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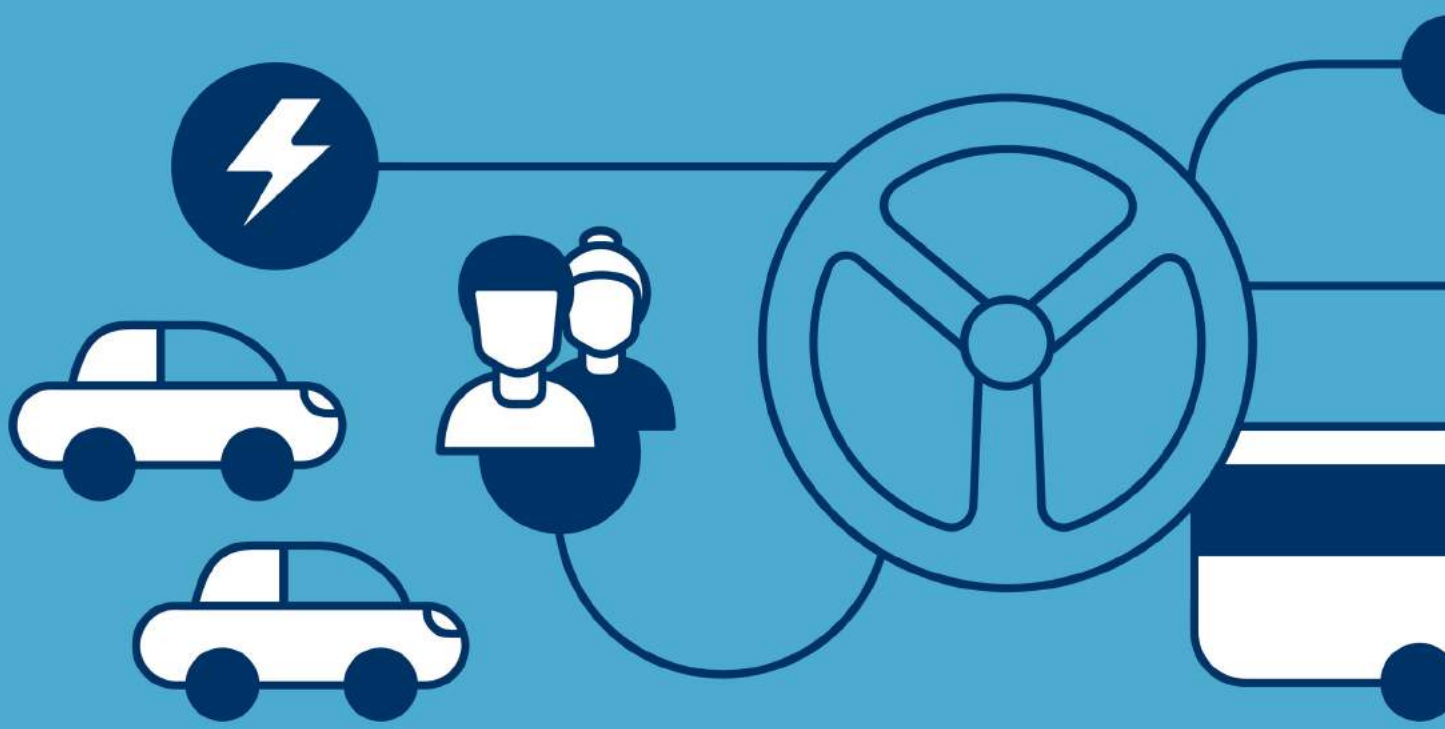

EMERGING TRENDS

Auto & Mobility Trends

2019

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NExTT FRAMEWORK

Auto & Mobility Trends in 2019

- R&D and design
- Material supply, parts sourcing, and vehicle assembly
- Distribution, marketing & sales
- Aftermarket services and vehicle use

NExTT Trends

INDUSTRY ADOPTION: High / Low

TRANSITORY	NECESSARY
Trends seeing adoption but where there is uncertainty about market opportunity. As Transitory trends become more broadly understood, they may reveal additional opportunities and markets.	Trends which are seeing wide-spread industry and customer implementation / adoption and where market and applications are understood. For these trends, incumbents should have a clear, articulated strategy and initiatives.
EXPERIMENTAL	**THREATENING**
Conceptual or early-stage trends with few functional products and which have not seen widespread adoption. Experimental trends are already spurring early media interest and proof-of-concepts.	Large addressable market forecasts and notable investment activity. The trend has been embraced by early adopters and may be on the precipice of gaining widespread industry or customer adoption.

Low — MARKET STRENGTH — High

The NExTT framework's 2 dimensions:

INDUSTRY ADOPTION (y-axis)
Signals include:


momentum of startups in the space


media attention


customer adoption (partnerships, customer licensing deals)

MARKET STRENGTH (x-axis)
Signals include:


market sizing forecasts


quality and number of investors & capital


investments in R&D


earnings transcript commentary


competitive intensity


incumbent deal making

Necessary

MOBILITY-AS-A-SERVICE

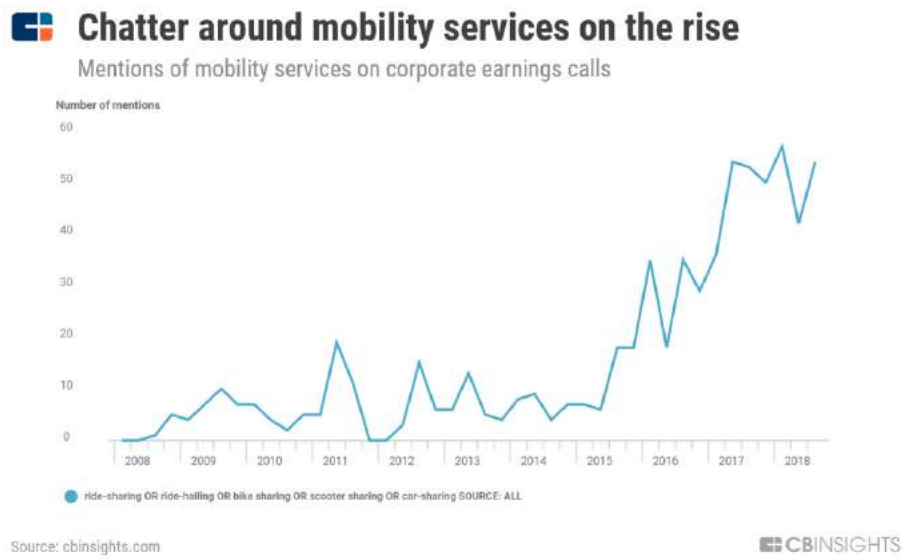
A growing number of companies are reshaping the way people move themselves, offering mobility solutions as on-demand services to cater to individual travel needs.

The rise of on-demand transportation services has transformed transportation in urban and suburban regions. Originating with ride-hailing and more recently expanding to bikes, scooters, and car-sharing, mobility-as-a-service (MaaS) has emerged as a viable alternative to personal vehicle ownership. In many cases, it's facilitating mobility across cities with subpar public transportation options.

MaaS platforms make more optimal use of vehicles, given that personal vehicles sit unused for 95% of the day. Shared mobility also allows users to avoid the costs associated with ownership, including insurance, tax, maintenance, and parking, while conveniently taking riders from point A to point B.

Traditional auto OEMs such as General Motors and Ford recognize the significance of MaaS, and are repositioning themselves as mobility service companies rather than car makers.

The rapid rise of ride-hailing and ride-sharing services has also shaken up corporations in adjacent sectors, such as rental car companies and parking management firms, as illustrated by the earnings call analysis below.



Companies that frequently mention this on their earnings calls:

Hertz (110 mentions) Avis Budget Group (75 mentions) General Motors - Self Driving Unit (38 mentions) Kandi Technologies Group (31 mentions) I.D. Systems (29 mentions) eHi Car Services (22 mentions) Yandex (21 mentions) Ford Motor Company (17 mentions) Zipcar (16 mentions) SP Plus (14 mentions)

BMW and Daimler merged their MaaS operations under a single umbrella in early 2018, with each company taking a 50% stake in the joint venture. The automakers have launched a number of services across the MaaS space, including car-sharing (Car2Go and Drivenow), ride-hailing (myTaxi, Chauffeur Privé, and Clever Taxi), parking (ParkNow and Parkmobile), electric vehicle charging (ChargeNow and Digital Charging Solutions), and on-demand mobility (moovel and ReachNow).

And MaaS isn't just about cars — the new vision for mobility services includes other modes of transport that cater to different lengths of transport. For example, bikes and scooters — more broadly referred to as micromobility — have seen a surge in investor interest following rapid consumer adoption, as these light vehicles provide short-distance transport solutions for urban dwellers.

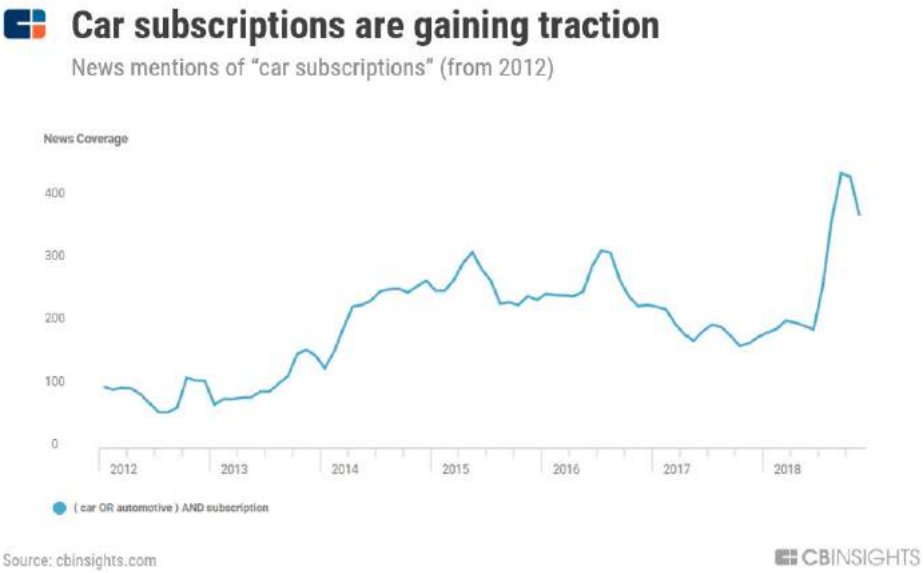
Source: Lime

Micromobility has driven unprecedented investor interest in 2018, generating a number of new unicorns, including Bird and Lime. Automakers are also taking notice, with Ford acquiring scooter-sharing platform Spin in November.

On the private side, ride-hailing giants Uber and Lyft — as well as Didi Chuxing in China — are looking to branch out into adjacent mobility services such as bike-sharing, scooter-sharing, car-sharing, and public transportation. In the US, Uber has partnered with public transportation platform Masabi, and it acquired e-bike-sharing startup JUMP Bikes in April 2018. Lyft has followed suit with its acquisition of Motivate in July. In China, Didi Chuxing has been notably active in the micromobility space, tapping into a number of startups operating bike- and scooter-sharing services.

Startups and automakers have also started to offer subscription services as an alternative to buying or leasing vehicles. While leases lock owners up for up to a few years at a time, these subscriptions allow users to rotate cars multiple times per year. These services also bundle the various costs associated with ownership, such as maintenance and insurance, into one monthly payment.

While the services are still relatively nascent in terms of scale, the flexibility associated with a subscription has resonated strongly across the mobility ecosystem. A number of automakers, including BMW and Volvo, and several startups have launched subscription options.

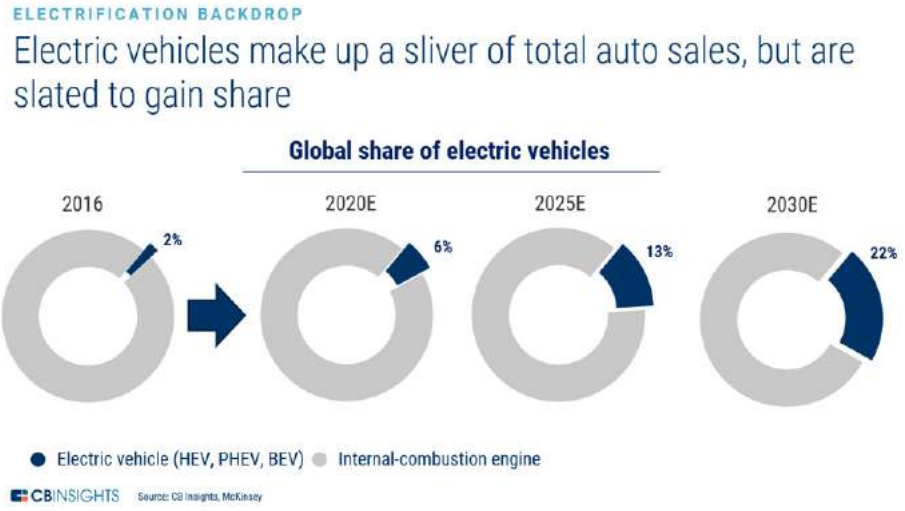


Questions around whether mobility services — namely ride-hailing — are worsening traffic congestion and replacing public transportation use are still looming, but many of these MaaS companies aim to reduce congestion and ultimately replace personal car ownership.

ELECTRIC VEHICLES

Automakers view electrification as critical to the future of the automotive space and are accelerating efforts to electrify their fleets.

Electric vehicles (EVs) currently make up a small fraction of total automotive sales globally. However, they are expected to gain share over the next several years as governments across the globe — mainly in China and Europe — aggressively deploy incentives to spur EV adoption.

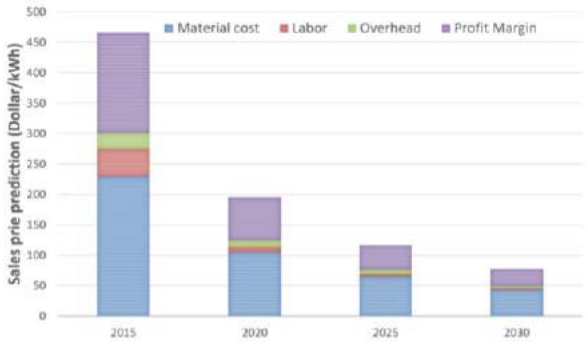


Simultaneously, the cost to produce a lithium-ion battery — the most commonly-used battery for electric vehicles — is falling, driven by advancements in manufacturing and scaled production of electric vehicles. Lower battery costs ultimately help drive down the cost of electric vehicles, which has been a major roadblock for consumer adoption.

Batteries cheaper to make, EVs easier to scale

Multiple factors are expected to **drive down the cost of manufacturing** a lithium-ion battery:

1. Improvements in material sciences
2. Maturing of the battery market
3. Higher production of electric vehicles

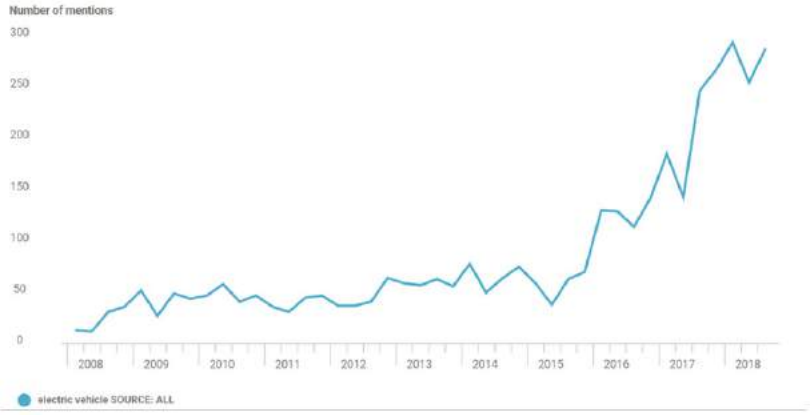


CBINSIGHTS Source: Energies

Automakers are heavily focused on vehicle electrification given this backdrop. Chatter around electric vehicles has picked up substantially on corporate earnings calls.

Electric vehicles taking center stage

Mentions of "electric vehicles" on corporate earnings calls (from 2008)

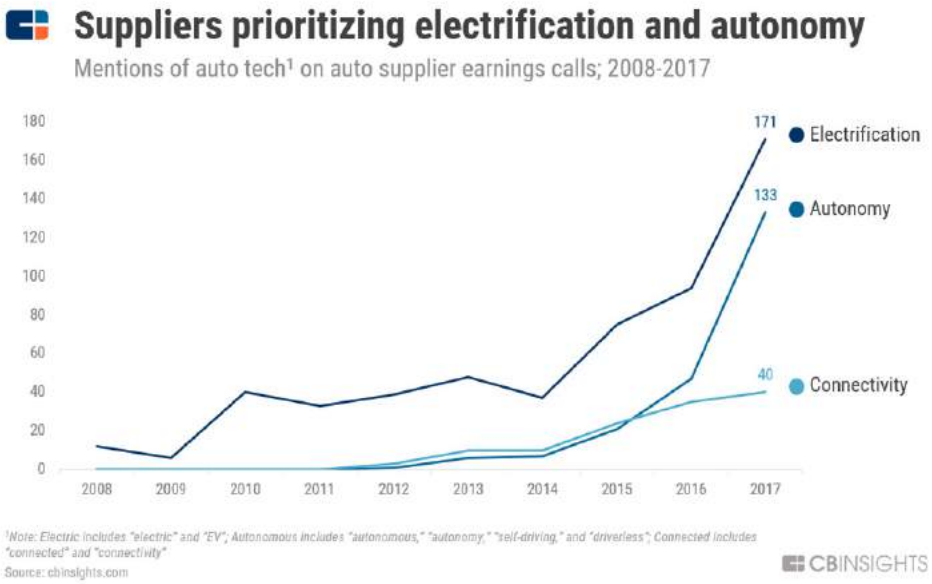


Source: cbinsights.com

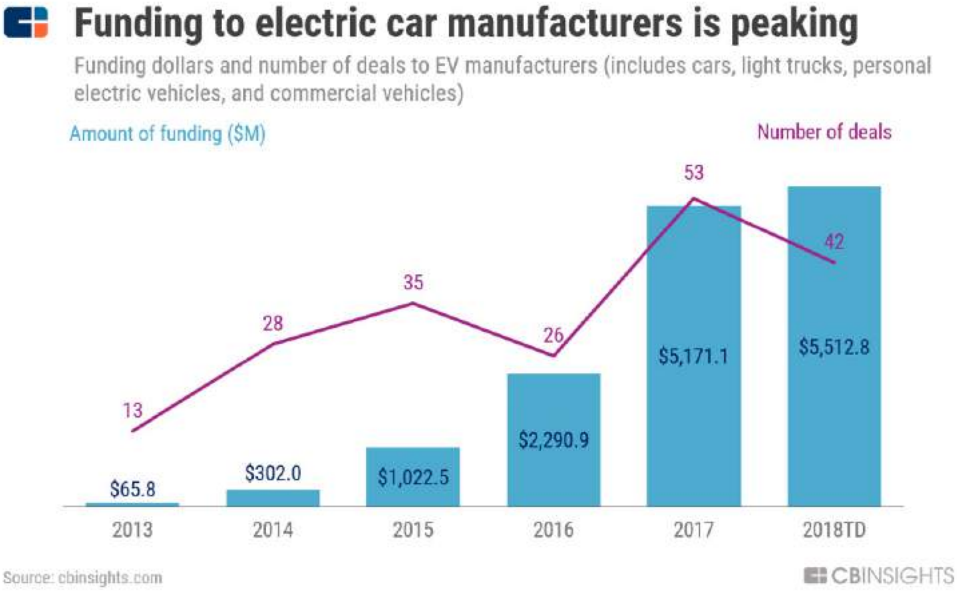
CBINSIGHTS

Most recently, Volkswagen announced in November that it's investing roughly $50B in the pursuit of electric vehicles, among other disruptive automotive technologies. The company plans to stop producing gas-powered cars entirely by 2026. Almost every other automaker has at least one fully electric model in development.

Tier-1 auto suppliers are also focused on vehicle electrification, as the components going into an electric vehicle differ substantially from those used in traditional internal combustion engines (ICEs). Mentions of electrification on Tier-1 supplier earnings calls have far outpaced those of autonomy and connectivity on an annual basis.



The broader investor ecosystem is also capitalizing on the favorable outlook for electric vehicle adoption. Investors have already poured over $5.5B into EV manufacturing startups this year, reaching a new annual peak.



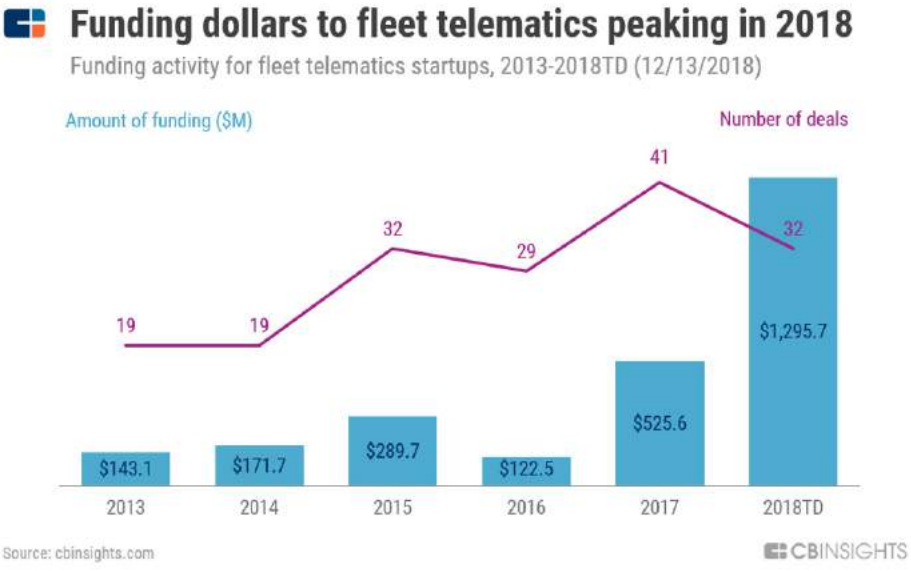
Startups looking to improve battery technology and build out a charging infrastructure for public and residential use have also seen notable attention from investors and automakers. BMW and Daimler, for example, have invested in charging infrastructure startup ChargePoint to build out charging networks to support their EVs. Volvo also invested in charging startup Freewire.

TELEMATICS

Connected vehicle technology that enables real-time fleet visibility and data collection is opening up a number of new revenue opportunities for automakers.

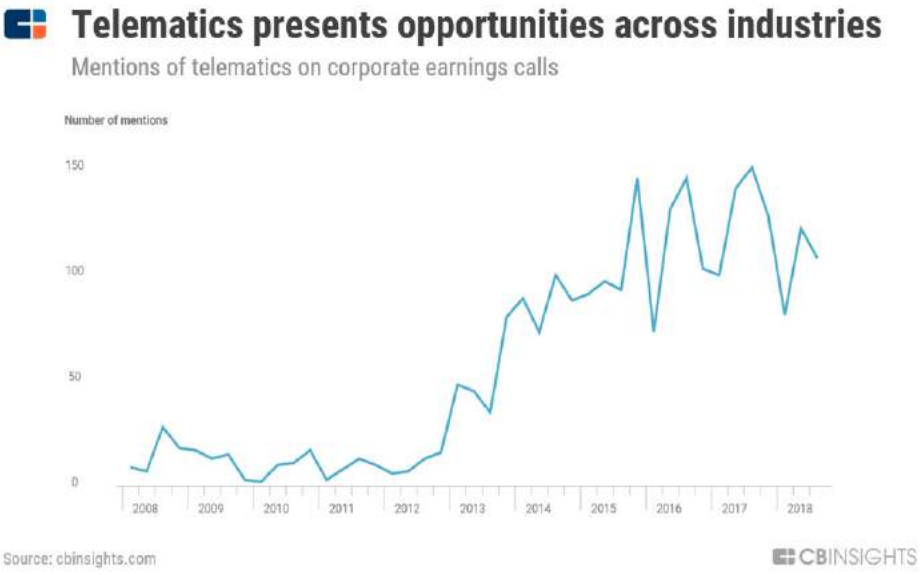
With advances in vehicle connectivity, it's now possible to track a car's movements in real time. This technology, known more broadly as telematics, is especially useful for fleet operators such as freight companies, rental car firms, and ride-hailing services, as it provides them with a live feed of their vehicle fleets.

A number of investors, including automakers and Tier-1 suppliers, are placing bets in the telematics space. The technology provides substantial cost saving opportunities for fleet managers, who can utilize telematics technology to track location data, fuel levels, and driver behavior. This allows them to optimize routes, minimize fuel costs, and increase fleet safety.



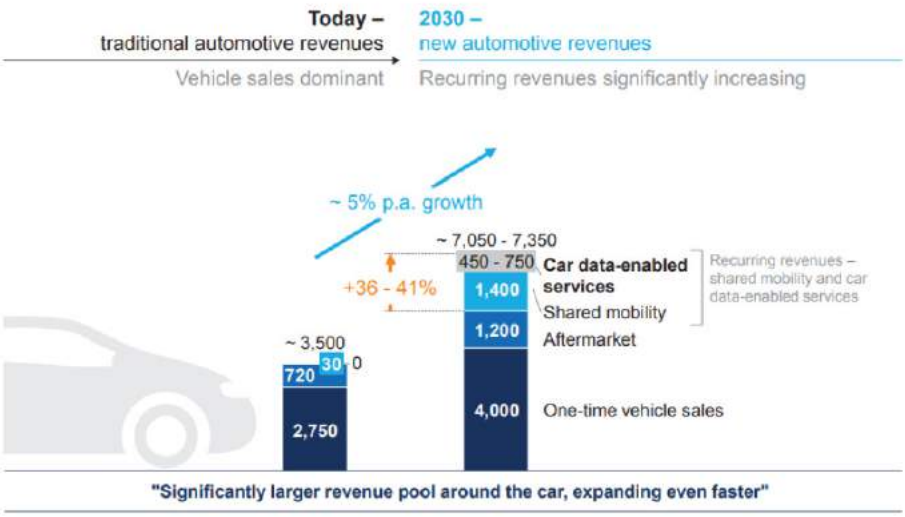
Telematics also has notable implications in the insurance space. Insurers can track driver behavior and charge more appropriate premiums based on specific metrics such as miles driven, rapid acceleration, hard braking, hard cornering, and airbag deployment. This approach, known as telematics-based underwriting, has received attention from major insurers, including Allstate, Progressive, and Kemper.

Telematics technology is resonating with corporates across industries, as mentions of the technology on earnings calls have picked up substantially over the past few years.



Perhaps most importantly, telematics will substantially impact the business model of the traditional auto OEM.

Connected vehicles generate a massive amount of data that presents a monetization opportunity for automakers, which is especially important given that new car sales are slated to taper off with the shift to shared mobility. Monetizing telematics data could generate $1.5T for automakers by 2030, taking share of an automaker's revenue as new car sales decline, according to McKinsey.



Source: McKinsey

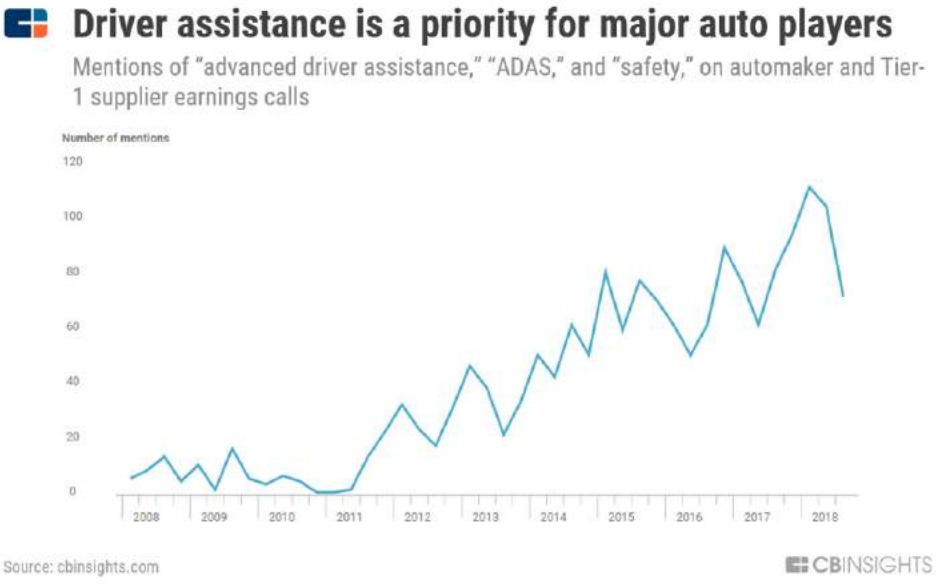
As a result, the majority of OEMs view connectivity as an integral component in the vehicle of the future, and hope to have 100% of all new vehicle fleets connected within the next few years.

Automakers have already started taking advantage of this data opportunity, with GM and Volvo using connected car data to drive more informed insurance plans. BMW's CarData platform currently offers driver data to third-party services like insurance companies and repair shops.

ADVANCED DRIVER ASSISTANCE

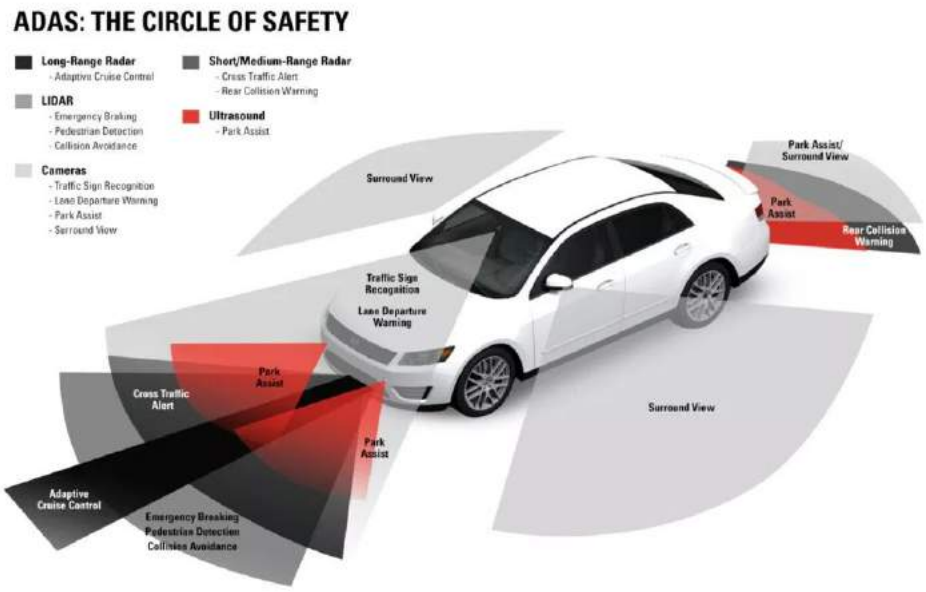
Until full autonomy is achieved, automakers are enhancing driver safety technology to work with the human driver and minimize errors.

Automakers and Tier-1 suppliers are prioritizing driver safety, as the majority of road accidents are caused by human error. Until fully autonomous vehicles become a reality, augmenting the capabilities of the human driver is one of the only ways to combat accidents on the roadway.



With advancements in sensor technology and developments in machine vision software, auto OEMs have been able to develop advanced driver assistance systems (ADAS) that enable semi-autonomous driving.

These systems feature new capabilities such as adaptive cruise control, automatic braking, traffic and lane departure warnings, and other alerts and automated responses to augment the driver's capabilities and assist them in the case of distraction or fatigue.



Source: Robotics and Automation News

On the hardware side, automotive sensors and their accompanying software help vehicles detect and process their surroundings — a critical feature for driver assistance technology.

Each sensor offers its own set of strengths. Cameras are most valuable for detecting colors and fonts; radar is most useful for detecting distance and speed; and lidar can create highly-accurate 3D renderings of the vehicle's surroundings.

However, these sensors also have limitations, and cannot be used in isolation given the detection accuracy needed for semi-autonomous and fully autonomous vehicles. Sensor fusion software addresses this issue by taking in and processing the data from all of the vehicle's sensors to create a coherent view of the car's surroundings.

Interestingly, some automakers are prioritizing advanced driver assistance rather than full autonomy. For instance, Toyota's goal is to develop a vehicle that is "incapable of causing a crash," which suggests a future that is not necessarily driverless.

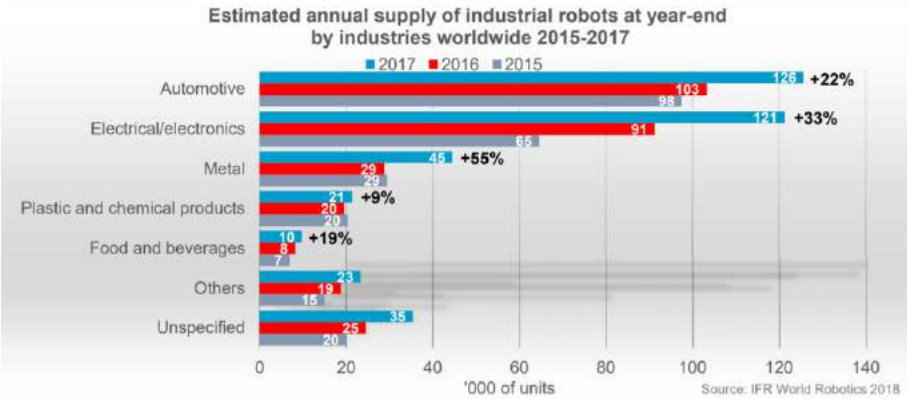
The company's approach is to improve driver assistance systems to monitor and augment the driver's capabilities, making the roads safer without removing the human from behind the wheel.

INDUSTRIAL ROBOTICS

Robots remain crucial to automotive manufacturing as new vehicle architectures will require higher levels of automation and flexibility.

The rate of widespread global adoption of industrial robots has picked up notably in recent years, driven by a shift to high-mix, low-volume production (manufacturing a large variety of products in small quantities) and advancements in digital manufacturing technology.

The automotive sector is the largest driver of demand in industrial robotics across industries, and it's forecasted to remain the largest moving forward.



Source: IFR World Robotics

With the transition to autonomous and electric vehicles, vehicle architectures are going to change drastically. The customization and personalization required for new vehicle makeups will demand high levels of flexibility on the manufacturing front.

Additionally, as automakers look to automate the final assembly line as much as possible, industrial robots will be in high demand.

Innovations on the robotics front have made robots more useful in the manufacturing process. Hardware improvements have enhanced robot dexterity, and collaborative robots — or cobots — have the ability to work alongside humans and augment human workflow.

GM has started using cobots in a number of its factories to operate around human workers without relying on safety cages. These cobots are helping workers aim headlights, calibrate radar for adaptive cruise control, and stack spare tires, replacing previous technology that took up much more floor space and drove up manufacturing costs.

Automated ground vehicles (AGVs) have seen a notable rise in adoption to facilitate the flow of goods across the factory with little manpower involved. Automakers such as BMW and GM are relying on AGVs in their factories.

Source: Living Map

Tier-1 suppliers are also relying on AGVs to drive efficiencies on the factory floor. Seating and exhaust systems supplier Faurecia has started using AGVs and found that they helped to reduce inventory storage space by 60%.

INDUSTRIAL SENSORS

As sensor prices continue to fall, the technology will remain central to automotive manufacturing, allowing automakers to monitor the assembly line, streamline operations, and predict costly outages before they occur.

With connected factory equipment, manufacturers can monitor the assembly line in real time, allowing them to improve productivity and drive efficiencies in the production process.

The sensors that connect the factory equipment feed into a digital ecosystem known as the Industrial Internet of Things (IIoT), which is enabling advanced analytics and streamlining the manufacturing process.

Audi has built a “smart” factory in Mexico, where it uses radio frequency identification devices (RFID) and smart logistics to enable coordination throughout production. The company has started utilizing RFID solutions in its Neckarsulm factory in Germany, which helps it to identify vehicles at every step of the production process.

Source: Audi

Digital systems will also allow automakers to track components as they move through the value chain, making it easier to identify where quality issues arise in the production process.

BMW's Connected Supply Chain (CSC) initiative is designed around tracking goods across the supply chain, allowing the automaker to more quickly respond to delays and minimize costs associated with a production slowdown.

Experimental

AUTO E-COMMERCE

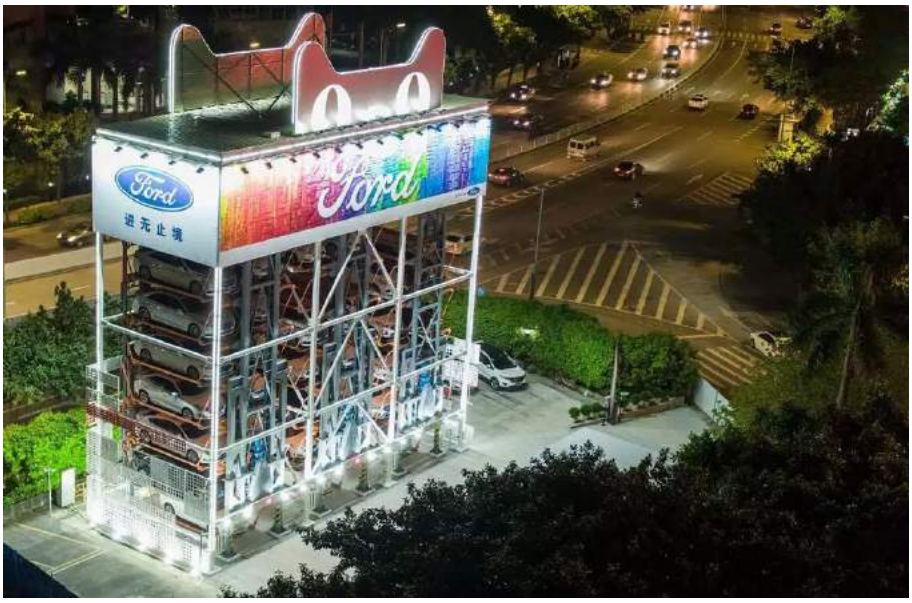
Car buying has remained a brick-and-mortar business for far longer than the rest of retail, but advancements in imaging technology and emerging distribution models could spark the transition to direct online buying.

As with most other categories across retail, consumers are looking to take the auto shopping process online. Early signs of this are already showing up in China, the largest auto market in the world, where online vehicle portals such as Yiche and Autohome are seeing strong demand from consumers.

In 2014, Chinese consumers purchased and reserved 170,000 cars worth $5B on Singles Day, the Chinese version of Cyber Monday. This number was up substantially from 28,000 the year before. Online vehicle portals are also working with dealerships to negotiate and contract leases. Moving forward, the platforms are looking to get more heavily involved in direct sales.

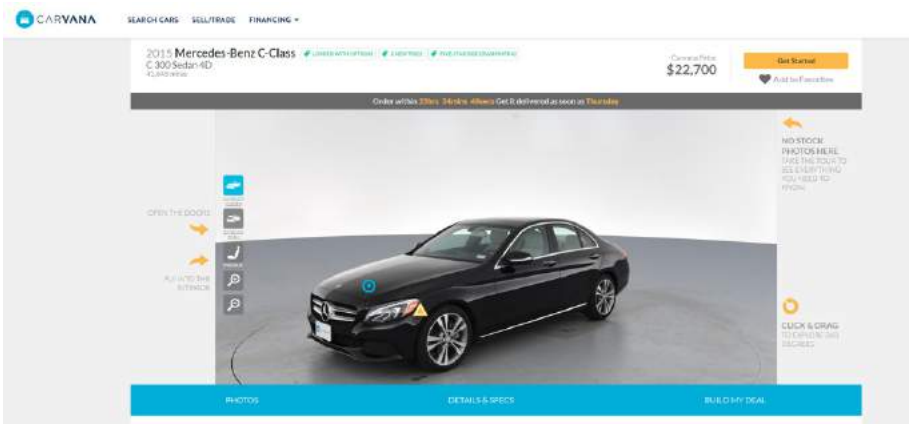
A number of automakers are also partnering with e-commerce sites such as Alibaba to promote new models and launch virtual showrooms. Some OEMs are even selling limited edition models on their websites or through third parties such as WeChat.

In March, Ford and Alibaba unveiled a car vending machine for car shoppers in Guangzhou. Using Alibaba's Tmall app, buyers can select a Ford car and visit the vending machine to take the car on a three-day test ride. Alibaba is also leveraging its user data by offering discounts and incentives based on usage to its highly-active customers.



Source: The Drive

Online-only used car dealer Carvana has pioneered the online car buying process in the US. Users can shop, finance, and trade in cars through the company's website, which includes 360-degree photos and virtual tours of each vehicle. The website also features full reports and financing options for users to browse. Users can either have their cars delivered to them, or if they live in a city with a Carvana vending machine, they can drive the car home from there.



Source: Carvana

In April, Carvana acquired Car360, a startup deploying 3D computer vision, machine learning, and AR technology, to improve smartphone images of cars. The acquisition was intended to help Carvana move away from more expensive camera technology that it uses to capture most of its images.

SIMULATION

Driving simulation platforms are helping autonomous vehicle developers reduce the time and hassle associated with real-world road testing.

Driver data — or the data collected from videos recorded onboard an autonomous car — is critical in the race to develop self-driving technology. The more data that self-driving software has to work with, the more driving scenarios it can learn to handle, and the safer the autonomous vehicle will be on the road.

Amassing this data is time-consuming and costly, and self-driving cars realistically need at least several hundred million — or even billions — of miles to validate their safety, according to the Rand Corporation. This would take years to accomplish, and would hold back AV development substantially.

A number of AV developers are increasingly relying on simulation technology to gather additional miles that would be too time consuming to collect on solely on public roads. Simulation is also helpful with training autonomous vehicles for dangerous, less frequent situations, such as blinding sun or a pedestrian jumping out from behind parked cars.

Chip manufacturer NVIDIA, which is currently supplying its GPU chip to major automakers including Tesla, Volkswagen, Volvo, and Daimler, is on the forefront of simulation technology.

Source: NVIDIA

NVIDIA has launched a cloud-based simulation platform called DRIVE Constellation that runs on the company's GPUs and generates a stream of sensor data for the autonomous systems to process. The technology has the potential to generate billions of miles of customized scenarios for training autonomous driving algorithms.

Other automakers are turning to startups for simulation technology. For example, Audi signed a multi-year agreement with Israel-based simulation platform Cognata to help speed up its autonomous vehicle development with simulation. Cognata's platform creates virtual cities with a range of testing scenarios to simulate real-world conditions.

Source: Cognata

WEARABLES

Given the limitations that come with complete factory automation, automakers are testing wearable technology to augment the capabilities of the human factory worker.

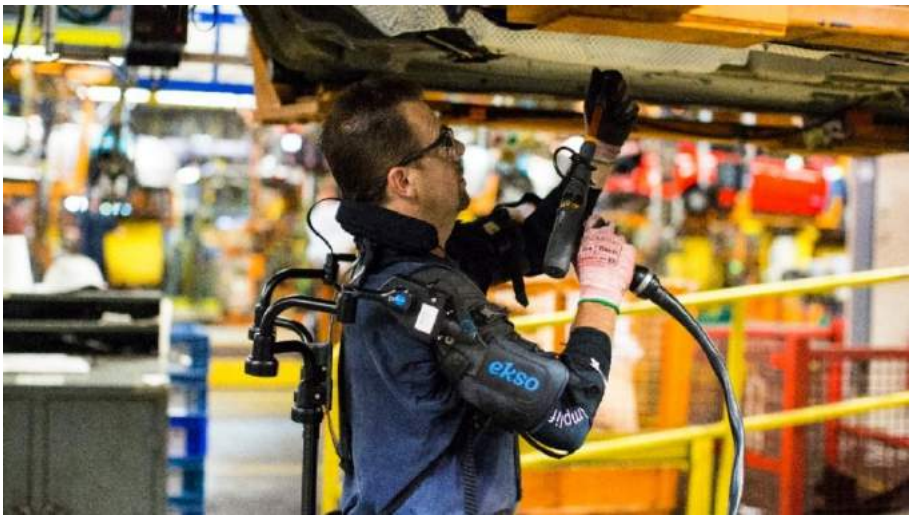
Automated technology that's improperly implemented can generate excessive costs and quality issues. Tesla missed its Model 3 production target in April due to excessive automation in the final stages of assembly. Even the most advanced auto manufacturers in Germany and Japan have scaled down automation in their factories.

Ultimately, humans provide the assembly line with a level of flexibility and dexterity that's difficult to replicate with a machine.

Now a number of automakers are looking to enhance the capability of human factory workers in an effort to minimize workplace injury and increase productivity. One approach has been equipping factory workers with wearable exoskeletons, or high-tech gear that mirrors a worker's limbs and back to support the body during repetitive tasks.

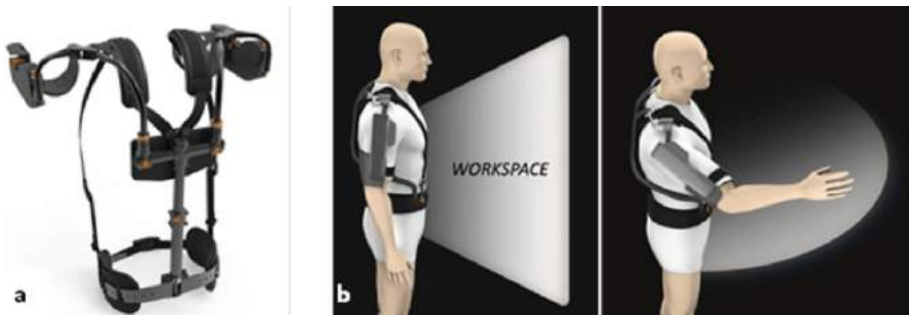
While still relatively nascent, wearables are effectively preventing strains and stresses for workers on the factory floor. This could ultimately help automakers save on medical expenses, minimize sick days, and improve productivity in their factories.

Ford is working with Ekso Bionics to test the company's upper body suit, called the EksoVest, at 15 Ford plants. Ford ordered 75 suits for its workers, which is the largest trial of exoskeleton technology by a single company to-date.



Source: Assembly Magazine

BMW and Toyota have turned to Levitate Technologies, which has developed an upper body exoskeleton that transfers the weight of the arms from the shoulders, neck, and upper back to the body's core.



Source: ResearchGate

Beyond exoskeletons, automakers have started to deploy smart glasses and smart watches on the factory floor, both of which can help train and inform workers on the assembly line.

There is a notable opportunity in smart glasses, as the hardware can be equipped with augmented reality to analyze complicated machine environments. Glasses with computer vision software can map out a machine's parts, similar to a real-time visual manual.

GM is currently testing the Google Glass to help train and inform workers on the assembly line.

Source: Google X

BMW is also utilizing data glasses and smart watches in a number of its plants to help support its logistics staff.

VEHICLE-TO-EVERYTHING (V2X) TECHNOLOGY

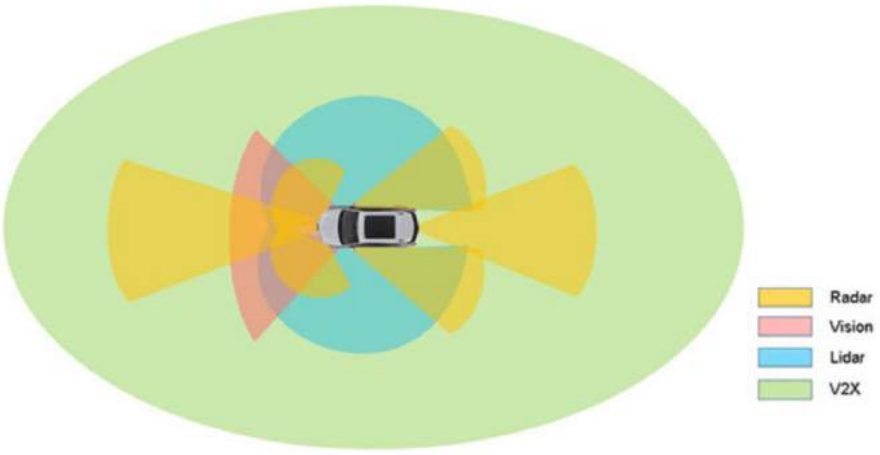
A new class of automotive sensors will allow the car to see beyond its line of sight, a crucial capability for fully autonomous driving.

Cars rely on a vast array of sensors — namely cameras, radar, and lidar — to understand their surroundings. These sensors have been critical to developing advanced driver assistance systems (ADAS) and semi-autonomous vehicles.

But the sensors can't detect objects outside of their line of sight.

Vehicle-to-everything (V2X) technology could solve this issue by enabling cars to wirelessly communicate with connected devices on other cars, pedestrians, and roadway infrastructure.

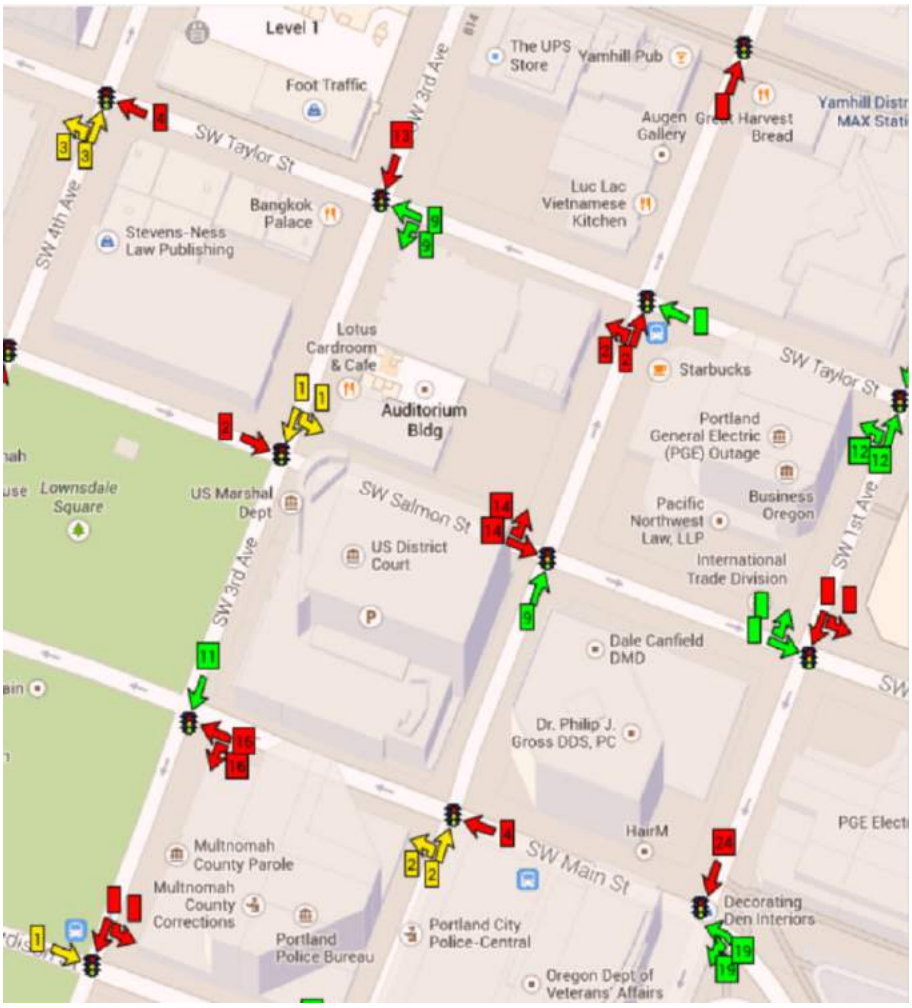
As long as the devices are connected to the same wireless network, V2X allows cars to detect the movement of objects outside of its field of vision, providing a layer of safety beyond traditional line of sight sensors.



Source: University of Minnesota, Duluth

V2X technology also encompasses vehicle-to-infrastructure (V2I) communication, which allows cars to identify and process traffic light signals and road signs.

Startups are using V2I communication to create software that reroutes cars to roads with fewer traffic lights and adjusts traffic light times to optimize traffic flow. This technology would help mitigate traffic and minimize fuel costs for individual vehicles.



Source: Traffic Technology Today

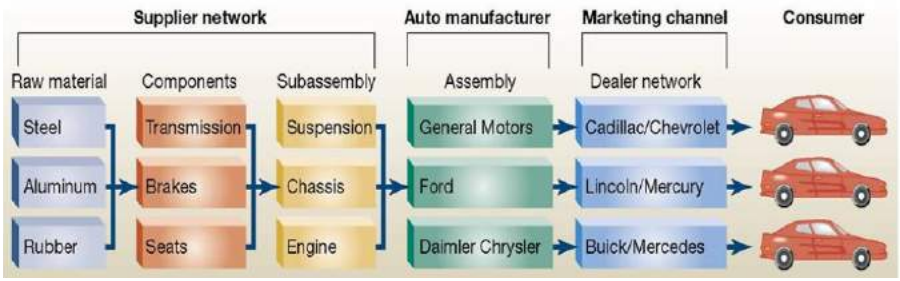
Deployment of V2X is still in its very early stages. Only a small set of corporates and startups are working on the technology, and even fewer are starting to test it.

One of the corporates most heavily involved in the technology is chipmaker Qualcomm. The company is working with a number of startups, including Savari, to develop the necessary software and chipsets for vehicles and points of infrastructure to enable V2X communication.

BLOCKCHAIN VERIFICATION

The lack of visibility in the automotive value chain has plagued automakers for decades. Blockchain verification has the potential to address this issue.

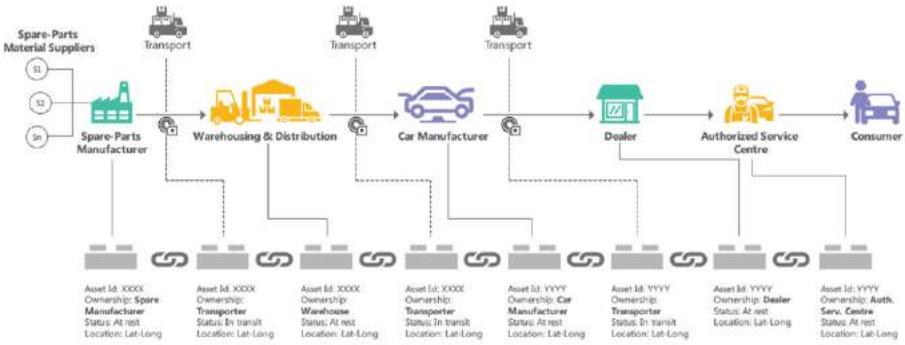
The automotive value chain is notably fragmented, as it involves thousands of firms that are providing more than five thousand parts in the car. The companies involved include everything from raw materials suppliers to component makers to subassembly suppliers, with the parts ultimately ending up at the automaker for vehicle assembly.



Source: McGraw Hill

This fragmentation and the lack of a centralized communication system limit end-to-end visibility for automakers, making it difficult to trace quality issues or ensure the legitimacy of parts. This presents issues when vehicle parts are faulty or counterfeit, as it puts the consumer's safety at risk and can cost automakers billions of dollars associated with recalls or other production disruptions. Counterfeit parts alone cost automakers an estimated $45B a year.

While still in its very early stages, automakers like Toyota are looking to develop a blockchain verification system for the automotive supply chain. Implementing a blockchain system would allow automakers to prove authenticity on sourced parts and track faulty parts, which would help prevent recalls.



Source: Mobiliya

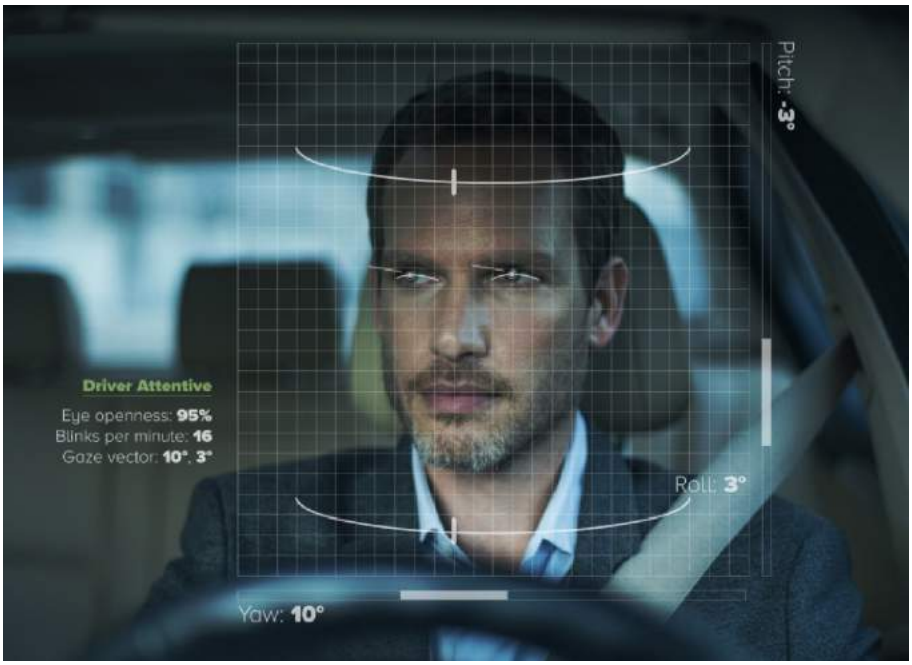
A blockchain system would also create a centralized source that could synchronize data and transactions across the thousands of companies involved in the automotive supply chain without having to involve a third party.

DRIVER MONITORING

Advances in computer vision and machine learning software are enabling a new set of in-vehicle driver monitoring capabilities.

Human error causes roughly 95% of car accident fatalities in the US, and while our future may be a driverless one, driver assistance is a priority across the automotive space.

A number of startups and component suppliers are developing technology that could help monitor driver behavior in real time. These companies are deploying in-vehicle dashcams and sensors coupled with computer vision software that can identify driver fatigue, boredom, and distraction by analyzing the driver's eyes, head position, and upper body movements.



Source: eyeSight

Major automakers are investing in and partnering with driver monitoring startups. Mack Trucks, a subsidiary of Volvo, has partnered with video telematics startup Lytx to deploy the startup's drivecam in a number of its models.

Source: Lytx

Hyundai has partnered with Netradyne, a computer vision startup that's developed a driver monitoring device comprised of four cameras in the interior and exterior of the vehicle.

Automakers are also developing their own in-vehicle sensor technology to monitor driver behavior. BMW is now using an in-vehicle optical camera that monitors driver eye movements in its semi-autonomous crossover the X5.

FLYING ROBOTAXIS

While still a ways away from commercialization, flying taxis are set to transform the mobility ecosystem.

Flying taxis, or vertical take-off and landing (VTOL) aircrafts, are gaining traction as major players in aerospace and transportation are collaborating and making aggressive bets on the technology.

Though the technology is still in its very early stages and adoption is low, estimates suggest the market potential for autonomous electric VTOL aircrafts could reach $1.5T by 2040, driven largely by passenger travel, logistics, and fulfillment.

Boeing and Airbus have stepped up their activity in the space, with their investment arms (HorizonX at Boeing and A3 at Airbus) focused on the future of urban airspace mobility. Boeing also acquired autonomous aviation company Aurora Flight Sciences in November 2017, and launched a joint venture called SkyGrid with AI startup SparkCognition.

Airbus subsidiary Voom is currently testing its on-demand air taxi services in Mexico City and Sao Paulo. Airbus is also testing an autonomous electric flying taxi called Vahana in Silicon Valley. The company is working with Audi on a flying taxi project in Ingolstadt, Germany, where Audi's corporate headquarters are located.

Source: Airbus

In terms of commercial services, Uber's team Uber Elevate has been vocal about UberAir, a flying taxi service that will feature a network of electric VTOLs that can last up to 60 miles per charge cruising at up to 200 mph. The team plans to launch the service by 2020 in Dallas and Los Angeles, and is looking to expand to another city internationally.

However, even as flying taxis gain ground, they still face a number of roadblocks, mainly around regulation and limitations with the technology.

On the regulation front, air traffic management dedicated to flying taxis is critical before commercial services can be offered. Boeing is currently working with SparkCognition to design an air traffic system, though it hasn't specified if the prototypes would be pilotless immediately.

Threatening

LIDAR

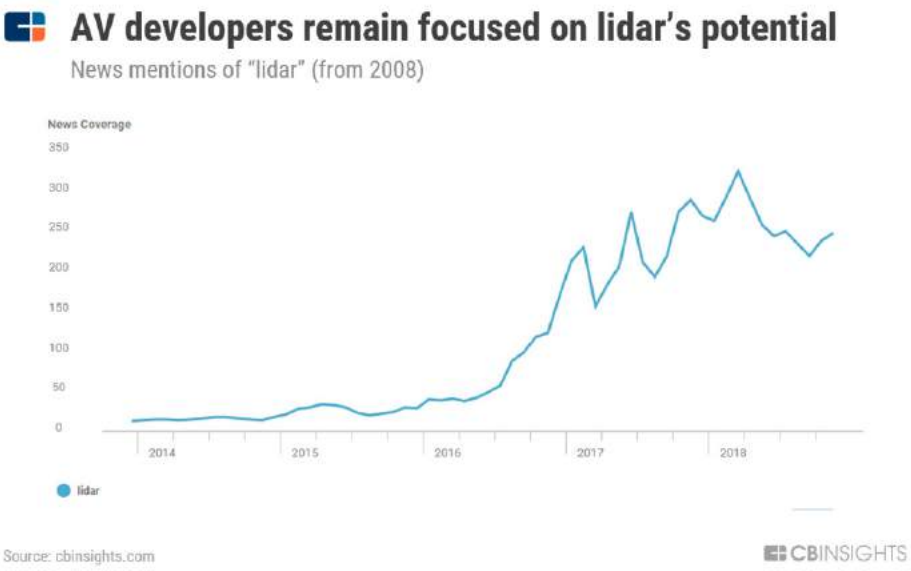
Once considered a costly impracticality, lidar technology is seeing a number of improvements that are driving down costs and increasing reliability.

One of the most advanced automotive sensors that's gained substantial traction over the past few years is light detection and ranging (lidar), which can render highly-accurate 3D visuals of a vehicle's surroundings.

Source: Velodyne

The technology sends pulses of laser light at a rapid rate to measure the distance of surrounding objects, and can generate a highly-accurate 3D rendering of the car's environment. This is more advanced than radar technology, which only detects distance and speed, and camera technology, which is used mainly for color and font detection.

However, lidar's practicality has been heavily debated, as evidenced by the surge in news mentions over the past few years.



The debate has largely been focused on cost, as some manufacturers charge over $100,000 for a unit. Traditional lidar units contain a number of spinning parts, designed to capture a 360 degree view of the vehicle's surroundings; but the parts are expensive to develop, and tend to be less reliable than stationary parts.

Adding fuel to the fire, Tesla CEO Elon Musk claimed that the technology isn't necessary for autonomous driving technology. Musk believes that with some modifications, radar, cameras, and ultrasonic sensors can be designed to closely mimic the capabilities of lidar.

Still, major pioneers of autonomous driving, namely Google's Waymo, are utilizing lidar sensors to power their self-driving systems.

A number of startups are working to improve the cost and performance of the lidar unit with solid-state lidar, which has no moving parts, thereby increasing reliability at a lower cost.

Major automakers and Tier-1 suppliers such as BMW and Aptiv have partnered with and invested in solid-state lidar startups. BMW announced a partnership with solid-state lidar startup Innoviz in April. The startup is also working with Tier-1 supplier Magna to deploy its lidar laser scanners for BMW's self-driving cars.

Source: Innoviz

A few auto incumbents are using lidar for advanced driver assistance systems.

On Aptiv's Q3'17 earnings call, CEO Kevin Clark stated, "Lidar is a critical technology required for both advanced active safety and automated driving solutions, and there's increased demand for solid-state lidar solutions as customers seek to accelerate functionality while reducing costs."

Still, lidar technology faces a number of limitations other than cost. Many lidar systems can be affected by inclement weather such as heavy rain and low-hanging clouds, which obstruct light pulses.

As a result, the consensus around autonomous vehicle sensor technology is to utilize lidar as a complement to cameras and radar. The vehicle can then combine the data from each type of sensor together through sensor fusion technology, or software that integrates the data from all sensors to create one coherent view of the car's surroundings.

FLEXIBLE ASSEMBLY LINES

As automakers push for vehicle electrification and full autonomy, the manufacturing process is expected to grow more complex, driving the need for flexibility on the production line.

Autonomy, electrification, and shared mobility will require drastic changes to a vehicle's design and component parts. Given the uncertainty around how quickly these technologies reach commercial scale, the most advanced automakers are aiming to have flexible production capacity — or in other words, have the capability to manufacture different types of vehicles (e.g. internal combustion, hybrid, and fully electric) on the same assembly line.

Automakers recognize the importance of a flexible assembly line, even in the final stages of assembly. In a BCG survey, 90% of automakers said that they expect a modular line setup will be relevant in final assembly by 2030. This would involve a multidirectional assembly line layout with smaller, more flexible lines, which would enable cost efficiencies even with higher levels of output.

Toyota has spearheaded the flexible assembly line, developing a system that allows it to produce different cars one after the other with no downtime. This flexibility is critical with the next wave of automotive manufacturing, as automakers will have to adapt quickly to new trends.

Source: Toyota

Magna has also adopted a flexible assembly line, allowing it to produce over 200,000 vehicles with various powertrains (i.e. conventional, hybrid, and electric) on the same production line.

Automakers are also using automated guided vehicles (AGVs) to make the assembly line more flexible. AGVs can replace conveyors, overhead cranes, and other forms of built-in conveyance to facilitate adjustments to production requirements. AGVs stand to transform the traditional assembly line, as they can autonomously drive parts to certain work cells as needed. They can also relay data to other vehicles.

Audi has invested in modular production startup Arculus to integrate modular assembly into its factories. Arculus offers software and AGVs for factory production, and is targeting car manufacturers. The company is also working with Audi, Porsche, and Siemens.

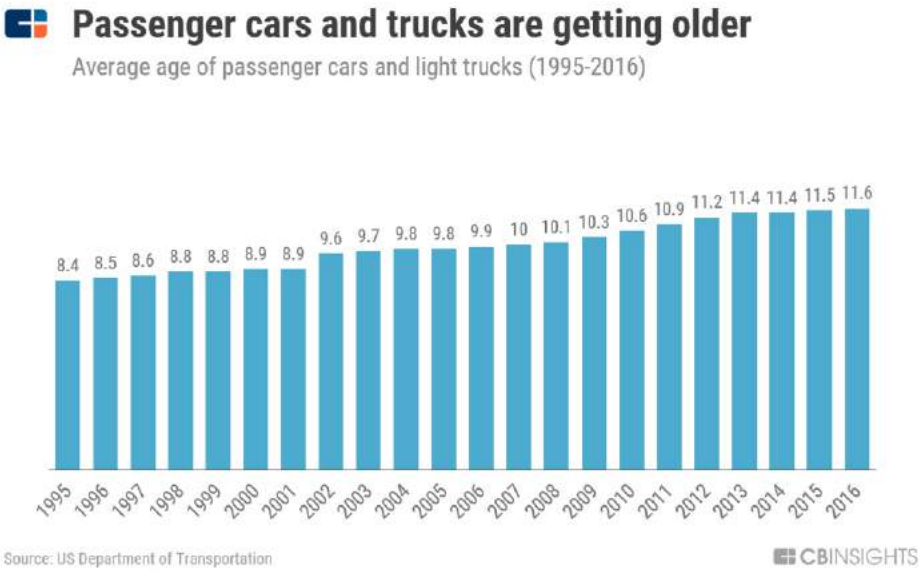
Source: Direct Industry

BMW has also outlined its plans for flexible production capabilities as it plans to produce ICEs, hybrids, and electric vehicles all on the same assembly line. Ultimately, the OEM could adapt production across the powertrain types depending on the market.

ONLINE AFTERMARKET

Facing disruption from e-commerce giants, aftermarket auto parts retailers are increasingly bringing their parts offerings online.

Cars are lasting longer thanks to improvements in vehicle design. The average age of passenger (light) vehicles in the US is gradually ticking upward, driving demand for more frequent upkeep and more replacement parts.



As with the rest of retail, online aftermarket auto parts offerings are gaining traction and taking share from brick-and-mortar parts retailers, with the shift mainly driven by Amazon's entry to the market in January 2017. The online market for auto parts is projected to exceed $10B within the next few years, and comprise roughly 10-15% of the overall aftermarket in the US and in Europe by 2030.

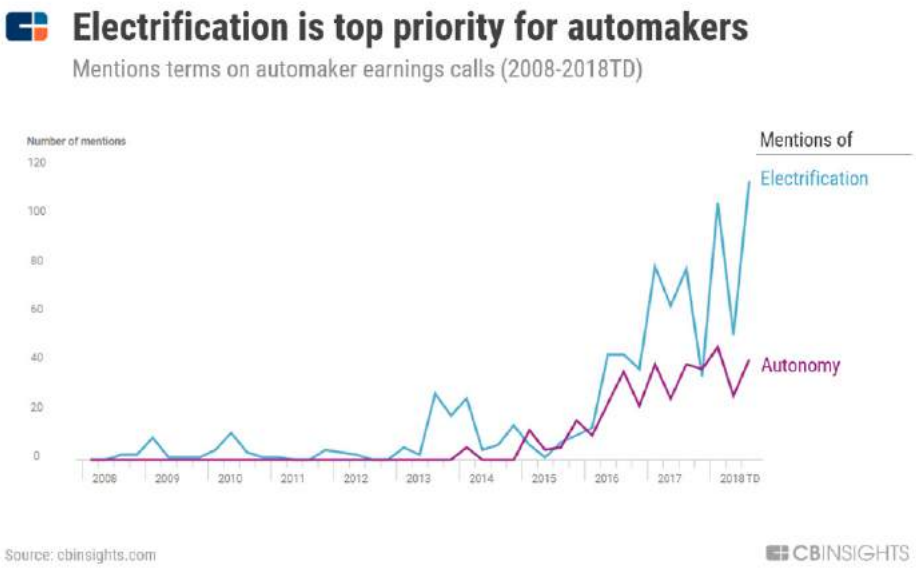
Walmart partnered with aftermarket auto parts retailer Advance Auto Parts in October 2018 to launch a specialty parts store on Walmart's website, allowing Advance to leverage Walmart's store footprint and logistics network.

FULLY AUTONOMOUS VEHICLES

Despite a substantial market opportunity for autonomous vehicles, the timeline for full autonomy is still unclear.

Fully autonomous vehicles are still years away from true commercial adoption. Only a select few AV developers such as Waymo and Drive.ai have launched commercial services, and even those services currently still use a human backup driver.

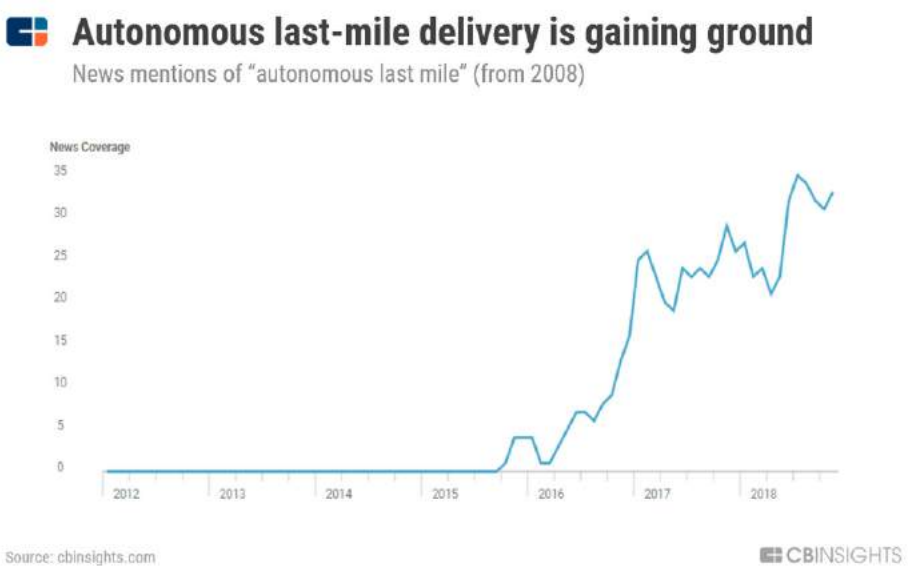
Electrification, rather than autonomy, has become top-of-mind for automakers in recent quarters, dominating the conversation on earnings calls.



But even with hesitation surrounding the future of the technology, automakers are still working towards full autonomy. The market is projected to reach roughly $80B by 2025.

Investors remain confident in companies developing the full autonomous driving stack, pouring hundreds of millions of dollars into GM's Cruise ($750M from Honda in October and $900M from SoftBank in May) and Zoox ($500M in July).

Some applications could see earlier adoption of fully self-driving vehicles, such as logistics and fulfillment.



Autonomous logistics — specifically autonomous last-mile delivery — is top-of-mind for retailers and fulfillment companies. Self-driving vehicles could help tackle the costly and arduous challenge of delivering goods at the last mile, which can add up to nearly a third of the an item's total delivery cost.

HD MAPPING

Though still in its early stages, highly-precise digital mapping technology will help autonomous vehicles localize themselves with centimeter-level accuracy.

Self-driving vehicles rely on high-definition (HD) maps, which are more precise than the digital maps used for smartphone navigation apps. HD maps require a complete centimeter-accurate visualization of the roads, including roadway information as specific as lane sizes, crosswalks, and barriers — all of which are critical for a self-driving vehicle to localize itself as it moves.

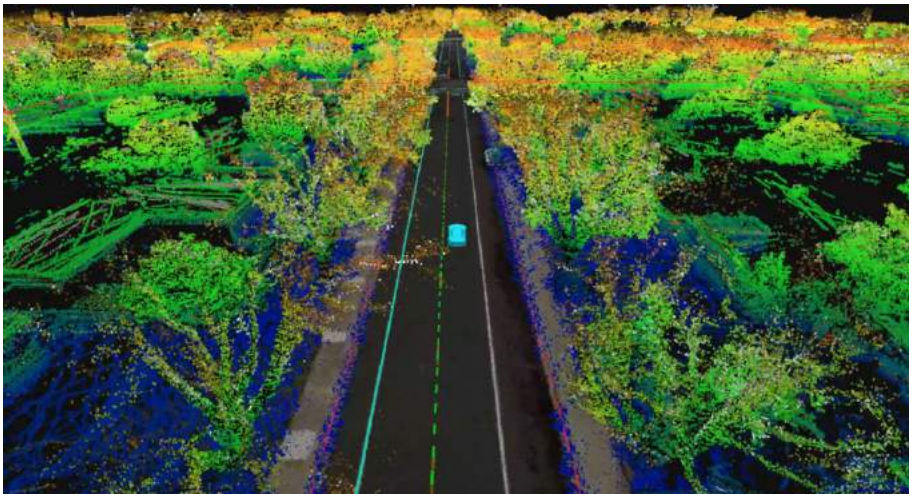
Source: NVIDIA

Building such complex maps can be quite costly. The process requires a fleet of sensor-equipped vehicles to capture roadway data, as well as advanced infrastructure and processing capabilities.

A number of automakers are investing directly into mapping technology. For example, Audi, BMW, Daimler, and Intel acquired mapping startup HERE Maps in December 2015, with Tier-1 supplier Bosch joining in 2018. TomTom also partnered with Chinese tech giant Baidu in July 2017 to integrate its maps of the US and Western Europe with Baidu's extensive maps of China.

Google is also making notable headway in the mapping space. Renault secured a deal with Google in September 2018 — despite being a TomTom client. The switch was reportedly driven by Google Maps' superior user experience. Google's self-driving arm Waymo is also building its own HD maps using data collected by its vehicles on the road.

DeepMap has developed map-building software that it plans to license out to automakers and AV-focused tech companies. Bosch invested in the startup in August, joining prior investors Andreessen Horowitz and Accel Partners.



Source: DeepMap

Chinese search engine giant Baidu is building out HD maps for its self-driving car software platform Apollo. The company sees an opportunity to monetize the maps by selling them to automakers, and either charging service fees or integrating the fees into the cost of the vehicle. Baidu believes that its HD maps business will eventually be larger than its search business, which is currently the largest in China.

Transitory

3D PRINTING

Additive manufacturing has simplified the automotive manufacturing process for years, but deploying the technology for parts construction or other more costly use cases will likely have limited applications.

Automakers such as Ford and BMW have been using 3D printing — also referred to as additive manufacturing — for decades. The technology has helped OEMs accelerate vehicle design and enhance quality through rapid prototyping, allowing them to bypass the timely and costly process of working through multiple iterations of a vehicle's design.

Accelerating product development has been the most common use case for 3D printing, and is expected to remain the number one priority for manufacturers for at least the next few years.

Top 3D printing priorities in 2017 vs. projected 2022
In 2017 Sculpteo survey, n>900

Connectivity, autonomy, and electrification are slated to upend traditional vehicle design — a challenge that 3D printing could help with, as it provides automakers with the opportunity to quickly and efficiently design, test, and validate new concepts.

3D printing is also allowing automotive companies to manufacture spare parts, jigs, and interior elements, all of which reduce the reliance on external vendors and can speed up the path to market.

Additive manufacturing also presents solutions for lightweighting, or using lighter materials in an effort to maximize fuel efficiency. Lightweighting has become a major concern for automakers as they prioritize fuel efficiency and range length with the shift to fully electric vehicles.

Some automakers are already leveraging 3D printing technology to print car parts, most often for luxury vehicles. BMW has been using 3D printing technology for over 25 years, and recently started utilizing the technology to develop metal 3D-printed parts for its 2018 BMW i8 Roadster. Ford recently announced that it will be 3D printing brake parts for its Mustang Shelby GT500.

BMW's 3D printed roof bracket for the i8 Roadster (Source: Additive Manufacturing Today)

NEXT GENERATION INFOTAINMENT

As automakers struggle to master the infotainment system, companies are turning to startups and tech giants to tackle the technology.

Advancements in in-vehicle connectivity have rendered the traditional infotainment system obsolete. OEMs are now designing more functional dashboards that provide more effective safety and navigation tools. With these updates, the underlying software and hardware in the vehicle are growing increasingly complex.

Visteon, a Tier-1 supplier of cockpit electronics, has doubled down on the infotainment center, aiming to create a centralized platform that features high-resolution displays and an open software platform.

Critical to the infotainment system moving forward will be the head-up display (HUD). A future HUD could utilize augmented reality to display driving directions for drivers, allowing them to keep their eyes on the road.

Porsche has invested in holographic AR dashboard startup WayRay, which has developed AR software that projects images into a driver's field of vision. WayRay is planning to bring its display technology to market next year.

Source: WayRay

The infotainment market is also facing potential disruption from Apple and Google. Many auto suppliers are choosing to partner on infotainment systems and leverage the expertise of these tech giants, rather than go up against them.

Both Apple and Google are offering their own in-vehicle software systems (CarPlay for Apple and Android Auto for Google) that can integrate their mobile interface into the infotainment system, adding familiarity and ease to the user experience.

Because cockpit electronics suppliers such as Visteon and Faurecia offer open source platforms, their systems are compatible with any software, including CarPlay and Android Auto. This leaves the compatibility decision to the automakers (i.e. whether or not to offer Apple or Google's services).

Voice is another feature that could eventually be integral to the car's future infotainment system. Some automakers are developing their own voice assistants, such as BMW, while others are relying on Amazon, Apple, and Google to deploy their voice assistants into the vehicle. A number of OEMs have also invested in voice assistant startups: Daimler and Hyundai invested in SoundHound; Volvo invested in Mobvoi; and Jaguar Land Rover invested in Mycroft AI and Cloudcar.

DIGITAL DEALERSHIPS

The car buyer's interaction with the dealership is changing as a growing share of consumers start the buying process online.

The internet has changed the way people shop for cars. Buyers can access extensive amounts of information about any car model from any maker with the click of a button.

Social media, blogs, and forums are also playing an important role in the car buyer's decision. This trend is driving fewer trips to the dealership. When buyers do visit, they're substantially more informed than they were in the past, and they are looking for technical experts rather than salespeople to help them navigate options.

As a result, a number of OEMs are upgrading their dealerships with AR/VR to provide prospective buyers with a realistic rendering of customized vehicles and an opportunity to view their vehicles in 360 degrees. This allows dealers to minimize the number of actual vehicles in their dealerships.

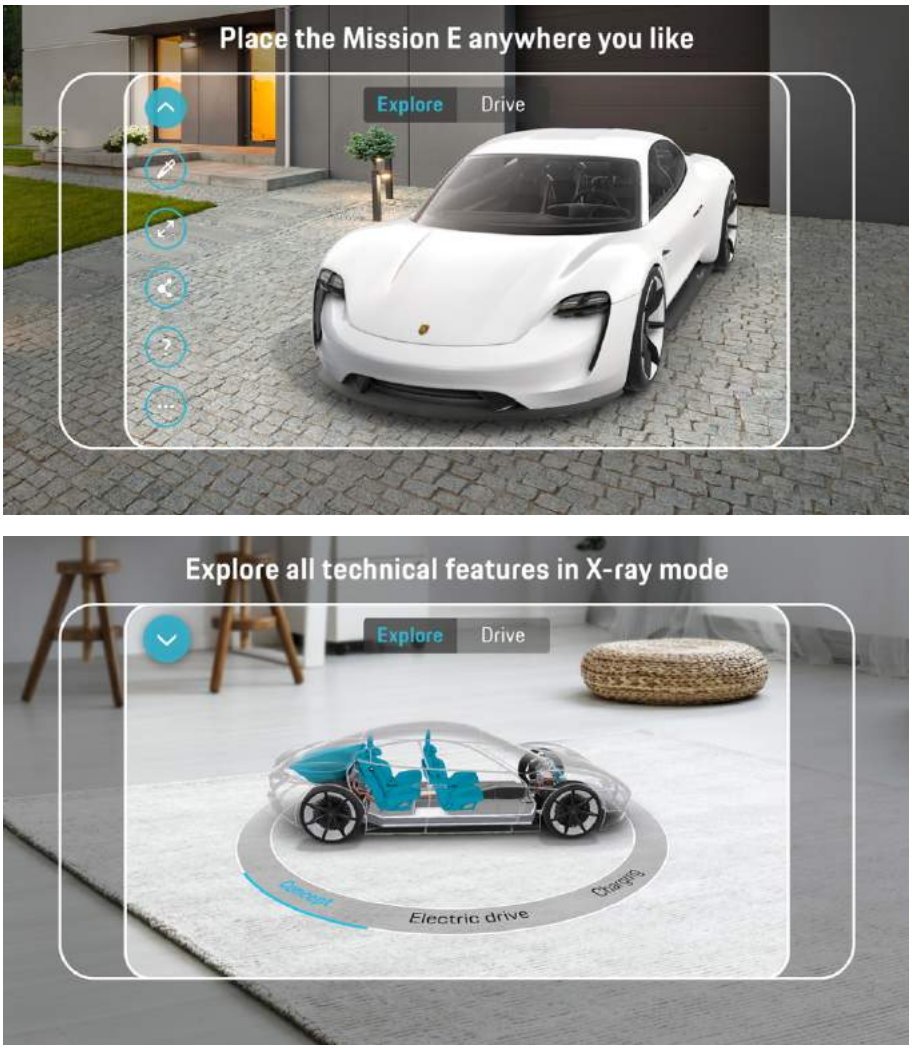
Audi and Cadillac are currently deploying virtual reality in the dealership, allowing car buyers to view customized vehicles in 360 degrees with light and sound effects, as well as visualizations during different conditions, like time of day.

Cadillac's VR technology allows buyers to pick any Cadillac vehicle, customize it, and experience a detailed walk-through in and around the vehicle at various distances.

Source: VR Scout

AR/VR technology also enables auto OEMs to bring immersive reality experiences to the consumer's living room, especially with the rise of auto e-commerce.

Porsche's "Mission E Augmented Reality" app allows customers to view the company's first electric sports car, the Porsche Mission E, and see complex technical aspects of the new vehicle technology.



Source: Porsche

OEMs will also need to redesign their marketing strategies to handle the shift to digital. Designing a mobile-oriented marketing approach is critical, as mobile site traffic is increasingly taking share from desktop searches. The proportion of time spent shopping for cars on mobile devices continues to increase, reaching 33% in 2016, according to a social media usage study by J.D. Power.

WHERE IS ALL THIS DATA FROM?

The CB Insights platform has the underlying data included in this report

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