have adopted two different ways of mixing autonomy and mobility by making driverless shuttles and taxis:

/ A couple of European startups are focusing on pendular urban transportation with the new kind of **AUTONOMOUS SHUTTLES**. Hundreds of cities around the world have already been attracted by this new technology and are currently testing these autonomous vehicles. As of now, uses are in limited area. Here are some examples of current experimentations

/ Since 2016, the city of Lyon in France has integrated a Navya shuttle into a tramway line to face the first/last mile challenge.

/ Easymile is working on integrated transport solutions with the University of Melbourne by providing autonomous shuttles in the university campus

/ In the mean time, very few startups are developing a **FULLY AUTONOMOUS ROBO-TAXI TECHNOLOGY**. Zoox and Voyage are two of them. This is a field that is mainly explored by tech giants and carmakers. Waymo is testing its robo-taxi offer in Arizona and Ford announced that they plan to operate a robo-taxi fleet of their own in 2021.

A few startups concentrate investments and research on the specific field of shuttle mobility. They are leading and endorsing the deployment of this new type of vehicles worldwide. This is notably the case of the 2 following French startups that have been leading the development of shuttles since 2014.

DRIVERLESS SHUTTLES

Created in 2014, these two French companies have raised together more than 60 million dollars.

Benefiting from a multiplicity of tests realised in various conditions, these companies provide a preview of tomorrow's urban mobility and accustom as of now users to new autonomous mobility.

These startups also capitalize on their learnings and experiences to think and design new services beyond simple autonomous shuttles.

NAVYA
Founder: Christophe Sapet
Series B – Funds raised: \$42.6M
Country: France

EASYMILE
Founders: Gilbert Gagnaire,
Philippe Ligier
Series A – Funds raised: \$18.6M
Country: France

Navya & Easymile

Autonomy will imply rethinking cars from the inside to offer news services

Vehicles will no longer be machines that simply move people from point A to point B. Once the car doesn't need a driver, the passenger will have time available for leisurely activities/entertainment.

Furthermore, as the level 5 of autonomy will erase the steering wheel and pedals, the inside of the vehicle could be redesigned in a completely different way.

This aspect is currently not addressed by startups. As of now, only few startups work on rethinking HMI and in-car experience. This is likely due to the very strong adherence to the vehicle's physical structure. However, companies that are working on shuttles and robo-taxis are already integrating tablets or touch screens that help passengers get touristic information or order drinks for example.

Furthermore, no startup has been specifically identified in on-board services, though different new activities could be imagined, like concierge or wellness services.

In short, everyone's priority seems to be focused on making autonomous vehicles run safely, on-board services will follow step-by-step.

Very few startups are imagining completely different transportation modes

While autonomous shuttles and robo-taxis are designed for a foreseeable future, some startups have decided to completely rethink mobility from scratch with disruptive and futuristic prototypes such as flying cars (e.g. Cora by Kitty Hawk) and modular vehicles (e.g. Next Future Transportation).



MODULAR PODS

Next Future Transportation

Next Future Transportation is an American startup developing a modular transportation system.

Autonomous Pods can be coupled with one another to guarantee as much flexibility as a personal car, while being more traffic efficient than a bus. A pilot project of this futuristic concept is being implemented in Dubai since February 2018.

Founders: Emmanuele Spera, Tommaso Gecchelin
Seed Phase - Funds raised: \$375,000
Country: USA

A leverage to wider autonomous mobility?

First uses don't necessarily require connected infrastructures but wider ones may need more communication

As the race towards core self-driving technology becomes fierce, only few startups are developing V2X technology.

The reality is that, for the moment, V2X does not seem to be set as a prerequisite for the first AV deployment on roads, considering that driverless cars are running in limited or dedicated areas.

According to a study carried out by Stanford University in 2014, autonomous cars could account for between 70% and 90% of taxis on the roads by 2060. At that time, and even before, autonomous vehicle-based mobility services and traditional cars will certainly coexist and, in that case, smart infrastructure could help in managing the cohabitation with other cars and with pedestrians who will be unfamiliar with such technologies. For example, connected traffic lights could help manage precedence between all road users.

Wider use of autonomy in transportation may require infrastructures that are able to communicate with the vehicles and analyze the data. It indeed could appear as a considerable leverage to develop more secure mobility services, improved traffic management and congestion reduction, and improve the sharing of roads between all vehicles and pedestrians, although very few use cases are being exposed for the moment.

« *Communication between vehicles, infrastructure and with other road users is crucial also to increase the safety of automated vehicles and their full integration into the overall transport system.* »

EUROPEAN COMMISSION COMMUNICATION "A EUROPEAN STRATEGY ON COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS, A MILESTONE TOWARDS COOPERATIVE, CONNECTED AND AUTOMATED MOBILITY" - 2016

Very few startups seem to be able to deal with road infrastructures

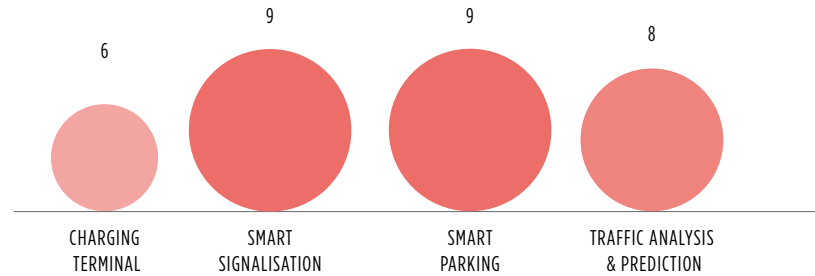
Very few startups seem able to penetrate the smart infrastructure market. It may be because it is closely related to a need:

- / To own heavy equipment (parking, roads, antennas...)

- / For authorizations to enter the street before you can deploy a service or technology
- / For communication standards, generally deployed by major players

These large projects are often carried by communities and supported by more traditional actors.

However, some startups are betting on the smart infrastructure. They are positioning themselves on particular and close use cases, or to handle interoperability between all infrastructures.



Source: Dealroom
Number of startups by smart infrastructure market segment

Connected Signals

SMART SIGNALISATION

Connected Signals, Inc. is an innovative startup in the connected car space that delivers real-time, predictive traffic signal data.

This startup has developed sophisticated techniques to predict upcoming signal states. Knowing the current state of traffic lights and how they will change creates opportunities to increase driving safety, increase fuel efficiency, and improve the driving experience. They partner with municipalities, handling the complexities of gathering real-time signal data and making it available in consistent formats for a variety of uses.

Founders: David Etherington, Matt Ginsberg
Series A – Funds raised: \$2.8M
Country: USA

Experimentations and labs are key to explore the whole field

towns” (K-City in South Korea, Transpolis in France, or Mcity in the USA for instance) planned to test new autonomous mobility services, integrating them in a connected infrastructure.

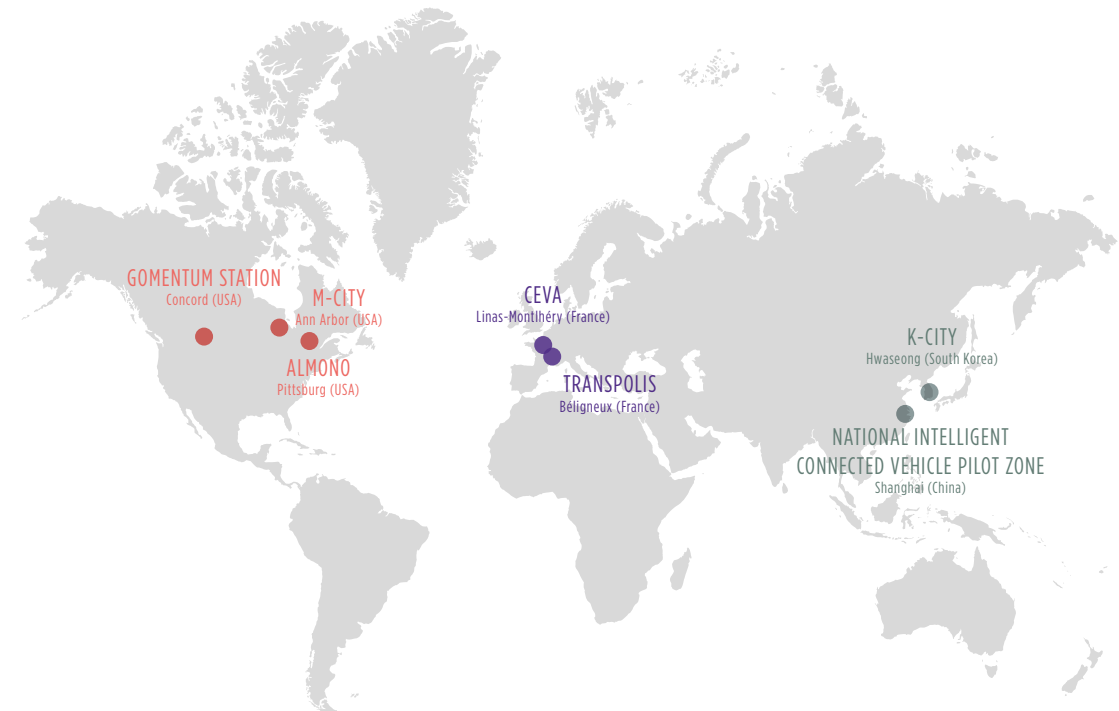
Talking with traffic lights

Some startups are beginning to make demonstrations with the use of V2X: for example, NAVYA has just launched an experimentation in an airport by taking into account the traffic light. The vehicle communicates through the API of the infrastructure.

“Ghost towns”

Understanding the future challenges of the smart city to develop optimized mobility, public authorities and communities are investing in the construction of “ghost

WORLD MAP SHOWING SOME GHOST TOWNS AND CLOSED CIRCUITS USED TO TEST AUTONOMOUS CARS



A last word

Startups are numerous in the road mobility sector, investors are multiple. In particular, tech giants, carmakers, and equipment manufacturers seem determined to gamble on mobility.

These private companies contribute greatly to reshaping the future of mobility. How does this dynamic contribute to public mobility challenges? Are startups contributing to make the right path possible? All the road mobility actors should now focus on

One aim: making mobility greener, safer, smoother

Green mobility

Low-emission transportation is one of the biggest issues we have to face in the 21st century. Indeed “Urban transport is responsible for 23% of EU’s greenhouse gas emissions” according to a European Commission communication. Startups seem to be completely in line with these expectations: they are contributing greatly to accelerate this transformation by providing electric vehicles for example.

On-board intelligence can also help cars to run eco-driving, whatever the power is.

Furthermore, shared services help raise cars’ occupancy rate. Thus, vehicles on the road are used more responsibly, ecologically speaking.

Safe mobility

Increasing automation holds great promises: speeding, drink-driving or red light running would no longer be an issue.

Very few startups focus directly on safety features, but their role is key in integrating safety by design.

As a matter of fact, artificial intelligence will have to learn about safety features :

- Image analysis and processing will need to become increasingly accurate,
- Abuse scenarios, whether in the form of cyberattacks or road infrastructure vandalism, will have to be better anticipated.

Smooth mobility

Congestion in metropolises deeply affects mobility effectiveness in terms of the time it consumes, gas emission and citizens’ comfort.

Working on next cars generation or future mobility services means being able to offer a seamless journey to travelers.

Indeed, enhancing offers helps mixing travelling modes, while accelerating cars’ connectivity and autonomy will help traffic management. The next step is to start thinking about on-board services to completely reshape user experience.

authors

LAURENT STOUPLY, Partner
laurent.stoupy@wavestone.com

AMAL BOUTAYEB, Manager
amal.boutayeb@wavestone.com

MATHIEU SABARLY, Manager
mathieu.sabarly@wavestone.com

contributors

Transport

THOMAS VERSTREPEN, Analyst
THÉO DUTHEIL, Analyst

Manufacturing

ZHONGYU MAO, Consultant
MAXIME DUPREZ, Analyst

Technologies & Cybersecurity

AUDREY PAMBRUN, Consultant
ANTOINE DE POUILLY, Analyst
FRANK BRAVARD, Analyst
AMAURY TRASSAERT, Analyst
ANTHONY DI PRIMA, Manager
MAXIME ROCHE, Senior Consultant
THÉO TAMISIER, Consultant

data providers

DEALROOM
CRUNCHBASE
REUTERS
FOLEY & LARNER LLP
EVLVOLUMES
STATISTA

contact

communication@wavestone.com

GRAPHIC DESIGN: STUDIO CLÉMENTINE BOL

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