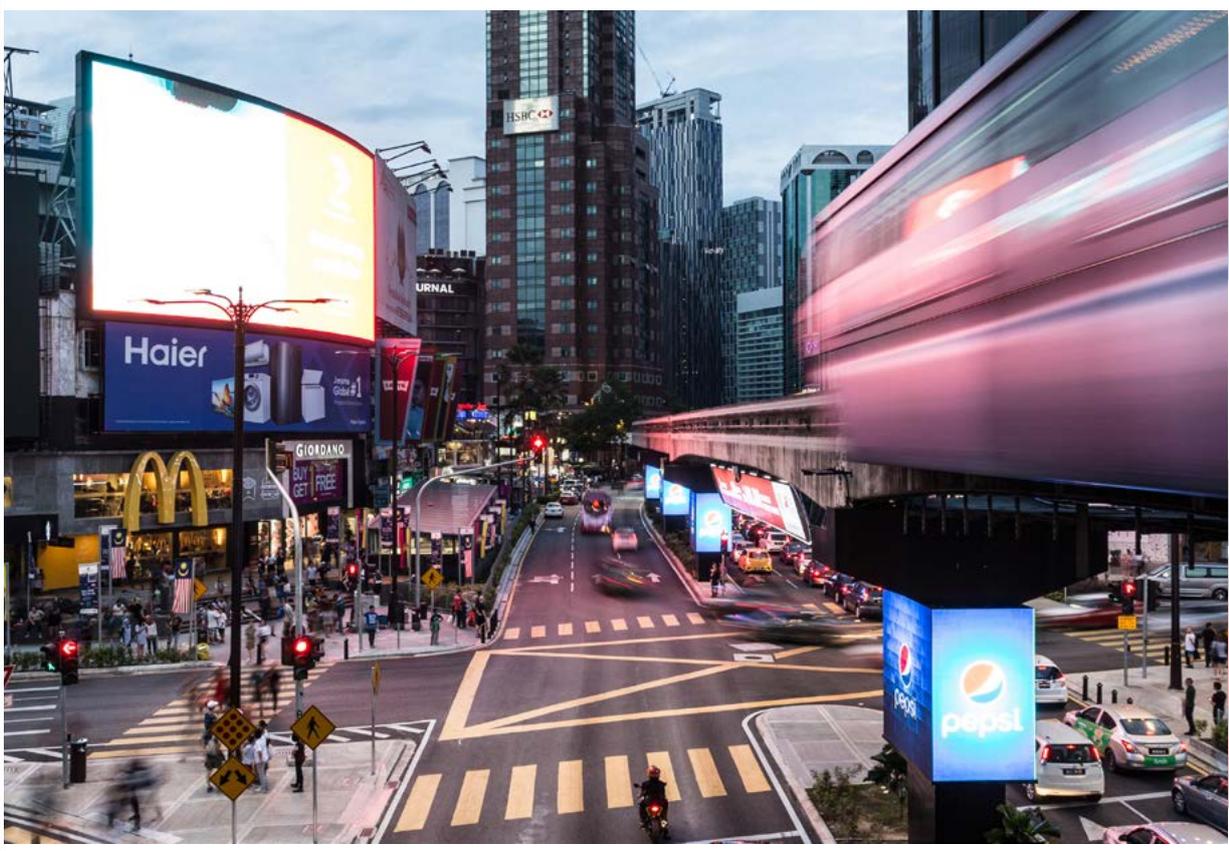


# DVN-I

## Auto Interiors in the World of New Mobility



## INTRODUCTION

The CASE (Connected, Autonomous, Shared, and Electric) mobility megatrends are progressively transforming the automotive industry. These megatrends are driving a passel of new technologies and creating new car use cases in resonance with what is happening in the increasingly digital and electronic greater environment surrounding us at home, at work, and everywhere else. Consumer behaviors, choices, and value are also shifting from ownership-based to service-by-subscription models.

Far from being exempt, automotive interiors are in fact being progressively redefined with a focus on user experience in the new reality. Optimized UX (user experience) is becoming the target, the lens through which the whole transportation sequence is viewed, and the standard by which it is adjudged.

Of course, this doesn't mean privately-owned cars are going to disappear any time soon. They'll be with us for the foreseeable future, but new HMI (human-machine interface) or UI (user interface) technology will create a new level of collaboration between driver and machine for greater safety, more comfort, and a better overall experience.

The driver—supervised, supported, and monitored by driver assistance systems—will become less of an operator and more of a passenger. This “passenging” experience is where interior, ADAS (advanced driver assistance systems) and AD (autonomous driving) technology are increasingly crucial, making car interiors a central new product differentiator and allowing occupants to do a whole new set of activities: relaxing, working, phoning, reading, watching movies...the car becomes a mobile lounge.

The in-car environment, then, must mirror the one at home and at the office: a people-centric place of comfort and connectivity, designed and configured to minimize annoyance, deprivation, boredom, and constraint.

HMI has become the true keystone of the interior, making the link between the vehicle's technology and its occupants—all of them, for control functions are no longer limited to just the driver. There's also a great deal of design and style involved in today's and tomorrow's HMI/UI configurations to create the best UX, and to fit with the maker's brand and model identity with sleek and elegant aesthetics.

One concept rapidly rising in prominence is the digital cockpit, which replaces traditional controls and displays with digital screens. A wide range of multiple-screen configurations is possible with elements including digital instrument clusters, head-up displays, infotainment system control screens, passenger screens, digital assistants, and more.

After two years of DVN Interior news and views, we reckon it's about time we zoom out and take a broad look at the status of automotive interior evolution, and this report is exactly that.

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## About the author

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Philippe Aumont is a highly experienced executive with almost 40 years in the automotive interior supplier industry. He's an engineering and business graduate, and has completed many general management programs. He acted as Chief Technology Officer at Faurecia Seating between 2011 and 2017. Previously he worked at Roth Frères, Johnson Controls, and Faurecia in various positions including R&D, marketing, strategy, new product development, open innovation, startups, university; his earlier experience was in JIT, production, program management, costing, and sales. He's had work assignments in France, Belgium, The Netherlands, and Germany, with frequent travels to the USA, Japan, China, and India.

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## Urbanization

More than half of the world's population now lives in urban areas, increasingly in highly-dense cities. Urban settings are a relatively new phenomenon in human history, and they've transformed the way we live, work, travel, and build networks.

As the population continues to grow and more people move to cities, our cities will get larger, and we'll have more of them. By 2030 there'll be 41 "megacities", each containing over 10 million people—more than the current population of Sweden. Meanwhile, the area of urbanized land could triple globally from 2000 to 2030, equivalent to adding an area bigger than Manhattan every single day.

These megacities will require a new level of infrastructure design and architectural planning, making it easier for residents to work and live in a dense urban setting. Smart cities will emerge, powered by robust technology infrastructure: sensors, data platforms, analytics, cloud, etc. Roads, public transit, and parkades will start to serve multiple purposes: generating energy, charging electric vehicles, and acting as traffic and emergency operators, in addition to their original function. Space will be at a premium, forcing us to rethink how we design products to fit in smaller, shared work and living space.



Shanghai highway

## City Limitation

Major cities around the world are already starting to ban high-polluting and/or single-occupant cars, so the idea of a car-free city is getting closer, but it's not without challenges. Though bikes and public transit are widely available in most cities, cars remain a preferred method of transport for many urban commuters. Even before the pandemic, which sharply increased the preference for private cars, studies have shown it's difficult to change a driver's commuting habits, even with free public transit.

More private cars put out more pollution; personal transport contributes to around 20% of the world's CO<sub>2</sub> emissions, which is why the phaseout of fossil-fuelled vehicles is one of the two most important parts of the general fossil fuel phaseout process. More than 14 countries and over 20 cities around the world have proposed or adopted ban dates after which sale of new fossil-fuelled passenger vehicles will be prohibited. Here are some of the places working to improve health and safety by banning polluting cars:

Here are some of the major cities that are determined to improve health and safety by banning private cars :



### **Madrid**

Madrid has designated its city center a low-emission zone, restricting access by older diesel and gasoline cars and planning to ban them from the zone completely; hybrid and electric cars may circulate freely in the zone.



### **Denmark**

Copenhagen already has one of Europe's lowest rates of owned-car commuting. The whole of Denmark is planning to ban the sale of new gasoline and diesel cars starting in 2030, and the sale of hybrid cars starting in 2035.



### **Paris**

Paris is set to ban all petroleum-powered cars by 2030 as part of a long-term strategy to reduce greenhouse gases.



### **Athens**

Athens will ban diesel cars by 2025, and already restricts the days of the week any given diesel car may enter the city center.



### **Brussel**

Brussels is working to ban all diesel vehicles by 2030.

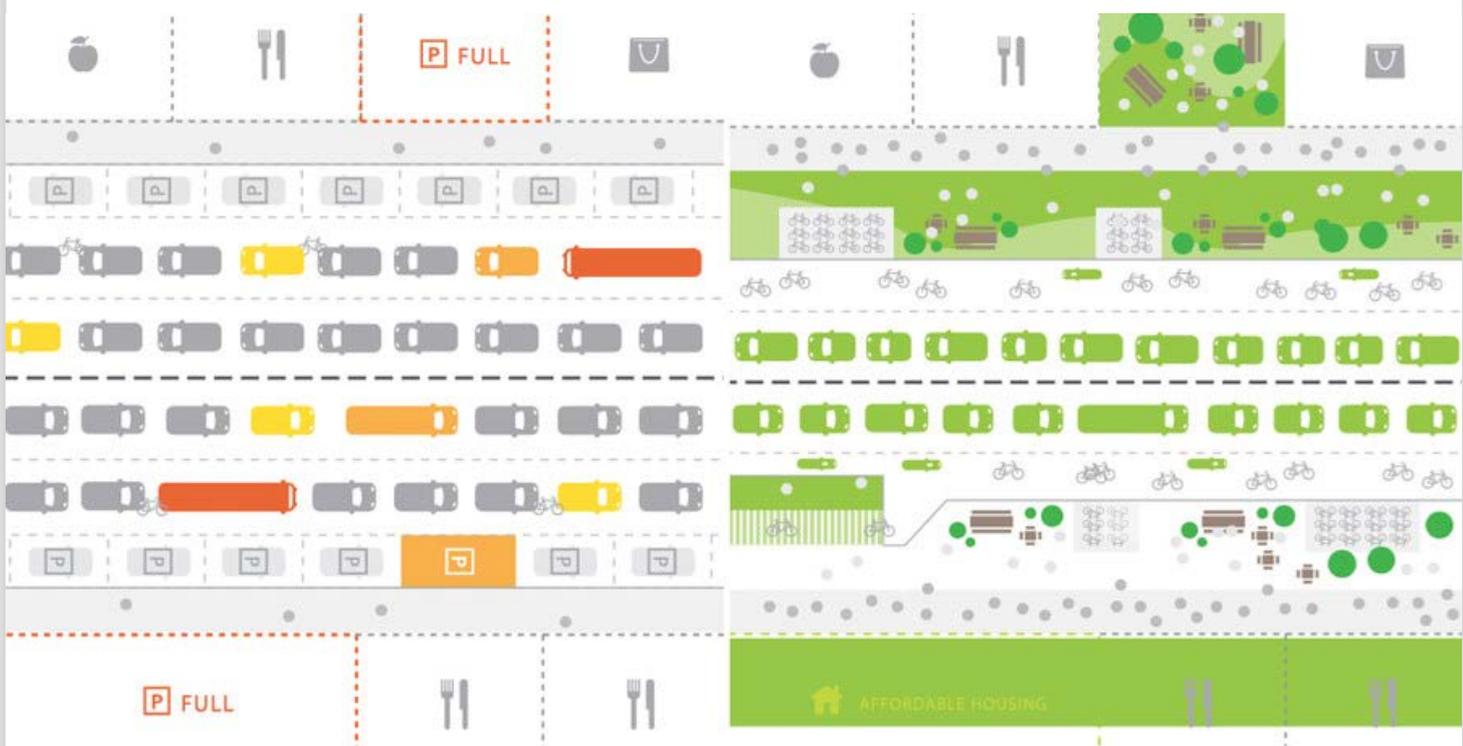
## Car Ownership in the City: Low Usage

Many city dwellers who own a car don't use it on a daily basis. With the hassle and stress of traffic congestion and difficult, costly parking, it's much easier to take public transport, a taxi, or a hailed ride. Cities are creating more space for people while reducing the space originally given to cars. The parking problem is not just about the general lack of parking spaces but the lack of real-time data about vacant ones. In peak hours, drivers in large cities can easily waste half an hour trying to find a place to park. In 2021 we don't yet have cars that drive you where you want and then go park themselves, but wireless smart parking solutions have already arrived to help find a parking spot quickly and efficiently.

This is achieved through special smart parking sensors on the IoT (internet of things). They keep a central processor apprised of every parking space's status, so the system can provide real-time to drivers seeking a spot. Autonomous cars will bring big transformations to urban mobility over the next 25 years. The effects on parking will be complex.

## Car symbiosis with the environment

Earlier this year, a governmental Department of Transportation held a contest asking dozens of local governments to submit visions for a city of the future with the likes of self-driving cars to tackle congestion and climate change. San Francisco's submission is interesting: a great exploration of how cities might use new tech and business models to take back scarce land from cars to build more park and green area. If (when) self-driving cars and buses eventually become a reality, they too can be connected into a centralized network to make sharing even easier. In theory, these vehicles could also reduce fatal collisions (assuming that self-driving technology proves safer) and eliminate air pollution, assuming the cars are electric and the local electricity is cleanly generated.



San Francisco proposed city layout

## Ride-Hailing

Ride-hailing services are near the front of a technological and transportation revolution, connecting the rider and the driver by a smartphone app, allowing riders to easily hail a ride, track where their driver is in real-time, and be given pricing before confirming the trip.

The trend has emerged in a futuristic landscape of shared mobility, catering to the need for quick, convenient, and cost-effective transport.

### History of ride hailing

The history of ride-hailing isn't very long, but it's essentially an iteration of the taxi model that dates all the way back to the first known horse-drawn taxi carriage in 1605. Ride-hailing per se was launched in 2009 by Garrett Camp when Uber first started, known at that time as UberCab. After their beta launch in May 2010, Uber's services along with their mobile app were officially launched the following year in San Francisco. In the early days, however, Uber was built around the premise of upscale private-driver service, with only black luxury cars and prices 1.5x that of a standard taxicab. After complaints were made by San Francisco-based taxi operators, UberCab became what it is today and was renamed to simply Uber.

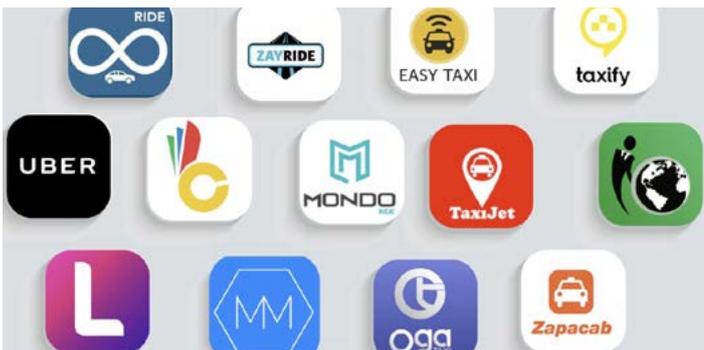


London taxi



New York Taxi

In spring 2012, Uber launched a service in Chicago allowing riders to request a regular taxi or an Uber driver. By that summer UberX was introduced, allowing people to drive for Uber using their own vehicles, as long as it met certain standards. After beta testing in the SF bay area, in summer 2014 came UberPOOL, an option to carpool with the Uber app. That same year, Uber begins looking at opportunities to implement ride-hailing in other ways, with plans to enter the parcel and food delivery industries. They launched UberFresh (now UberEats) to deliver restaurant food to consumers in Beverly Hills.



Main players



Uber

Having already shaken up the mobility world by offering cheaper and more convenient alternatives to renting and owning vehicles, ride-hailing has a promising future. However, it does still have certain challenges to overcome in order to dominate.

In the future, blockchain technology may be integrated for better driver screening. Another future expectation, of course, is autonomous ride-hailing, which takes the driver out of the equation altogether, perhaps advancing the safety of ride-hailing and allowing for even lower costs per ride. AVs (autonomous vehicles) would also be available 24 hours a day, allowing for more convenience and availability.

After Lyft, a Uber competitor launch in 2012 has a partnership with General Motors to launch an on-demand network of AVs, which are currently in beta testing along with similar Uber vehicles in US cities.

Tesla CEO Elon Musk believes the AV transition will occur through a network of autonomous car owners renting their vehicles to others, which may create a new form of ride-hailing. And with the shift of both ridehailing and car ownership moving towards autonomous vehicles, we can expect the very nature of our cities, whose infrastructure has long catered to private car ownership, to change dramatically.



Self-service car



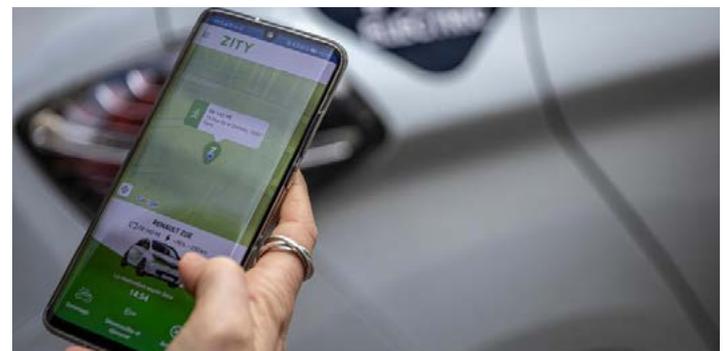
Future autonomous interior - Volvo 360Concept

## Business Players

Traditional car manufacturers and suppliers are evolving and opening their service portfolio to a wider range of product for the Urban area. On-demand mobility concepts, such as ride-hailing, have the comparative scale and the potential to plug gaps in modern consumers' journeys, so every automaker is trying to offer a serious alternative to private car ownership.

### Zity by Renault

Since March 2020, a fleet of 500 electric Renault ZOE cars is made available to Parisians on a self-service basis using a free mobile app. This is a flexible scheme that responds to a strong trend: 20% of the French capital's inhabitants use car-sharing.



### Free to move by PSA

Free2Move is providing access to a fleet of 550 electric Peugeot i0n and Citroën C-Zéro vehicles in Paris. The free-floating car-sharing service offers free parking, a giant attraction in that city. User can park in authorized public places as well as in dedicated electric vehicles spaces.



## Tesla

Tesla plans to launch its own ride-sharing app, with drivers covered under the automaker's own driver insurance. Once fully autonomous vehicles are a reality, Musk says, robotaxis on the Tesla network could cost as little as \$0.18 per mile to run.



## Mercedes-Benz and Bosch

Bosch and Mercedes-Benz's pilot project for an app-based ride-hailing service using automated S-Class vehicles has been launched in the Silicon Valley city of San Jose.



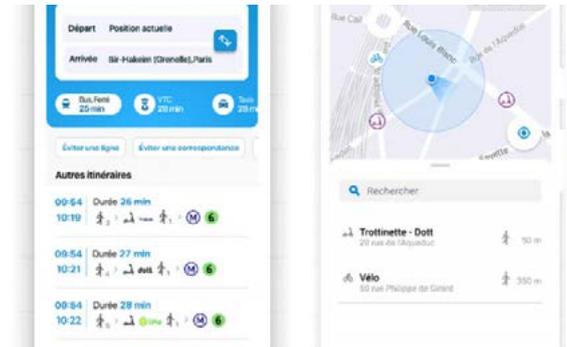
## Avis

Major-name car rental company Avis has a strategic partnership with Lyft. During the second quarter of 2019 the company expanded its coverage through Lyft to four new cities, bringing the total up to nine cities. There are currently 3,000 vehicles in Avis' Lyft fleet, fully integrated with the Lyft app.



## SNCF

France's national state-owned railway company offers a wide range of transport options—regional train, metro, bus, car with driver, bike, and more. The app handles everything from booking to boarding to arrival at the destination, and covers public and shared transport options in 500 cities across France—that's 70% of the French population.



## History of Mobility within the City

We have a rich history of mobility, documented and immortalised by technologies whose sole purpose is to take us where we are going. We have come a long way, from horse-drawn carriages and rickshaws to app-controlled ride-hailing and bullet trains; getting from point A to point B has become easier and faster.

1826

### The Omnibus

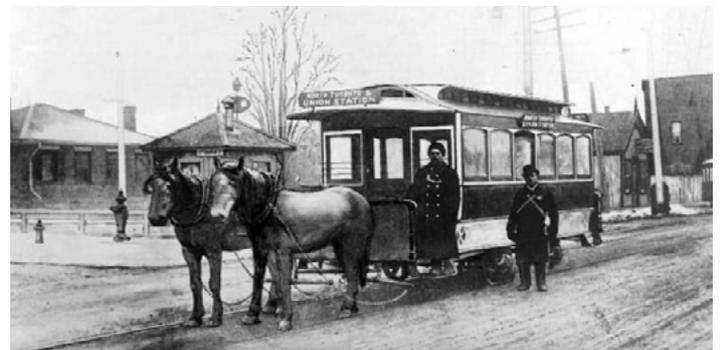
Omnibuses were horse-drawn cars designed to hold eight to 10 people. It was a good system, but a terribly uncomfortable ride for passengers, as most streets were still paved with stones at the time. The horses and cobblestones have gone, as have the first four letters of the word, but the last three are still around: bus!



1832

### The Horsecar

Railroad technology of the time expanded onto city streets and brought us the first rail transit system. Smooth rails laid into city streets made for a much more comfortable ride than the bumpy cobblestones.



1863

### The Underground

The London Underground, which opened in 1863, was the world's first underground railway system. More than 30,000 passengers tried it out on the opening day, and it was hailed by the Times as a great engineering triumph. The London Underground (the «tube») now carries 1.17 billion passengers a year.



1873

### The Cablecar

The cable car offered a relatively easy alternative to horse-drawn cars. Existing cars were drawn along city roads by a cable inside the track system. Cable cars were great for cities with steep hills such as San Francisco, but at least in the early years they were quite unsafe due to the consequences of a snapped cable.



1881  
The Streetcar

Drawing power from overhead wires, streetcars used existing rails but didn't require a tow cable to move along. It was easier and safer for citizens to commute to the city for work.



1897  
The Modern Taxicab

Battery electric taxicabs became available at the end of the 19th century. In London, Walter Bersey designed a fleet of such cabs and introduced them to the streets of London on 19 August 1897.



1905  
The Bicycle

During the first half of the century, the bicycle became more and more popular, especially due to the improvement made in the surfaced roads.



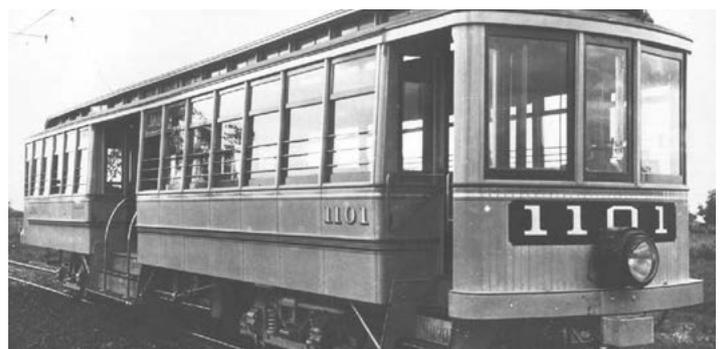
1908  
Private Automobile

One of the first cars accessible to the masses was the Ford Model T, which changed the way of travelling for a substantial portion of the population.



1920  
The Tramway

In the 1920s the tram was already established as the main form of public transport in most major towns and cities. Trams proved popular and reliable, and they integrated well into the street environment.



1960

### The Motor Age

The automobile became more and more used for daily transportation. High-speed, controlled-access motorways, such as the U.S. Interstate Highway System, fuelled their utility by giving rise to suburbs; living in the suburbs practically required ownership of at least one car per family.



1980

### High-speed rail

The 1973 oil crisis substantially and suddenly increased oil prices. In France, the TGV (Train à Grand Vitesse, i.e., High-Speed Train) under development was switched from gas-turbine to full electric power in 1974. An electric railcar named Zébulon was developed for testing at very high speeds, reaching a speed of 306 km/h (190 mph) with a very high standard of interior fixtures.



1988

### AirBag in cars

Chrysler became the first American automaker to fit a driver-side airbag as standard equipment in six different models.



1991

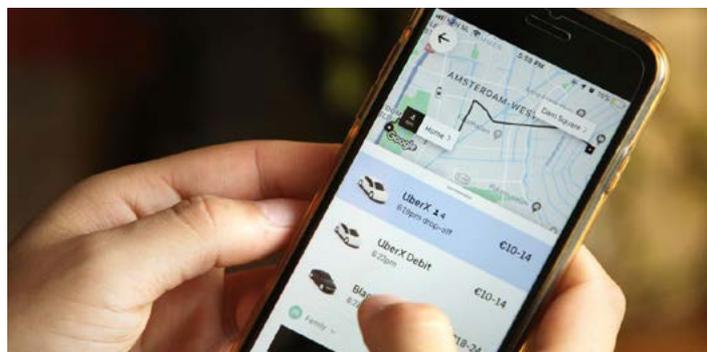
### GPS Navigation

When the United States turned off scrambling and allowed non-military use of the Global Positioning System satellites, Toyota introduced GPS car navigation on the Toyota Soarer.



2009  
Ride-Hailing

Since launch, Uber, Lyft, and others have spread around the globe. More flexibility and convenience for riders, though driver pay and working conditions are increasingly criticized.



2017  
Autonomous Buses

Companies like EasyMile bring driverless transport for people and goods



2030  
Hyperloop

Hyperloop is another one of Elon Musk's dreams, and its feasibility has been sharply questioned. But perhaps it will work after all. Musk describes it as a sealed tube with low air pressure, through which a pod may travel substantially free of air resistance or friction, and claims the pods would be able to reach 1200 km/h (745 mph).



2040+  
Drones

At least 50 cities worldwide are incorporating urban mobility drones into their long-term plans. Passenger drones will be trialled in Dallas, Texas. But before air mobility can resolve gridlock, urban airflow needs to be better understood.



## Point A to point B

The customer journey is the process by which a customer interacts with a company in order to achieve a goal, illustrated here with Mobility Service



## Comfort

The future portfolio of AVs will mainly be focused on the interior with the comfort and versatility mostly focused on the back seats. Luxury car manufacturers around the world are increasingly shifting their focus to pampering rear-seat travelers by dint of technology and design innovations.

A couple of years ago, Mercedes introduced their Luxury in Motion autonomous concept car, which besides the basic mobility function is envisioned as a private retreat or a mobile living space for the car's occupants. It's got luxuries like wooden floors, front seats that swivel to face the rear, a retractable steering wheel, and OLED screens instead of windows.

The car's components are IoT-enabled to make it a seamless and smooth experience. Although it's autonomous, you can still drive if you want by swiveling a seat into the driving position.



The interior of the MINI Vision Urbanaut, for its part, provides an ideal journeying environment. Having arrived at the chosen destination, it can transform into a living room in just a few simple steps. Occupants enter the innovative cabin through a large sliding side door—the ideal design for urban driving conditions where space is at a premium. There are no other doors on the driver’s side or front passenger side.



With their new 360c autonomous concept, Volvo tackles one of the main challenges around the introduction of autonomous technology and calls for a new, global standard in how AVs can safely communicate with all other road users. They present four potential uses of AVs: a sleeping environment, mobile office, living room, and entertainment space, all reimagining the ways people travel.



BMW's i3 'Urban suite' concept could be a glimpse of the future of ride-hailing. A standard i3 was refitted—only the driver's seat and dashboard were left as-is. The interior now has the relaxed feel of a boutique hotel; the aim was to create an inviting, relaxing space—a nice place to spend time, perfect for enjoying in-car entertainment or focusing on work in a laid-back setting.



### Seamless continuity with Home and Office

Thanks to the new interior trends and architecture, we are now able to have a smooth transition between our homes and offices, as more and more architect and interior designers are thinking the outside world as an extension of our homes. This continuous moment is made possible thanks to common technologies and standardization of uses.

Home



Transportation



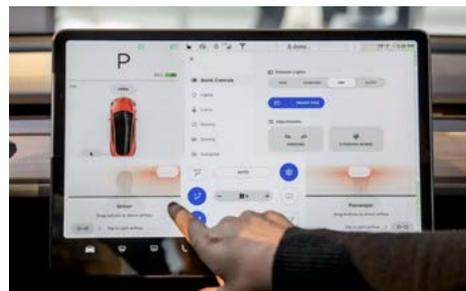
Office



Home



Transportation



Office



VW Group Design Director Peter Wouda says his vision is that the interior will be configured exactly the way you want it to be on an ongoing, dynamic basis.

The steering wheel will disappear when it's not needed, and eventually it won't exist, nor will pedals. The vehicle interior will become an experience for all the senses, including smell. Virtual and augmented reality will create ever-changing new worlds inside the vehicle.



**The main objectives of transport as envisioned for today and tomorrow are:**

- Safe, clean, affordable, freedom of mobility
- As cars grow smarter and more autonomous, drivers will gain more and more free time for self-care and discretionary activities.
- Offer fragmentation: vehicles are becoming safer, greener, and more connected. A rapidly-increasing variety of comfort, ADAS, energy-saving, and other features are helping passengers and drivers to feel safer and more comfortable on the road. Combining and permuting all these new options, together with price, size, and body segmentation will wind up with a much more fragmented offer in all automakers' catalogs. Car interiors are reflecting this fragmentation, and even extending it to strengthen the overall product attractivity.



BMW European Line Up

## «Passenging»

If a driver drives, then a passenger passenges!

The neologism implies working, relaxing, sightseeing, meeting—all the things it's hard to do if you have to keep eyes and attention on the road as a driver.

The CASE megatrends are progressively transforming the driving experience into a passenging experience, and that's where interior and driving assistance technology are of increasing importance. That's where car interiors are becoming a new product differentiator.

Car makers are aggressively rebranding themselves as mobility providers. That's a bit at odds with the motoring media, focused more than ever on a thrill-of-driving approach, celebrating the fastest and most expensive sports cars. The car manufacturers and their whole value chain of suppliers are making a paradigm shift to the user experience, while media are still hyperfocused on the extreme driving element of this experience.

There's a realistic balance somewhere in between, where passengers are willing to get a driving experience which has to be far above what you get in any public transport system.



— The New State of the Interior Art —  
**Mercedes S-Class**  
Case Study



### Mercedes S Class as the “full monty”

The new S-Class is a modern statement of the high-tech integration in the automotive industry.



Mercedes S Class Rear Airbag

The new S-Class is a modern statement of the high-tech integration in the automotive industry. It has the world's first rear-seat airbags. Based on the photos, it appears the airbag will be built into the front seatback and will inflate into a U-shape to cradle a passenger's head as they move forward during a crash—similar to Autoliv's Life Cell. Daimler says these rear-seat airbags will work with inflatable seatbelts and will be able to adapt to child seats as well.



The new S-Class also introduces a new integrated active and passive safety solution, the upgraded Pre-Safe Impulse Side function. This feature inflates the seat air cushions to move front passengers towards the center of the vehicle in the event of a side impact. Simultaneously, the active suspension raises the vehicle to divert the force of impact through the lower, stiffer structure of the car.

## Mercedes S-Class Interior Functions and Lighting

The S-Class has an interior wherein shapes are emphasized horizontally, accentuated with modern technology and screens that do not rely on total reduction, but on a proud representation of what is technically possible.



The instrument panel presents its messages in 3D graphics if desired, and the head-up display projects information directly onto the road and thus in the driver's field of vision. The augmented-reality head-up display merges the assistance systems and navigation content practically with the area in front of the vehicle.

Blue arrows running along support you when changing lanes at intersections and before turning. The huge touchscreen in the center console controls the complex operations, in combination with the steering wheel buttons. There are up to five screens, OLED displays and the three-dimensional screen, which varies the display depending on the position of the driver's eyes. This 3-D effect is just as stunning as the huge head-up display—one of two available. It is dimensioned so expansively that it offers a real augmented-reality experience.

Mercedes has deleted 27 individual elements and thus clearly simplified the cockpit. But it feels like a thousand new functions are included! Some of them can be assigned to MBUX voice control. The S-Class pays tolls and parking fees online using a fingerprint scanner. The driver and the vehicle environment are constantly monitored. It reacts on a specific-seat basis to voice commands («Massage, please»), and it can import various instrument graphics from sporty digital to classic analogue. The seat belt buckles can be illuminated if desired, slim airbags are embedded in the belts themselves, and the rear passengers are additionally protected by the frontal-crash airbags already described, as well as the side airbags.

The rear blind lowers automatically when the driver turns his head. The emergency braking function prevents parking bumps in reverse. Burmester, a Berlin-based high-end audio company founded 45 years ago by an Austrian-born musician and engineer, supplies the hi-fi system with 30 speakers to create what Mercedes calls "4D sound": the sound waves are amplified by vibration using eight "exciters" in the seats.



The S-Class' ambient lighting has 250 LEDs. The contour lighting in the instrument and door panels form a continuous line as brand identifier. The contour lighting below the overhead and center consoles and below decor trims and armrests create floating effects of the components, and amplify the styling of the interior. The illuminated speaker grilles underline their claim for high quality. The dynamic ambient lighting in the door panels flickers to warn of approaching traffic as soon as the passenger makes as though to exit the vehicle.



The car can memorize five different driver profiles and can drive autonomously at L3, with L4 autonomy said to be very close to practicability.

## Design Perspective

The S-Class interior design focuses on a new direction that highlights the UX/HMI anchored on Mercedes' MBUX, using 5 displays and an extended HUD. There's exuberant use of materials such as glass (displays), wood (instrument panel) and floating elements (with lighting) that showcase superb craftsmanship while raising the typical Mercedes comfort experience to new levels.

Then Mercedes-Benz's Head of Design explains it in [this video](#).



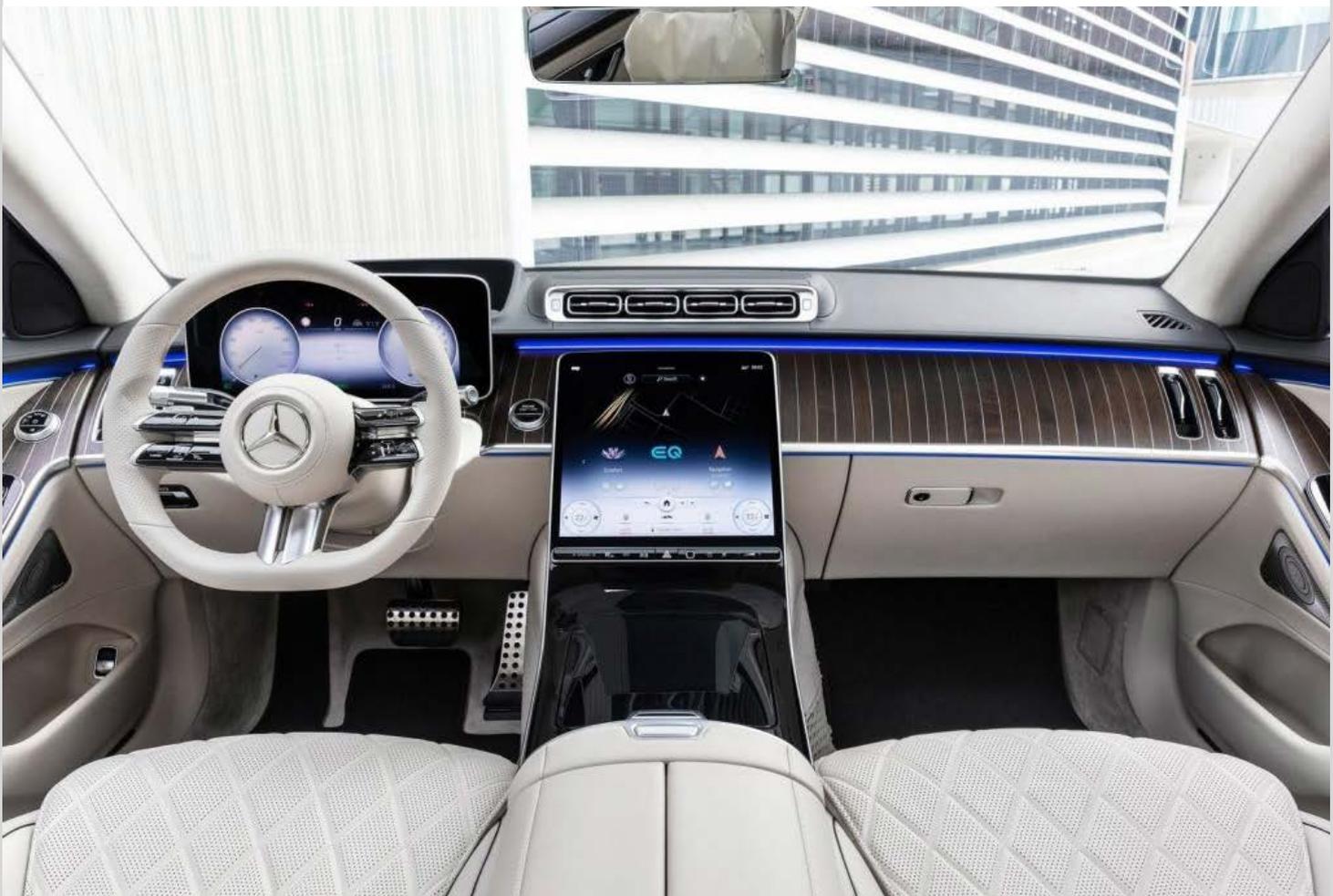
2021 Mercedes S-Class exterior has the traditional rear wheel drive proportion but is very restrained aesthetically



Contrasting the exterior design direction is new interior design direction for the S-Class and Mercedes.



A full width wraparound gloss wood panel that brings to mind old wooden powerboats has now become Mercedes' main design element, displacing wood trim inserts used previously.



By using wooden elements with aluminum inlays and the large high resolution glass displays, a strong hard-touch aesthetic replaces the previous soft-touch direction used previously by Mercedes and other luxury brands.



Ambient lighting is also incorporated to highlight these floating hard elements such as the displays, and set them off from the softer leather-covered surfaces.



Even the door pulls and seat controls are offset from their base surface and highlighted with lighting. This aligns with Mercedes' new emphasis on the user experience.



As for the rear occupants, notice the wood inlays and floating displays on the back of the front seats that creates miniature cockpits. Two variations are presented. The individual 'business class' seating, which creates a plush cocoon for the rear occupants that also integrates heated, pillowy head restraints...

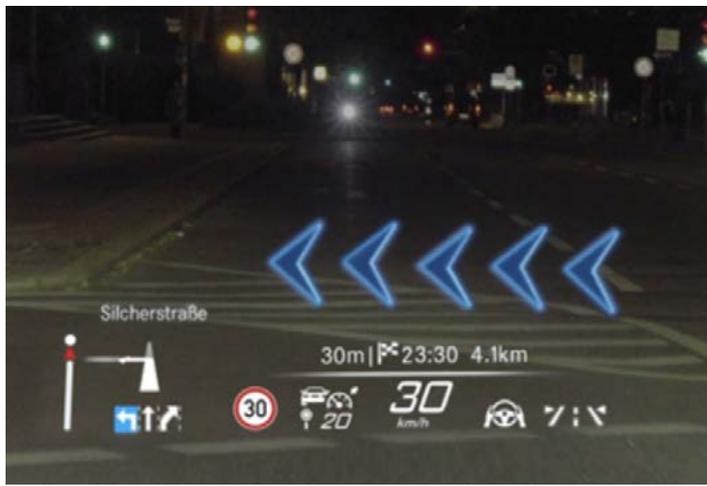




and a three-across bench version, offering a more open, spacious environment while also retaining these new mini-cockpits for the rear occupants.



Mercedes has highlighted the driving and vehicle experience by not only using the highest quality materials but also by integrating them with UX/HMI interaction that goes beyond the latest touchscreens and tablets, incorporating ultra-high-resolution displays for both front and rear passengers with an augmented-reality HUD.



### ENERGIZING Comfort programs

- Joy**  
Generating good feelings and reducing stress.
- Well-being**  
Relaxation with spa-like amenities.
- Vitality**  
Staying fit during long drives.
- Refresh**  
Refreshing on a hot day or preventing fatigue.
- Warmth**  
Providing a feeling of warmth and comfort, especially on cold days.

All programs are supported by corresponding sound, ambient light, massage and further interior comfort features.

Mercedes-Benz



Comfort driving modes are visualized with a new 3D effect cluster display, and My MBUX upgrades can be bought.

# My MBUX: the new Mercedes-Benz User Experience

Four different methods of authentication



 Voice recognition

 Face recognition

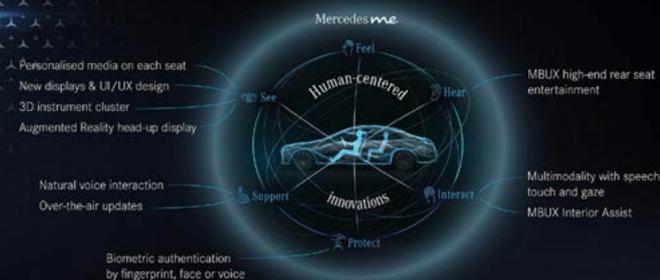
 Fingerprint

 PIN

Mercedes-Benz  
The best or nothing.



A first glimpse into a new dimension of personalisation and interaction



Processing power for the ultimate digital car



Large **12.8"** media display with 1,888 x 1,728 pixels (optional)

Memory bandwidth **41,790** MB/s

**Augmented Reality** head-up display

Natural voice interaction in **27** languages

**320** GB SSD **16** GB RAM

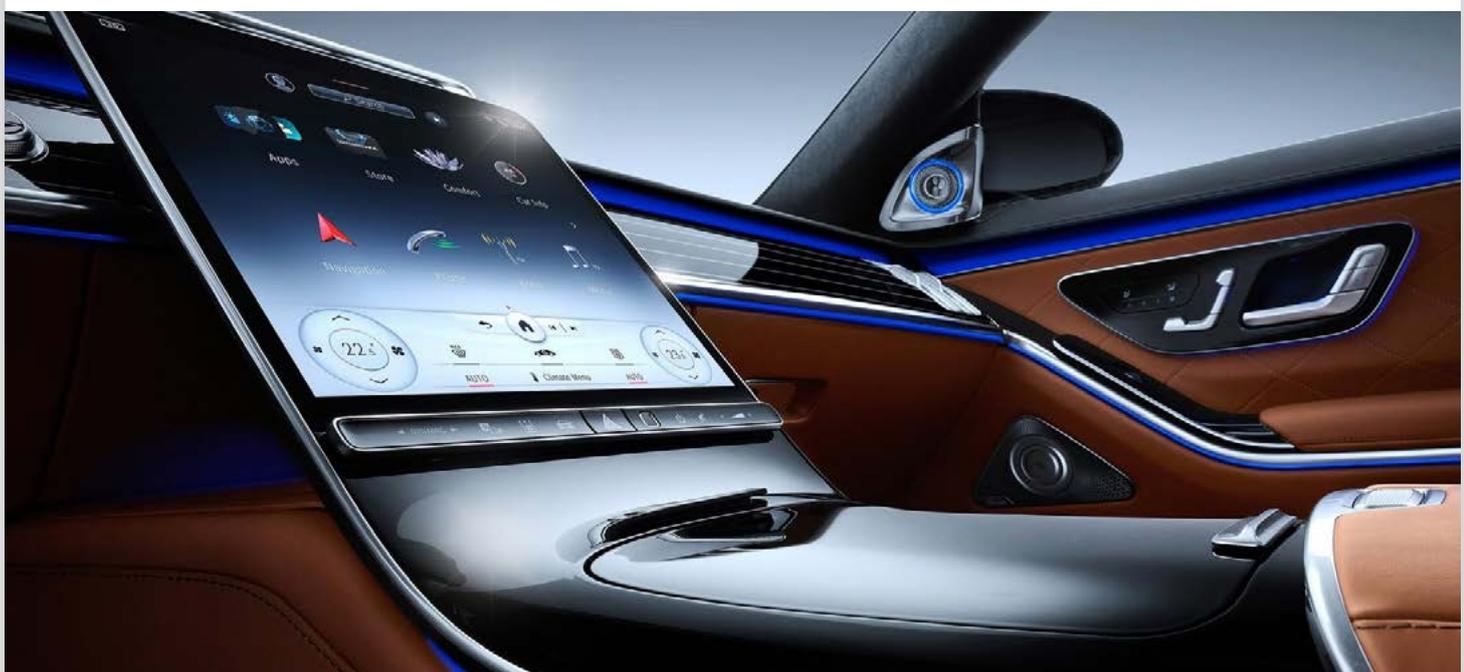
**50%** more processing power compared to previous system

**27** fewer hard keys compared to previous dashboard

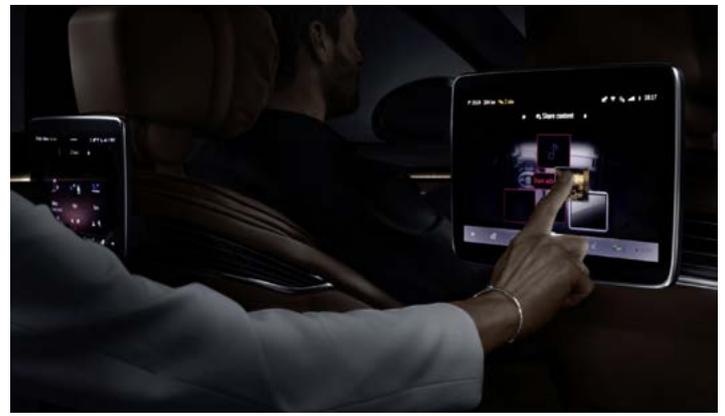
**Over-the-air** updates

GPU with **691** gigaflops

Status as of July 2020



The large central display flows into the center console while also highlighted with ambient and contour lighting.



The large high-resolution display is not only integrated physically with the center console but also digitally with the rear displays allowing digital interaction between the occupants.



This interaction between the physical luxury environment and the digital environment defines the new S-Class experience.

## Wellbeing

Covid-19 will influence car interior features at two different levels: directly, through greater importance of health and cleanliness in the car (as everywhere else), and indirectly by affecting mobility behaviors: maybe less car sharing and more longer trips because of wanting to avoid the hazards and hassles of planes and trains, acceleration of driver monitoring systems because of multiple activities, and so on.



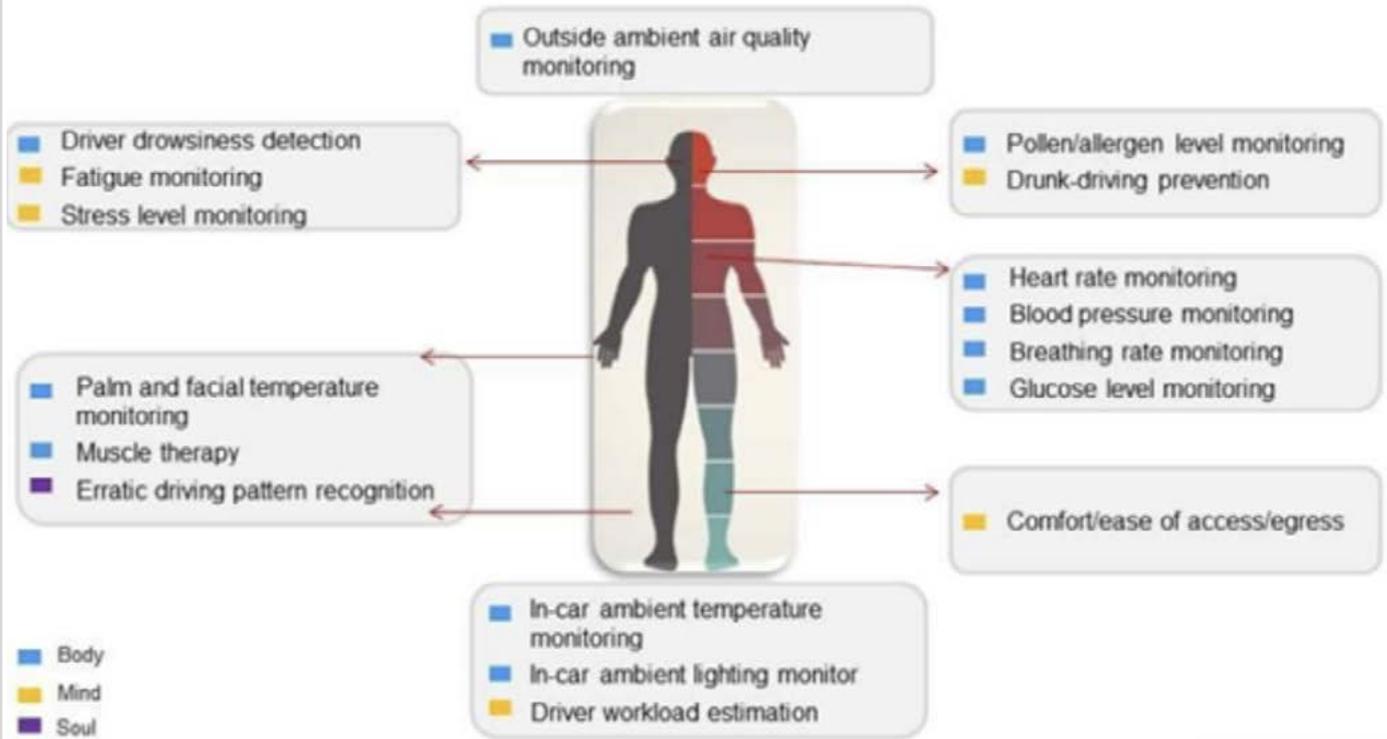
The pandemic has created momentum for automotive manufacturers to push forward on their health, wellness, and wellbeing features like disinfection of in-car air and surfaces.

The target is to measure and purify. "Going green" (or blue, more recently) has long been color-code shorthand for increased sensitivity and compatibility to ecological and environmental matters. We expect there'll be similar color-coded signification for increased automotive attention to health, wellness, wellbeing, hygiene, and sanitation.

What'll it be? Pink, perhaps? We'll have to see. Health goes beyond air and surfaces. Just as healthcare is progressing beyond hospitals, going into smart connected homes and smart wearables, so too will it most likely extend into smart cars, integrating medical-like technologies.

Cars, becoming progressively smarter and more autonomous, will become much more than a mobility tool. While cars are taking over (some) driving responsibility, drivers are gaining more and more free time, giving them time for self-care. Here's an illustration by market researchers Frost & Sullivan, listing potential features along that line:

## Automotive HWW Technologies: Key Features List, Global, 2014–2025



Source: Frost & Sullivan

The traditional automotive business model is to introduce features first in expensive cars, then they filter down and out to the different car segments along the volume/cost curve.



DS 7 Crossback with massage seat technology

Seating comfort will continue to be upgraded as it is an obvious ingredient of occupant wellbeing, with smart seats offering heating, cooling, and massage capabilities, and extending front seat capabilities to rear seats. For most of the features, sensor and software technology facilitate closed-loop optimization via measurement and correction. That idea, in turn, raises the question of seat self-adjustment for results perhaps better than can be achieved by guess-and-try operation of manual controls. This remains an open topic, as comfort is a moving target—a complex, multicriterial feeling, and the human body must move from time to time, even if we're seated comfortably; we aren't meant to be sedentary!

## Air Quality

Interior air quality management continues to grow increasingly relevant in the automotive world, and growing consumer demand suggests IAQ is becoming a new area for innovation, and probably regulations.



There's still a public misperception that once you go inside and close the door, you're protected from the exterior air pollution. That's not so, and researchers and data are confirming the importance of IAQ management, reinforced by degradation of exterior quality. According to Emissions Analytics, the worst filtration systems are 60% effective and the best are 99%, but even at these levels of efficiency in-cabin pollutant concentrations can be anywhere between 80% lower and four times higher than outside. And it's not necessarily correlated with vehicle price.

A study carried out by Airlabs, who develop tools to measure, map and mitigate air pollution, showed vehicles driving in central London during working hours were averaging a 72 µg/m<sup>3</sup> concentration of NO<sub>2</sub> within the cabin—almost twice the 40 µg/m<sup>3</sup> World Health Organization guideline, and 70% higher than at the roadside. As published recently in *Atmospheric Environment Journal*, scientists at the University of Birmingham have found that if vehicle ventilation is set correctly, drivers and passengers are exposed to up to 49% less PM<sub>2.5</sub> and 34% less NO<sub>2</sub> than the on-road levels. The lowest exposure to particles and gases is when the windows are closed with recirculation and air conditioning switched on, though of course recirculation means the air will grow stale. NAQTS (National Air Quality Testing Services in the UK) says the company's tests show 80% of fine particle emissions can be kept out by switching air-conditioning to recirculation mode.

But this comes with a downside; CO<sub>2</sub> concentrations from occupants' exhalations can quickly reach 1,000 ppm—more than double the background level. This can affect cognitive functions—decision-making and concentration—and in the context of driving a car, that becomes very important. With two people in a car for 30 minutes with recirculation mode on, you would typically see concentrations getting to above 5,000 ppm, so more than 10 times background levels. Interior components and materials release VOCs that affect IAQ. Rubber, leather (surface coatings), vinyl, and urethane-based foams are examples of some materials that outgas and negatively affect IAQ.

BreezoMeter is the first location-specific, real-time global air pollution, pollen and active fires data provider, and provides an air quality map that highlights the best, and worst, parts of any city, helping drivers plan the most non-polluted route. It can also be used to automatically activate the windows, sunroof, A/C and filtration systems to keep the vehicle clear of pollutants. BreezoMeter is accurate to 5 m, is updated hourly, has global coverage, and provides a four-day forecast. GPS and air quality monitoring systems will allow for the likes of location-based allergen and pollution warnings. These could influence travel plans and routes, just like we currently plan routes to avoid traffic congestion and road work.

IAQ management continues to grow increasingly relevant in the automotive world. Growing consumer demand suggests it is becoming a new area for innovation, and probably regulations. Marelli North America says their upgraded HVAC setup purifies passenger car cabin air, even destroying the COVID-19 virus. Offered for taxis, ambulances, and other shared-use vehicles, including autonomous-driving models, the system also has retrofit potential.

The design originated at Calsonic-Kansei North America, whose parent company merged with Magneti Marelli in 2019 and now goes by Marelli. The supplier is calling the system a solution to the problem of interior air quality in shared-use/autonomous vehicles.

## HMI/Display/HUD/AR

The Cadillac Lyriq has a 34-inch seamless curved LED screen stretching from one side of the dashboard to the other, a feature that will be coming to other future Cadillacs as well. There are still physical controls for those who don't want to rely only on touchscreen inputs. A large crystal rotary knob controls all screen functions.



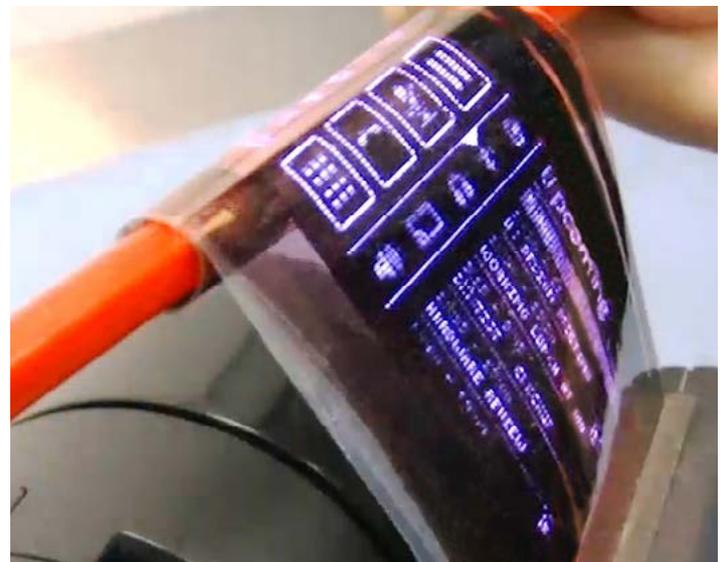
Mercedes S Class The instrument panel presents its messages in 3D graphics if desired, and the head-up display projects information directly onto the road and thus in the driver's field of vision. The virtual reality head-up display merges the assistance systems and navigation content practically with the area in front of the vehicle. Blue arrows running along support you when changing lanes at intersections and before turning.

The huge touchscreen in the center console controls the complex operations in combination with the steering wheel buttons. There are up to five screens, OLED displays and the three-dimensional screen, which varies the display depending on the position of the driver's eyes. This 3-D effect is just as stunning as the huge head-up display—one of two available. It is dimensioned so expansively that it offers a real augmented-reality experience.



Curved display : FlexEnable, based in Cambridge, England, has a new glass-free OLCD (organic liquid crystal display) technology to address the need for conformed and shaped displays inside cars. It delivers bright, durable, flexible, affordable, thin, lightweight, shatterproof displays that scale to large areas.

Most cars today feature glass displays and they are often the only flat surface in the entire vehicle. More and bigger displays mean a need for them to be curved to conform to the contours of the interior. These curved displays will have a function that is more important than just bringing design aesthetic. They will play an important role in improving the user safety and experience too.



For a safety-based example, a curved display on the A-pillar of the car can show the driver what is behind the pillar when combined with external cameras and sensors.

HMI has always been driver-centric, and as we gradually transition to more and more vehicle autonomy, we are likely to see the HMI spread out, with a more democratized control of the vehicle across multiple occupants. It will help create smart surfaces around each occupant.

This creates as well an opportunity to provide customizable and downloadable elements of HMI. In the future, shared mobility vehicles can be configured and personalized; each passenger will be able to feel like they are using their own vehicle, in the same way people can select their mobile device screen background. It will also allow car designers to design the cockpit of the car without constraints and deliver automotive HMIs of the future. Non-flat and non-rectangular displays will be key to these evolutions.



General Motors has named LG Electronics an Innovator of the Year for the supplier's contribution of the OLED display screen for the 2021 Cadillac Escalade.

It has more than 38» of total display and double the pixel density of a 4K television, producing bold images, perfect blacks, and the largest color range available in the automotive industry. It's a system made of 3 screens: a 7.2» touch control panel driver information center to the driver's left, a 14.2» cluster display behind the steering wheel, and a 16.9» infotainment screen to the driver's right. The curvature positions these displays for optimal visibility by the driver.

OLED technology eliminates the need for an overhanging hood at the top of the dashboard, as vivid color and visual quality will be not spoiled by ambient or extraneous lights. The new curved OLED display is the centerpiece of the interior, enabling designers to integrate and customize the entire environment, rather than simply inserting a standard rectangular screen into a conventional instrument panel. As buttons and switches are supplanted by touchscreens, haptic feedback is a practical necessity to be able to locate and execute features by touch, without being distracted by eye accommodation on the screen—a HUD can't present all the information, or the driver would quickly get overwhelmed and distracted in that direction, too.



BMW Augmented Reality Head-Up Displays Concept

Therefore, one concept under development is augmented-reality (AR) HUD systems. An AR HUD supplements the exterior view of traffic conditions in front of the vehicle with information for the driver. It could overlay blind spot or crossroad information, speed limits and other traffic signs, traffic lights, lane watch...3D imaging allows overlay of critical information in front, and less critical information in the background.



Mercedes A Class Wireless Charging

Another family of features integrates smart phones and wearable devices to mirror them into the car screen, by dint of protocols like Apple CarPlay and Android Auto. And high smart phone usage requires wireless charging, of course, so that will also proliferate.

Personal assistants like Apple's Siri and Amazon's Alexa are growing into the auto interior space as well. Amazon plans to expand its Alexa-enabled offerings, with the idea being that drivers could control everything a traditional voice command system could do, including placing phone calls and tuning the radio, along with controlling all smart devices at home and at the office. Amazon, alongside their substantial investment in EV startup Rivian, has signed agreements with automakers including Audi, BMW, Lamborghini, and others.

A lot of these features are nowadays existing as Apps on smart phones. With occupant having more time available in their car, it becomes a value capture challenge for automakers and suppliers to get it in the car, either during vehicle build or afterward through OTA.

## Car Interior design with aroma



Volvo S90 Ambience concept (2018)

In 2018 Volvo presented their S90 ambience concept, a sensory experience Volvo described as synchronizing «visuals, sound, and scent to redefine in-car luxury». Korean designer Jinsop Lee established the theory of 5-sense design, according to which good design not only looks good, it also sounds, smells, and feels good. Hygge (a Danish and Norwegian word for a mood of cozy, comfortable conviviality and feelings of wellness and contentment) for all the senses.

Our favorite place would therefore be somewhere that makes us happy in as many of these five categories as possible. The five human senses are of great importance for an individual's experience. It is through senses that a customer can differentiate one product or brand from its similar competitors. Makers have to go to market with «sensory branding»— attributes like touch, taste, smell, sight, and sound to trigger emotions that make customers desire a particular product over other options. It's a multisensory brand experience when more than one of the five senses contributes to the perception of sensory experience and how an individual reacts. Multisensory convergence zones in the human brain indicate that one sense can be affected by relations with others.

Comfort and wellbeing; good design and how it feels, looks, and sounds are everyday topics for DVN Interior readers. But what about how it smells? Let's have a look at some recent examples:



The Nio ES8 is full of product improvements, including the maker's Nomi in-car AI system. Among many other features, on vocal request it provides a scent it calculates you will enjoy. Three new fragrances have been created for Nio's intelligent fragrance system. This optional system interacts with the vehicle's other systems for automatic pairing with different user accounts and situations, with concentration adjustment also available via Nomi or the center screen.



In the new S-Class, Mercedes features new fragrances as well. The Mercedes-Benz Technology Centre in Sindelfingen has a Social and Technological Research department, where they examine zeitgeist and long-term social trends in the world's cities. The research results then flow into strategies and products, most recently into the perfume atomizer in the new S-Class.

Fragrance is part of a redefinition of quality of life, a growing desire for the authentic and unique, and preferably that which should be signed personally by hand. Seals of quality such as Made in Germany or Made in Japan or Made in USA are set to become more important again. And European culture with its understanding of enjoyment, elegance, and style is now viewed again as a desirable life model. Sabine Engelhardt, a futurologist in the Society & Technology Research Group at Daimler, says the challenge lies in redefining European luxury as a life quality in a world which is becoming more ecologically sensitive—green luxury, as it were.

For a number of years now, automakers have offered factory-installed perfume dispensers, such as the one in the Citroën C3 shown here. In that car a dial on the dashboard allows one to adjust the fragrance intensity. The intensity is also tied in with ventilation or air conditioning settings.

Premium Scenting's research indicates that if two senses are triggered, brand impact on the consumer increases by 30%. If three senses are triggered, that more than doubles to an incredible 70%. That same research shows that fully 48% say a pleasant smell would encourage them to stay longer in a space.



The opposite is true as well—a disagreeable smell can be very offputting. In the new Hyundai Palisade, the top-of-the-range Ultimate AWD trim's interior has a foul smell that defies easy remediation. At fault is the nappa leather wrapped around the head restraints. Hyundai has developed a three-stage fix and they're hard at work de-stinking customers' cars.



So smell is part of the in-car experience, but it's not the only part. While first impression is vital to any vehicle sales, scent marketing is growing in importance. A signature fragrance at a car dealership showroom magnifies brand perception, and over time helps create loyalty if it is present consistently along time.

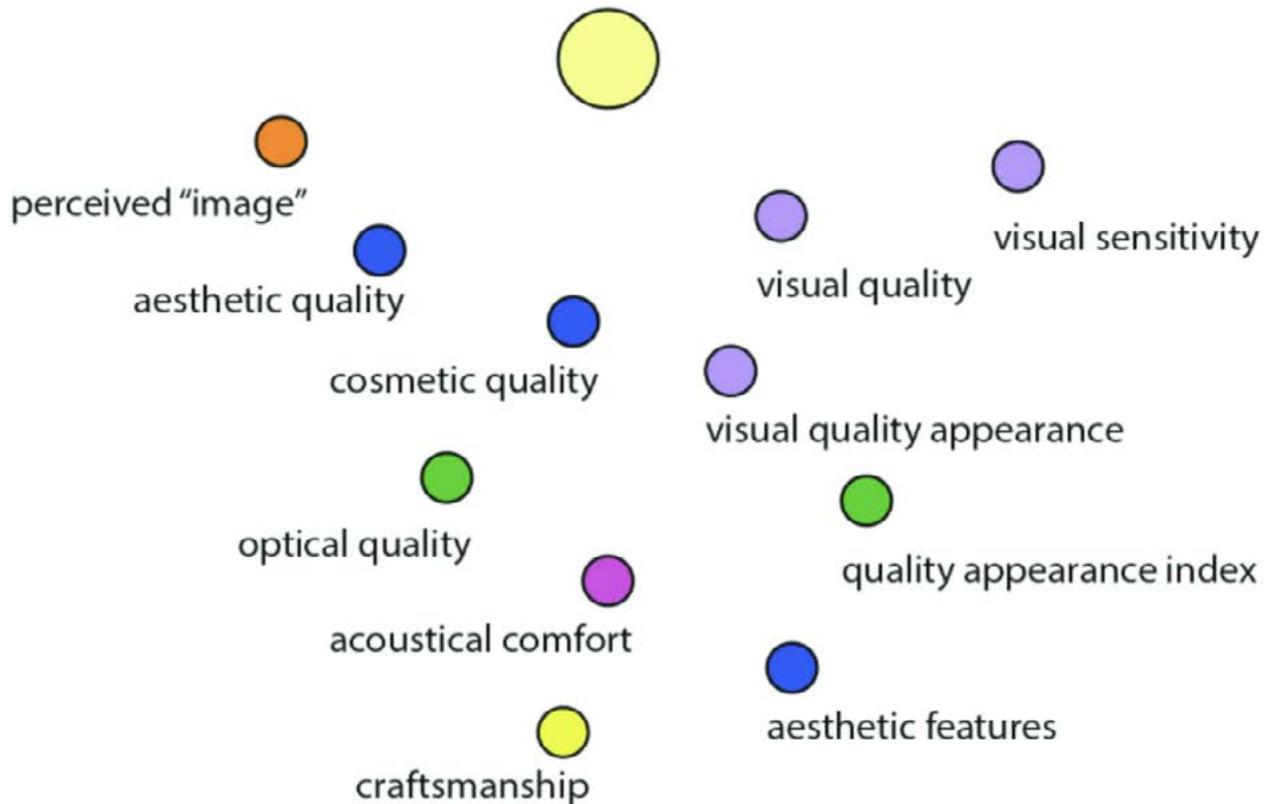
Why is this so? Because the human sense of smell strongly affects human emotion and plays a vital role in the formation of memory. Any scent has strongly-linked emotional pulls. Vanilla is said to evoke trust and dependability, mahogany and leather suggest elegance and luxury, and so on and on with a variety of scents that elicit a positive emotional response in consumers. Negative scents specific to the auto industry include rubber, wax, and paint; also, odiferous bacteria, mold, fungi, and micro-organisms can start to grow in various parts of the car. For example, mildew on the air conditioning evaporator causes an unpleasant odor from the HVAC air outlets.

The perception of smell consists not only of the sensation of the odors themselves but of the experiences and emotions associated with these sensations. Smell sensations are relayed to the cortex, where cognitive recognition occurs, only after the deepest parts of our brains have been stimulated. Humans have 400 smelling receptors, and researchers think humans may be able to smell over a trillion scents. Neither number is as high as super-smeller animals (dogs, for example), but the much more complicated human brain makes up for the deficit. Still, smell is not understood to the same degree as hearing, sight, taste, or touch; there's still a great deal of research to do. According to Ambius—the world's largest interior landscaping company—smell has other strong links, as well.

With memory, for example: studies have shown that people can remember a scent with 65% accuracy after one year while visual memory drops to 50% after only a few months. The smells we experience play a crucial role in how we associate with memories and places. A distinctive car interior scent will sink into our brain and stay there. And pleasurable fragrances have been shown to suppress the perception of time; perhaps a clever tool to help occupants cope with traffic jams. Then there's health and wellbeing: lavender fragrances are often used in nursing homes to calm people. A scenting solution could do double duty here, putting occupants at ease while simultaneously masking bad odors. Attention and focus, too, are on the list: specific smells have been found to increase alertness, and some scents help to revive our concentration levels.

## Design and Perceived quality

### Product Quality & Perceived Quality related terms



Perceived quality refers to customers' cognitive and emotional responses to a particular design, often also associated with craftsmanship and customer satisfaction. Previous research defined a taxonomy of perceived quality and provided understanding about how engineering design decisions impact customer satisfaction. Perceived quality is the one of most important factors underlying success of car manufacturers today. There is a large body of literature regarding the perceived quality from a marketing research perspective, applied psychology and consumer research.

As to the engineering viewpoint, perceived quality is represented in the literature mainly by the work to assess different aspects of it in the early design stages. There is not yet a theoretical framework built up to combine customer views on perceived quality and the engineering prospects of this broad term. As a consequence, terms regarding perceived quality components and elements often have multiple ambiguous meanings. There is a need to standardize the terminology and definitions related to perceived quality more concretely. The overall interior look and feel is dominated by the larger and larger displays used for the UX/HMI. This is further enhanced by minimizing the buttons and control surfaces, to create a serene, luxurious space. We can look at many examples: let's start with Cadillac Lyriq and Jeep Grand Wagoneer.





The Lyriq's interior is dominated by screens for both front and rear occupants. A floating display and flowing metal trim parts create a fluid, organic, elegant integration. Although the Wagoneer also floats its rear displays, they aren't fully integrated physically, causing them to be a bit less harmonious than the Lyriq's execution.



The emergence of the BEV is making an impact on the overall marketplace, including design execution. Perceived quality means to put the highest importance to the details, as here in the Lyriq:



Let's continue with The Hyundai Tucson, which creates a very driver-centric environment with the center console flowing up into the instrument panel and into the door panels. These elements create two isolated areas for both the driver, with a floating display cluster, and passenger with an open clear space. Attention to



Perceived quality means high priority to fit and finish. The main risk here is around the split lines, so it's best if they're minimized or avoided altogether. The Nissan Ariya uses unfinished-looking wood with integrated buttons and symbols to bring a fresh and clean tactile environment to the interior.



Compared to more traditional switch and buttons



For the Volkswagen-brand vehicles, the use of capacitive switching enables a more high-tech, modern feeling as seen in the window switch pack, and here again, reduced split lines compared to the older execution with conventional switches.



Perceived quality means also authenticity. The new Ford Bronco, for example, presents authenticity by dint of premium design and execution even in the cargo compartment.

Additional authenticity comes from the backpack seat arrangement.



Perceived quality is also interior materials. The Lucid Air, for both the interior and exterior, is quite refined and well executed with top quality materials and fit and finish—craftsmanship that is required to enter this market—but the key differentiator (other than performance, range, etc.) is in packaging and layout instead of detailed feature elements.



The overall cockpit uses floating elements—even the OLED cluster—to create an airy, driver-oriented atmosphere.

Perceived quality is simplicity and spaciousness, whatever the segment. The Volkswagen ID.3 interior has a bright and airy atmosphere.



Volkswagen ID.3 capacitive lighting and defogging switch pack



## Self driving cars

After early (premature, as it turned out) optimism that fully self-driving cars were just around the corner, industry is increasingly now focusing on how to support and assist drivers with technology, rather than how to replace them. General Motors' Super Cruise system, available on Cadillacs, offers advanced L2 capability: the vehicle can drive for hours on certain highways without driver engagement.

It can change lanes if the driver clicks the indicator, same as systems from Tesla, BMW, and Mercedes. It uses a camera in the steering wheel to monitor the driver's head position and eye level to make sure eyes are on the road, not looking down or closed. If the system detects inadequate driver vigilance, there will be a series of escalating warnings, starting with the light bar on the steering wheel flashing green, then flashing red with audio warnings and seat vibrations. If that still doesn't get the driver to steer, a voice prompt commands the driver to take over, or else the vehicle will activate emergency braking.



Driver monitoring systems are a large family of potential features keeping track of vehicle occupants' body position (like head relative to head restraint), eye gaze, and physiological criteria such as heart rate, respiration rate, blood pressure, and glucose levels. This will open opportunities for safety alerts (drowsiness, vigilance, driver workload); health (air quality, stress); and wellness (position, massage, heat/cool).

But will AVs really meet with broad market acceptance? Following an initial wave of euphoria in the mid-2010s, self-driving cars have more recently been the object of considerable skepticism. One reason for the change in attitude is the realization that AVs are unlikely to be available at scale soon. The evolution of AVs will coincide with a rapid rise in electric and hybrid cars. As declining ownership costs and tougher regulations drive EV adoption, we expect all shared AVs to be powered by electricity. Energy consumption declines by 12% because of the switch from private cars to more efficient electric AVs. An increase in shared mobility and the growing popularity of micromobility, mass transit, and walking contribute to the drop as well. (The calculated decline does not take into account additional effects from widespread electrification of private cars, taxis, buses, and other vehicles). Evolution of AV doesn't really take cost in consideration, even if we can expect AV to be much more expensive than today's car, and then predisposed to be shared.

## Safety

Safety goes along with comfort, and there are matters in need of diligent attention on that front. For example, gender parity in safety protection is still far from being achieved. As the interior is the interface area between the passenger and the car, we, in the auto-interior community have a central role in addressing that and other related issues. Likewise, security is a half-step from safety, and we'll see how biometric recognition will progressively help with that as car sharing comes into its own. Through it all, designers' perspectives take center stage in raising awareness and understanding of how design and product content reciprocally drive each other.

## Motion Sickness

Motion sickness is a difficulty that AV passengers will face. When passengers focus their gaze on something inside the vehicle and thus see a fixed environment, while their bodies feel movement, the mismatch in senses can bring on nausea, dizziness, headache, and other unpleasant effects. Reading or interacting with a smartphone, for example, while riding in a car can cause motion sickness. Nevertheless, it is important that passengers in an autonomous car can go about their business without worrying about the road.

Automated driving should therefore be careful not to worsen this sensation for those subject to it, or even, if possible, to reduce its intensity. Jaguar Land Rover is working on it. JLR first established a "feel-good score" to assess the level of motion sickness that a given drive might or might not cause, using biometric sensors that record physiological signals. This score had already been used by JLR, in particular to adapt the interiors of their cars to minimize the risk of motion sickness. Engineers then assessed the feel-good score over 32,000 km (20,000 miles) of real and virtually simulated driving. Through a machine learning process, the system would allow an autonomous car to adapt its driving based on the data collected.

## Materials

Within the context of new mobility solutions, with new architecture, always connected, and compliant with weight and environment specifications, a new range of materials is needed in car interiors. That's what material suppliers are developing, such as Covestro's high-end polycarbonate, composites, and polyurethanes; coatings, adhesives, and specialty films, and 3D-printable materials.

Covestro's concept car interior shows off the maker's abilities: it's got polycarbonates and carbon-reinforced composites, compact polyurethane foam claddings on the seat surfaces, and Insqin®, waterborne polyurethane synthetic materials designed especially for shared mobility. It's very robust, with a premium feel, and it can be illuminated with LEDs from its underside to create different mood experiences. Polycarbonate allows to create complex curves and geometries not possible with conventional materials such as glass. The concept interior integrated display and projection areas to allow individuals to adapt the experience for flexible infotainment and communication on PC films. The privacy dome seen on the concept adapts to individual passenger requirements and creates a personalized experience.

The privacy dome also demonstrates the advantages of polyurethane foam for acoustic management in an electric car. The floor integrates illuminated marble, built on material combinations with a digital-print surface film, and opportunity to use any natural material, such as marble, granite and other stones. Low mass is also a key criterion for material selection. Covestro uses 3D-printed polycarbonates to create lightweight dashboard structures. The table is made of carbon-fiber reinforced Maezio®, to achieve its ultra-slim, ultra-light and super-stiff structure.

## Car Makers

AV mobility will be consumed as a service, as users request robo-shuttles and robo-taxis via their mobile devices and digital mobility platforms. Other sectors of the greater automotive industry will rely on automakers' production knowledge to manufacture self-driving vehicles at scale. Car makers are increasingly realigning their products and business models to prioritize greater connectivity and to move into adjacent business areas such as owning and operating AV fleets. They're also moving away from standard traditional vehicle designs, such as four-seat automobiles with steering wheels, toward more purpose-built vehicles. Such a sea change necessarily involves total reworking of exterior and interior design and configuration. Depending on the city, the optimal mobility solution may be different, meaning car interior could be different—the iconic London taxi is a prime example of a city-specific solution.

Five city archetypes have been devised:

**Archetype 1:** The Highly Compact Middleweight. Most of the inhabitants live within a well-defined central area, making this archetype compact. Berlin and Seattle are good examples. Population growth and density, although above average, are not the highest among our five virtual cities. Inhabitants use a broad range of transportation modes, with demand evenly distributed across options.

**Archetype 2:** The Car-Centric Giant. This automobile-dependent archetype includes North American cities like Los Angeles and Toronto with large populations and very low population density. Owing to the city's large geographic area, dispersed population, and underdeveloped public transportation network, about 60% of all trips are currently taken by private car. The car-centric giant has a densely populated center and smaller low- and medium-density satellite hubs. Because this archetype is relatively new, it has a highly regular grid-shaped street pattern.

**Archetype 3:** The Prosperous Innovation Center. This archetype represents established cities that have developed over an extended period, with low population growth and average density. London and San Francisco are examples. Several medium-density hubs are contained within the city boundaries. The street pattern is irregular and thoroughfares are often narrow. Inhabitants use a range of transportation modes equally.

**Archetype 4:** The Developing Urban Powerhouse. Bangkok and Buenos Aires are typical of this city archetype. Both are modern, rapidly growing metropolises with a high population density. Developing urban powerhouses are often found in tropical and subtropical regions. They are composed of multiple distinct hubs clustered along a coastline or river. Most inhabitants currently use public transportation.

**Archetype 5:** The High-Density Megacity. Relatively modern cities, such as New York and Shanghai, that have grown considerably over the past century fall into this archetype. Such cities have a large population, with a high-density central hub surrounded by densely populated satellite hubs. The archetype is typically located on a coastline. Its streets are generally configured in a grid pattern. At present, inhabitants use a range of transportation options.

## Mobility as a service

A robotaxi, also known as a self-driving taxi or a driverless taxi, is an L4 or L5 autonomous car operated for a ridesharing company, also known as MaaS (Mobility as a Service).

AV technology firm AutoX CEO Jianxiang Xiao has called the robotaxi “the premier market for self-driving cars”; shared 24/7 use as a hailable service makes it much faster and easier to justify and amortize the high cost of an AV, compared to private ownership.

The robotaxi is a specific business model, very similar to aircraft: very limited private ownership; maximum time-in-service to minimize cost per minute or per distance. Just as luxury cars have their own increasingly specific interior configuration needs, so too would a robotaxi need a purpose-made interior to accommodate numerous passengers and their potential activities.

Since 2018 new robotaxi ventures, entrants, and technologies have popped up all over the place. To list a few:

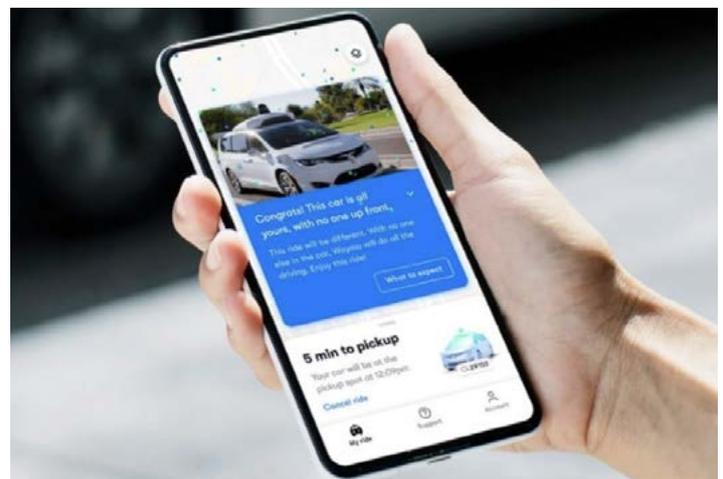
- Aurora, founded in 2017 by three veterans of the autonomous vehicle industry who led programs at Google, Tesla, and Uber, is focused on building full self-driving module. the underlying technology that will allow vehicles to navigate highways and city streets without a human driver behind the wheel.

- Waymo will relaunch after the pandemic and expand their fully-automated robo-taxi ride hailing service in Phoenix, Arizona, rebooting its effort to transform years of autonomous vehicle research into a revenue-producing business.

This new next step is to convince customers it's clean and safe with new enhanced health and safety policies and procedures; the vehicles will be cleaned more frequently, cabin air flush refreshes the cabin air on a regular basis, and fleet maintainers will be thoroughly screened.

- After successfully obtaining road test qualifications in Beijing, Shanghai, Suzhou, California, and other places, and the first batch of manned demonstration application licenses issued by Shanghai, DiDi is accelerating development in that field.

They have bolstered their partnership with BAIC, creating a JV for new-energy (electric) vehicles.



## Navya: 160 Autonomous Shuttles in Circulation



- Last year, Navya sold 43 autonomous shuttles, including 22 in the United States. The company, based in Lyon, France, now has a fleet of 160 shuttles in circulation, up 38%. In 2019, they launched an autonomous shuttle service on an open road to serve the Parc Olypique Lyonnais. They also marketed their first prototype robotaxi, and carried out their first real-world experimentation of an autonomous baggage tractor at Toulouse Blagnac airport.

Navya turnover reached €15m, of which €12.1m came from the sale of vehicles (-28% compared to 2018 and its 68 shuttles sold) and 2.9 million from the sale of services (+ 26%). In 2020, Navya will inaugurate the first autonomous shuttle service on an open road in Sakai, Japan, circulating the shuttle with L4 autonomy without a safety driver on board. Navya uses cutting edge multi-sensor technology, with GNSS Antenna, odometry on the wheels, cameras, and lidars for precise vehicle positioning and obstacle detection.

## VW's New AV Tech Company for Self-Driving Taxis, Vanst



- Volkswagen Group set up an autonomous driving unit, led by a former Apple executive, to bring self-driving cargo vans and robotaxis to market. Volkswagen Autonomy is based in Munich and Wolfsburg, with subsidiaries in Silicon Valley and in China. It's a center of excellence for L4+ autonomous driving, providing expertise to all VW Group brands, including light commercial vehicles.

## Toyota Pours Money into US AV Shuttle Company



- May Mobility, a U.S. self-driving shuttle company, raised \$50m in one round of financing, with a substantial chunk coming from Toyota, whose involvement marks another signal of its interest in business models that stretch beyond traditional vehicle sales.

## Aptiv, Hyundai in AV JV



- Aptiv (formerly Delphi Automotive) and Hyundai formed an autonomous driving joint venture to advance the design, development, and commercialization of L4 and L5 autonomous technologies, furthering the partners' leadership position in the global self-driving ecosystem. The two companies began testing fully driverless systems in 2020, and plan to have a production-ready autonomous driving platform available for robotaxi providers, fleet operators, and automotive manufacturers in 2022.

Valet Parking is part of MaaS, and could be a separate service like in airport, shopping mall, concert theatre, example with Ford, Bedrock (Real Estate), and Bosch are launching a demonstration project with connected Ford Escape test vehicles that can drive and park themselves inside Bedrock's Assembly Garage in Detroit using Bosch smart infrastructure.

This is a first infrastructure-based project of its kind in the U.S. The intelligent parking infrastructure communicates with Ford Escape SUVs equipped with vehicle-to-infrastructure (V2I) communications technology. They're using Ford Co-Pilot360 driver-assist technologies, which provides awareness of the car surroundings with optimum onboard computing to help improve design, packaging and affordability. The parkade's sensors recognize vehicles, pedestrians and other hazards, and uses this information to guide the Escape to an open parking spot.

While the system is configured for a demonstration basis, the technology would allow people to pull up to a parkade, exit the vehicle, and use their smartphone to tell the car to park itself. When the owner is ready to leave, they'd walk to a designated pick-up area and tell their vehicle to come get them; the vehicle and the parkade would once again cooperate to bring the car safely out of its space and over to the waiting driver.

The primary main objective, from a business-case standpoint, is to make parkades more efficient; they can accommodate up to 20 percent more vehicles in the same amount of space, and could be equipped to offer automated services such as car wash or charging stations—new revenue streams for parkade operators to cover technical investments. Infrastructure is needed as robotaxi and self-driving vehicles will start out on geofenced roads or zones like university campuses, or as in Michigan with efforts to sketch a corridor between Detroit and Ann Arbor (69 km / 43 miles) with a dedicated infrastructure that can speed deployment and enables safer movement of these vehicles.

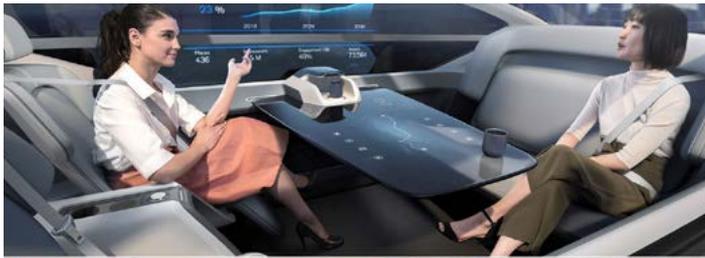


- Momenta announced recently that their entire robotaxi fleet will operate without safety drivers in 2024, while some of their vehicles will already be driverless by 2022. Just this month, Momenta secured its first license to recruit passengers for their robotaxis running on chosen public roads in Suzhou, China.



## Why smart vans and mobile offices are the future

There was a time when the phrase “mobile office” meant a leaky old portacabin or wooden shed on a building site. Today, however, the phrase applies to modern vans.



The Nissan e-NV200 WorkSpace concept, for example, was produced in partnership with UK-based design workshop Studio Hardie.

It's designed to show how the smart vans of the future will make it easier to work remotely, stay in touch with the office and do all kinds of formerly land-based activities while on the go. There's a built-in desk, office chairs, computer and wifi making it easy to work remotely.

The possibilities are broad; properly-equipped vans will allow electricians, for example, to use wireless connectivity to perform diagnostic tests without having to get out of their vehicle. Engineers will also be able to check emails and stay in touch with the office. Bespoke vans, with built-in tech, are already in use by large broadband suppliers and power companies, but in the future all vans will boast this tech as standard.

Waymo carried out successful trials of autonomous taxis in California, transporting over 6,200 people in the first month and many thousands since. They're proving a practical business case for autonomous vehicles.

Walmart is using autonomous cargo vans to deliver groceries in Arizona, while Pizza Hut is working with Toyota on a driverless electric delivery vehicle that even has a mobile kitchen in it to cook pizzas en route to its buyer.

Renault is making great strides in autonomous vehicles; since showing the Symbol in 2017, the first vehicle designed for mind-off automation, Renault has been testing on-demand car services in Paris and partnering with Waymo to investigate driverless transportation possibilities to and from Charles de Gaulle Airport. Renault's Valerie Pecresse has said that the company is investing €100m in autonomous vehicle infrastructure, in hopes of bringing the project to a successful conclusion for the Paris Olympic Games. Tesla is also making big steps forward in taking autonomy into mainstream use, both in terms of real world use cases and potential monetization of self-driving technologies.

They've supplied customers with more than 780,000 vehicles, the majority of which arrive with pre-installed self-driving capabilities available to users who purchase the requisite software. Tesla autonomous vehicles have logged enormous cumulative distance driven since their introduction, growing from 160 million km in May 2016 to an estimated 3 billion km as of October 2019, and further exponential upward progress since then. Self-driving Ford vehicles are being tested in Pittsburgh, Palo Alto, Miami, Washington D.C., Detroit, and Austin. Together with their partner Argo AI, Ford has plans to launch a broader autonomous taxi and delivery service this year.

### **Obstacles and hurdles**

There are a few things slowing autonomous vehicle deployments, ranging from regulation issues to business models to the technology itself. In terms of regulation, for example, Waymo wants to deploy their robotaxi service beyond testing zones in California as soon as possible, but they're arguing about regulatory particulars with the California State Government. Some industry analysts perceive overregulation as jeopardizing California's reputation as the world leader in driverless technology. GM subsidiary Cruise, which GM bought for \$1bn in 2016, has also experienced delays to its deployments in New York, after safety concerns kept the company from gaining regulatory approval from the state government.

Business models remain a challenge to deployments, too. Michelle Avary, Head of Autonomous Mobility at the World Economic Forum, has said, "We see some big divergence between the whole idea of the business model of the robo-taxi versus what we see in areas like commercial trucking, mining, and construction, where the business model case might be more readily made." Car-as-a-service might be one workable way forward, with around half of car owners recently admitting they would consider giving up car ownership in the future if on-demand autonomous mobility solutions were available to them. But it's something car manufacturers are still trying to work out.

### **Levels of automation**

Guidelines issued by the American outfit SAE International (formerly the Society of Automotive Engineers) classify the various levels of autonomy. L1, driver assistance, involves computer assistance of simple driving functions like the cruise control or braking. The driver is still very much the driver. L2 refers to partial automation, wherein the vehicle assists drivers with steering or acceleration, allowing drivers to disengage from some tasks. L3 concerns conditional automation, where the vehicle takes over some of the monitoring of the environment from the driver, using sensor technology like lidar. L4 is high automation: much greater control has been handed to the vehicle, which is in charge of steering, braking, accelerating, monitoring the vehicle and roads, and also responding to events like deciding when to change lanes, turn or use signals. Audi introduced L3 AVs in 2018, while Ford stated their intent to go straight to L4; Ford's philosophy is "We're not going to ask the driver to instantaneously intervene—that's not a fair proposition".

There is a Level 5—full automation—in which the vehicle is in control of everything, and the proposition is that the human driver has to do nothing, ever, anywhere, on any kind of road, in any kind of condition. This is not presently practicable; Frost and Sullivan say L5 AVs are unlikely to be introduced before 2025.

## 5G and autonomous vehicles

France is making big steps forward in supporting autonomous vehicles. Telecoms provider Orange has an agreement to work with Renault on a connected vehicle and 5G project. The idea is to measure the capacity of 5G and how it can be used to enrich communications between vehicles and their environments, giving AVs more information and enabling better traffic flow and improved road safety.

## City Future: Smart Cities

A smart city is an urban area that uses different types of electronic methods and sensors to collect data. Insights gained from that data are used to manage assets, resources and services efficiently; in turn, that data is used to improve the operations across the city. This includes data collected from citizens, devices, buildings and assets that is then processed and analyzed to monitor and manage traffic and transportation systems, information and communication technology, power plants, utilities, water supply networks, waste, crime detection, schools, libraries, hospitals, and other community services. At the Tokyo Motor Show in October 2019, Toyota presented a wide range of mobility tools along the different sections. Their exhibits were positioned in the main hall as a city planner on a backdrop of science fiction-like stages with demonstrations of new mobility ideas—scooters, the e-palette, and the magic broom, to list a few. As city planner they announced a plan for a 2,000-person city-of-the-future they called Woven City, where they will test autonomous vehicles, smart technology, and robot-assisted living. It's in the foothills of Japan's Mount Fuji, about 60 miles from Tokyo. Toyota's CEO Akio Toyoda described the new city as a living laboratory where researchers, scientists and engineers test emerging technology in a real-life environment.



Woven City is on 71-hectare (175-acre) site that was previously home to a Toyota factory. Toyota says the city is fully sustainable, powered by hydrogen fuel cells and rooftop solar panels. Only fully autonomous and zero-emission cars are permitted to operate on its streets. A fleet of self-driving vehicles known as Toyota e-Pallettes are used for delivery and retail purposes.



The Volkswagen Group and the Greek Government, meanwhile, are working to create an innovative mobility system within the closed perimeter of a small island Astypalea. The plan is to transform Astypalea into a model for climate-neutral mobility. The project will run electric vehicles and renewable energy generation, starting in the first half of this year and running through 2027. Astypalea, with 1,334 residents, is a Greek island in the Dodecanese, an archipelago of twelve major islands in the southeastern Aegean Sea. The island is 18 km long, 13 km wide at the most, and covers an area of 97 km<sup>2</sup>. More than 70,000 tourists visit the island every year. Today 1,500 combustion-engine cars are circulating there; they will be replaced by 1,000 EVs. All public vehicles—police, emergency, etc.—and commercial vehicles will be EVs. Car rental will be transformed into service for shared e-cars, e-scooters, and e-bikes.

This setup will replace the old bus system as well. VW will provide the cars (new ID.3, ID.4 and e-Up models), and about 230 of their Elli charging points spread over the island. Currently Astypalea gets its electricity almost entirely from diesel generators, making the power dirty, but in the future a large part of the electricity demand for households, companies and traffic will be covered by wind and solar power systems, which the Greek government will install on the island. The electric fleet will be powered entirely by green renewable electricity. This island pilot project aims to prove that a purely electric transport system is already possible today, without crimping the mobility of its inhabitants.



Hyundai unveiled their vision for urban mobility at CES 2020, for vitalizing human-centered future cities. To envision this future, Hyundai showcased three mobility solutions for the future: Urban Air Mobility (UAM), Purpose Built Vehicle (PBV), and Hub, a place for mobility transfer and community activities. Based on these mobility solutions, Hyundai aims to free future cities and people from constraints of time and space and allow them to create more value in their lives.

## Main Takeaways

Here are the main takeaway points we retain from our DVN analysis :

The CASE (Connected, Autonomous, Shared, and Electric) mobility megatrends are progressively transforming the automotive industry. These megatrends are driving whole new categories of technologies and creating new car use cases in resonance with what is happening in the increasingly digital and electronic greater environment surrounding us at home, at work, and everywhere else. Consumer behaviors, choices, and value are also shifting from ownership-based to service-by-subscription models.

That is the environment in which automotive interiors are being progressively redefined with a focus on user experience in the new reality. Optimized UX (user experience) is becoming the target, the lens through which the whole transportation sequence is viewed, and the standard by which it is adjudged.

As cars grow smarter and more autonomous, drivers will gain more and more free time for self-care and discretionary activities.

Privately-owned cars are not going away, but new HMI (human-machine interface) or UI (user interface) technology will create a new level of collaboration between driver and machine for greater safety, more comfort, and a better overall experience.

There's unprecedented interest and R&D drive toward comfort in all vehicle interior positions, with personal "cocoon", where everything can be personalized—ergonomics, indoor air quality and temperature, sound, lighting, and even smell

The driver—supervised, supported, and monitored by driver assistance systems—will become less of an operator and more of a passenger. This "passenging" experience is where interior, ADAS (advanced driver assistance systems) and AD (autonomous driving) technology are increasingly crucial, making car interiors a central new product differentiator and allowing occupants to do a whole new set of activities: relaxing, working, phoning, reading, watching movies...the car becomes a mobile lounge.

The in-car environment, then, must mirror the one at home and at the office: a people-centric place of comfort and connectivity, designed and configured to minimize annoyance, deprivation, boredom, and constraint.

HMI has become the true keystone of the interior, making the link between the vehicle's technology and its occupants—all of them, for control functions are no longer limited to just the driver—allowing all vehicle occupants to create and manipulate their own optimized experience.

One concept rapidly rising in prominence is the digital cockpit, which replaces traditional controls and displays with digital screens. A wide range of multiple-screen configurations is possible with elements including digital instrument clusters, head-up displays, infotainment system control screens, passenger screens, digital assistants, and more.

The area of urbanized land on Earth could triple between 2000 and 2030, equivalent to adding an area bigger than Manhattan every single day.

Megacities will require a new level of infrastructure design and architectural planning, making it easier for residents to work and live in a dense urban setting. Smart cities will emerge, powered by robust technology infrastructure: sensors, data platforms, analytics, cloud, etc. Space will be at a premium, forcing us to rethink how we design products to fit in smaller, shared work and living space.

The phaseout of fossil-fuelled vehicles is one of the two most important parts of the general fossil fuel phaseout process. More than 14 countries and over 20 cities around the world have proposed or adopted ban dates after which sale of new fossil-fuelled passenger vehicles will be prohibited.

Cities are creating more space for people while reducing the space originally given to cars.

L4-5 vehicle will mainly be used as robotaxis owned by mobility companies and used as a service. Interiors will be configured and specified accordingly, and segmented consistent with the nature and price point of the intended service. Robotaxis will most likely develop faster for delivery services, with interior configurations specific to particular tasks.

More and bigger screens, and even curved screens to better fit with interior contours; with OLED technology and augmented reality. Curved displays for difficult areas of the car (see-thru A-pillar, etc).

Lighting is becoming the new chrome; its decorative-ambiance role is made possible by LED light sources and related optics, unlocking new opportunities for design with light. It amplifies the design language, contours key elements of the interior (air outlets, speakers, cup holders, storage cubbies, floating elements), reinforces brand identity, and personalizes to every single user. Interior lighting has getting many other roles, especially in the domain of safety as an alert trigger, with blind spot detector warning, and creating machine human dialog in the driver monitoring loop.

Car architecture and Interior space are even more related than ever. Maximizing wheelbase dimension for a given overall car length is paramount, while integrating smaller-sized components, such HVAC, and seat backs. Electric vehicle platform is offering additional architecture benefits when using no-tunnel architecture with completely flat floors.

Covid-19 will influence car interior features at two different levels: directly, through greater importance of health and cleanliness in the car (as everywhere else), and indirectly by affecting mobility behaviors: maybe less car sharing and more longer trips because of wanting to avoid the hazards and hassles of planes and trains, acceleration of driver monitoring systems because of multiple activities, and so on.

Interior air quality management continues to grow increasingly relevant in the automotive world, and growing consumer demand suggests IAQ is becoming a new area for innovation, and probably regulations. Interior air can be much worse than roadside air

Customizable aroma will complement the 5-senses perception to reinforce experience, personalization and brand with new fragrances.

Seat comfort will continue to be upgraded with a focus on occupant wellbeing. Sensors and software technology allow closed loop optimization for adjustment superior to that obtainable by a manual guess-and try operation.

Perceived quality means high priority to fit and finish—crucially, split lines. Replacement of traditional switches and buttons by digital, voice or gesture technology reduces the number of potential split lines.

Perceived quality and authenticity meet as well with environmentally-sensitive natural and renewable materials such as wood, natural fibers, recycled plastic bottles, etc.

Motion sickness will hinder AV passengers' ability to go about the business of whatever they're doing while the car drives itself. Machine learning and artificial intelligence are being deployed to figure out countermeasures.

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Honda, Japan  
Renault, France  
Valeo, France  
Marelli, Japan  
ZKW, Germany  
Osram, Germany  
Covestro, Germany  
TI, US  
GXC-coatings, Germany  
SMR, India  
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