Special report: M:bility | California – key takeaways

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Executive summary

The automotive industry faces a growing number of challenges as it prepares for a new era of mobility. Autonomous driving, connectivity, electrification, mapping, artificial intelligence, data and Mobility as a Service (MaaS) all play a key role in changes taking place across the automotive industry.

These themes and more ran throughout M:bility | California, a two-day event designed by *Automotive World* to help stakeholders from the automotive industry, mobility sector and transportation providers understand the future of mobility.

Topics were addressed in panel debates, a live Q&A and keynote presentations. The conference also included a case study on the future of mobility in San Jose.

Speakers from Toyota AI Ventures, Byton, Zenuity, Renovo and AAA Northern California, Nevada & Utah were joined at M:bility | California by experts from a wide range of companies and organisations with a vested interest in the future of mobility, including Otonomo, mpathy.ai, Sixt, TomTom and Navigant Research.

Specifically, the agenda addressed some of the major questions facing automakers and mobility stakeholders:

- What is the future of mobility?
- Mastering maps and sensors–the key to the autonomous car?
- Grounding the future of mobility–why start-ups must address real pain points
- Artificial intelligence–the ultimate mobility value driver?
- Is 5G connectivity the link to a self-driving future?
- Is automotive data the new oil?
- Managing the relationship between shared autonomous vehicle and rider
- What does the consumer want from the vehicle of the future?
- How do we test the autonomous vehicle

- Case study–the future of mobility in Silicon Valley
- Is the auto industry prepared for the future of mobility?
- Will mobility as a service become the new normal?
- How do you predict the mobility behaviour of consumers?
- Are electric vehicles ready for the mainstream?
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"Automakers used to be at the centre of that ecosystem, with everybody else following their lead... That dynamic is changing dramatically as a result of the CASE trends"– Alexandre Marian, Managing Director, San Francisco, Alix Partners

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"We've been really excited for a while about millennials not going towards car ownership. But that is being flipped on its head–they are purchasing a car because it is their own space"– Jill North, Innovation Manager, City of San Jose

Silicon Valley: on a mission to change the future of mobility

It may be the world leader in technology, but the Bay Area is not immune to the socio-economic struggles presented by urbanisation. By Freddie Holmes

Home to the likes of Google, Apple and Facebook, Silicon Valley has garnered cult status as the world's consumer electronics tech hub. But Silicon Valley has a bigger purpose: it is changing the way the world works.

That's according to Justin Rose, Partner & Managing Director, Chicago, Boston Consulting Group (BCG). Speaking during M:bility | California, a two-day event hosted by

Automotive World in San Jose, he explained that within the thriving mobility ecosystem, Silicon Valley is making the world a better place. What exactly does that look like? In short: safer, cleaner and more easily accessible. "However, it's important to keep in mind that we have a responsibility to get it right," he said.

Indeed, there is more at stake here than simply appeasing shareholders. Cities across the world are more congested than ever before, air pollution is dangerously high and there is as yet no solution to sky-high traffic mortality rates. "If we get it wrong, it will fundamentally be a major negative for the world over the next 50 or even 100 years," warned Rose.

With all this in mind, how is the City of San Jose flying the flag for the future of mobility?

Public transit vs car-sharing

Occupying the south of Silicon Valley, San Jose is the third largest city in California, following Los Angeles and San Diego. It is also a city that drives: rail networks are neither well established nor far-reaching; the middle class is swelling, and the area is a magnet for the wealthy. All of this naturally encourages locals to own a car to get around.

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We have good weather for it and progressive cities, so I think you will see an increase in micromobility options

Some believe that public transport needs to be a focus point moving forward. "I'm not sure why we don't see more done around Bay Area Rapid Transit (BART) solutions. It's not a technology problem–frankly I'm not sure what the issue is," said Ruth Cox, Chief Executive of Prospect Silicon Valley, a non-profit innovation hub focussed on urban communities.

Others suggest that car-sharing is the way forward–particularly the electric and autonomous variety. Societal benefits aside, the business model could also make serious money. BCG has conducted research that estimates fleet operators in the Bay Area could make as much as US$2bn in profits a year.

As BCG's Rose detailed, around 100 million miles are driven by car each day in San Jose and San Francisco combined. In the future, he estimates around half of those miles will be covered by shared, electric vehicles. A fleet consisting of 120,000 vehicles roaming around–each driving 300 to 400 miles per day–would accumulate 16 billion miles per year in total. That would equate to something like US$9bn in revenue for the fleet operators, he suggested, and US$2bn in profit. "It is a very big deal," he remarked.

Using the M:bility | California conference venue as a case study, Rose went into further detail on how the shared, electric and autonomous business model fits in with life in the Bay Area as we know it. The airport is around 4.5 miles away, and the train is one option. The trip itinerary is as follows: a five minute walk to the metro stop, a five minute changeover, a ten-minute light rail trip and another five minute walk to the convention centre. "All told, it is a 40 minute trip that costs about US$2.50," said Rose. "By comparison, an Uber X was US$25."

A robotaxi may charge as little as US$0.70 per mile, he suggested, which would equate to around US$3.50 for a solo rider. "Plus it's door to door, and there is limited waiting time," he explained. "From a customer experience standpoint, it is pretty attractive, and from a cost economics point, you are getting pretty darn close to that of public transport."

However, with eye-watering house prices many choose to share a home with friends and acquaintances. This is turning many toward private vehicle ownership, suggested Jill North, Innovation Manager, City of San Jose. "We've been really excited for a while about millennials not going towards car ownership. But that is being flipped on its head–they are purchasing a car because it is their own space."

Micromobility

Robotaxis and private cars aside, the Bay Area is also an early adopter of the micromobility wave that has flooded streets with shared pedal-assist bicycles, e-scooters and even electric mopeds.

"We have good weather for it and progressive cities, so I think you will see an increase in micromobility options," said Cox. "They are a really good option for first- and last-mile transport, so I hope to see more flexible and cost effective options to support the public transit backbone. Simply replacing combustion engine vehicles with electric or autonomous vehicles will not solve our congestion problem."

North believes the industry needs to be realistic with its expectations. Improvements will be gradual, she suggested, but they are by no

means guaranteed as a result of new tech. "We will continue to see progress in some areas, but in others we will see things worsen," she warned. "Congestion will remain an issue, but some of the investments we have made in safety may pay off."

Cox believes that in order for micromobility to become more usable, and less of a menace to pedestrians in some cases, Silicon Valley's infrastructure needs to adapt. "Scooters are great mobility solutions, but they are also dangerous," she said. "Car drivers are impatient and are not used to seeing these vulnerable road users riding around. It is important that we make those modes of transport safe."

Fit for purpose

It is also important that business models and technologies are crafted and deployed to suit the specific needs of Silicon Valley.

Ideas from other 'mobile' cities around the world cannot simply be copied and pasted, suggested Carol Kuester, Director of Electronic Payments and Systems at the Metropolitan Transportation Commission, which is responsible for transportation planning within the nine counties around the Bay Area. "While it is great that we look for inspiration from cities like Helsinki and London, California is not Europe. It's naïve to think we can apply those solutions here blindly," she explained. "We simply don't have the same kind of funding mechanisms."

Silicon Valley's traffic problem is also influenced by social issue factors. "The most dominant theme is that, as a transportation agency, we are spending less time focussed on transportation, and being more drawn into the housing crisis," advised Kuester. "We spend a lot of time figuring out how to get people to transit and simplifying fares, but I would be very conservative in my hopes for new technology to just solve our jobs-housing conundrum."

A straightforward approach to reducing city congestion would be to encourage remote working, Kuester suggested. "Being able to stay

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> Ten years from now we will start to see some of the benefit to all of this investment, but I think we still have a long way to go

at home and telecommute is huge," she continued. "The housing and commute pressure means that more people are telecommuting than taking public transit."

Flicking the switch

The idea that mobility issues can be 'solved' by an injection of technology, then, may be slightly naïve. However, the panel agreed that collaboration will be important when cherry-picking the right ideas for Silicon Valley. "There is a lot that we can do with our two dozen transit agencies in the Bay Area," advised Kuester. "The challenge is that everyone in this space wants to get involved in some way, so it is hard to juggle all of those ideas and figure out which way to go."

Things happen fast in Silicon Valley. New start-ups have been known to launch products overnight, and the area is at the heart of all things 'future mobility'. A wealth of venture capital money pits amid a vast–and growing–start-up ecosystem would suggest that the Bay Area will lead the way in terms of mobility optimisation. Alas, a key takeaway from the M:bility | California panel was that expectations may need to be managed moving forward. "I don't think there will be a moment where all these technologies come together at once at the flick of a switch," concluded Cox. "Change will be incremental; ten years from now we will start to see some of the benefit to all of this investment, but I think we still have a long way to go."

Consumers must be kept in the loop with public AV testing

The American Automobile Association may be best known for its roadside assistance, so why is it closely involved with AV developments? Freddie Holmes investigates

Consumers may have a choice in whether they ride in an autonomous car in future, but today they are powerless when it comes to sharing the road with automated test vehicles. Public testing and development will continue indefinitely, and third-party organisations want to ensure it goes ahead safely.

The American Automobile Association (AAA) Northern California, Nevada & Utah has been closely following the development of autonomous vehicles (AVs) for years, and in 2017 founded a dedicated AV Strategy division to better address industry trends. In October 2018 it concluded a public self-driving shuttle pilot in Las Vegas with AV developer Navya, and also partnered with Waymo's 'Let's Talk Self Driving' campaign. AAA Northern California, Nevada & Utah has even snapped up a dedicated AV testing facility in California; in August 2018 it acquired the GoMentum Station, a sprawling abandoned naval base that has been used as a test bed by the likes of Honda, Toyota and Lyft. That puts one of the largest not-for-profit member benefit organisations in charge of the largest AV test site in the nation.

But why is a company known for its insurance and roadside assistance getting so closely involved with the AV industry? Any

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> AAA Northern California, Nevada & Utah is in a unique position to help public agencies and private companies develop and test self-driving technology safely

opportunity to reduce the impact of human error—linked to 94% of road incidents according to the National Highway Traffic Safety Administration (NHTSA)—is good news for AAA. Autonomous driving technology is deemed a viable solution, but while the technology has potential, AAA believes it must be tested responsibly.

"We need to help ensure the technology is implemented in a safe way before it is on public roads," explained Ignacio Garcia, Vice

President of Autonomous Vehicles Strategy at AAA Northern California, Nevada & Utah. "With a long heritage, experience, relationships and resources in the mobility industry, AAA Northern California, Nevada & Utah is in a unique position to help public agencies and private companies develop and test self-driving technology safely. "

Gaining GoMentum

The GoMentum Station essentially embeds AAA at the heart of the AV testing community. To say the facility is vast is an understatement: within its 2,100 acres lie various multi-lane carriageways, bicycle lanes, tunnels, fly-overs and fully-functioning traffic infrastructure. "But GoMentum is much more than a test track," said Garcia. "In collaboration with Contra Costa Transportation Authority and the City of Concord, AAA Northern California offers a comprehensive programme where companies can test their AVs as well as have an

opportunity to deploy their technologies in various public-private programmes to benefit communities in the Bay Area and beyond."

Since taking over management of the GoMentum Station from the Contra Costa Transportation Authority last year, gradual improvements have been made to its infrastructure. "We have added roadway features like bike lanes and roundabouts, and testing equipment like programmable traffic lights to make GoMentum a more versatile proving ground for testing AVs," said Garcia. "We also added AV testing equipment like dummies and services to help improve our customers' test operation efficiency."

In future, AAA also plans to launch a so-called 'digital twin' of the facility, which will allow developers to devise and simulate test procedures before taking to the track. A high definition (HD) map of the site will also be launched, which will help AVs to better understand their surroundings and plan ahead

Consumers must learn the limitations of automated driving features

whilst driving. Garcia is quick to point out that simulation is a "complement to, not a replacement for" closed-course and real-world testing, but suggested the site's broader capabilities will open the door to new players in the AV space.

"We realise that a lot of AV start-ups, as well as independent developers and researchers, are often limited by resources. For them, our digital offerings, namely the HD map and digital twin of GoMentum, will dramatically reduce their barriers to testing at the GoMentum Station," said Garcia. "With these additional tools, developers can get a jump start on testing at our facility."

The view of the nation

As the de-facto car club for drivers in the US and Canada, AAA has access to nearly 60 million members and thus a strong position to

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Developers can get a jump start on testing at the GoMentum facility

guage consumer sentiment on a range of topics, including AVs. Many of its members will already be familiar with early levels of driver-assistance technologies, some of which have been involved in well publicised road collisions.

"Our members and consumers are looking for more validation that self-driving vehicles are being developed safely, and we are in a unique

AAA Northern California, Nevada & Utah acquired the GoMentum Station in 2018

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> The key to helping consumers feel more comfortable with self-driving technology will be by evaluating and educating the public on benefits and limitations of the emerging technology

position to fill that need," said Garcia. "However, consumer confusion exists in the marketplace and the public sentiment towards AVs is mixed."

AAA released its annual National AV Consumer Sentiment Survey earlier this year, and found that 71% of Americans surveyed have reservations about riding in fully self-driving vehicles. While most, if not all, of those who took part are unlikely to have travelled in a self-driving test vehicle just yet, it does provide an indication of consumer expectations. It is also a sign that for developers, such vehicles will be a hard sell. However, there are use cases that prove more palatable; the survey found that 53% of Americans are comfortable with self-driving vehicles such as shuttles found at airports and amusement parks.

"This was apparent during research AAA Nevada conducted in Las Vegas using a self-driving shuttle in the busy downtown area," said Garcia. "The shuttle was the first and largest self-driving shuttle for public use in live traffic. It was also the first in the country to be fully integrated with smart city infrastructure to operate on open, public roads." A survey conducted with passengers after their ride showed that 27% left with a more positive attitude about automated driving technology.

AAA Northern California, Nevada & Utah is well-placed to keep on top of the AV space as it evolves. With a sizable test facility

at its disposal and direct access to consumers, it hopes to add-value across the board–no less in educating how technology may be deployed in future, and managing expectations as new features become available.

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> GoMentum is much more than a test track

"We believe the key to helping consumers feel more comfortable with self-driving technology will be by evaluating and educating the public on benefits and limitations of the emerging technology," concluded Garcia. "Driven by a commitment to advance traffic safety towards zero fatalities and revolutionising mobility, AAA Northern California, Nevada & Utah is working with automakers, tech providers, and governments to shape a legislative and regulatory environment that ensures the safety of the public is at the center of taking self-driving vehicles mainstream on America's roads."

COMMENT:
Are these the four S words of future mobility?

What links sheep, scooters, start-ups and sickness? Martin Kahl reflects on themes raised during future mobility debates at M:bility | California

W hat links sheep, scooters, start-ups and sickness? And more to the point, what are they all doing in an article about next-generation transportation? Each, we heard at *Automotive World*'s M:bility | California conference, has a role to play in the development of future mobility solutions.

Let's start with the easy one. Depending on where you live, work and walk, scooters are either something you've heard about, something you've tripped over, or something you've ridden and enjoyed.

They're easy to use, fun and convenient. And anyone can use them–which has many upsides, and huge downsides. Scooters democratise mobility, but they also put fast-moving vehicles into the hands of people under no obligation to prove previous experience, road traffic knowledge or sobriety, and they're certainly not allowed to be ridden on the sidewalk–a rule as widely flaunted as any traffic regulations by those riders who do venture off the pedestrian walkways.

Scooter riders zip across roads, dart on and off pavements and amongst parked cars. In an era when automakers and suppliers are making

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Scooters are either something you've heard about, something you've tripped over, or something you've ridden and enjoyed

huge strides in programming autonomous vehicles (AVs) to identify vulnerable road users (VRUs), along comes a mode of transportation that creates a new VRU segment, and moves erratically and inconsistently, adding huge complexity to AV coding.

Scooters and sheep are unlikely to be found in the same areas, but sheep–we heard at M:bility | California–also present a major challenge for AV developers; they, too, move erratically and inconsistently, running and gambolling across

roads in ones and twos, and in flocks. When moving together, their irregular silhouettes create additional identification challenges for vehicle sensors. To be fair, other animals present similar issues–and kangaroos are a different story entirely–but sheep certainly keep robotaxi coders awake at night.

As we prepare for a world of robotaxis, the industry must also properly address the unpleasant issue of sickness. As this publication has previously noted, motion sickness–or kinetosis–is a make-or-break issue for AVs, and robotaxis create perfect conditions for kinetosis: riders may find themselves in significantly different seating configurations compared to the traditional vehicle layout; in-vehicle infotainment, with movies projected onto large screens or vehicle windows, will prevent clear visibility out of the vehicle, let alone clear visibility of any kind of horizon; and riders will have no control over the vehicle's acceleration, braking and turning.

Rider sickness–caused by kinetosis, or possibly inebriation–will undoubtedly take a robotaxi off the road. Returning it to a depot for cleaning will see the operator incurring considerable cost, as well as lost revenue.

But how will a robotaxi operator even know about the condition of the vehicle's interior? Occupant monitoring will be essential, but it raises questions about how this will be implemented, as well as issues of anonymity and

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> ## Sheep certainly keep robotaxi coders awake at night

privacy. Remote monitoring by human operators would require considerable manpower. Silicon Valley start-up mpathy.ai, however, told the conference it believes it has a workable solution–a fully connected artificial intelligence-driven camera system that it says can be easily installed in the robotaxis of tomorrow.

And what about the smell of the cabin's interior? If someone has been sick–or even if they haven't, but are nonetheless the source of unwanted and unpleasant smells–the vehicle at best needs airing, or more likely deodorising. Enter 'artificial nose' technology, which can detect malodorous conditions and activate cabin ventilation or perfume ducts accordingly.

Such technology comes from nimble, agile start-ups, but to move ideas from the drawing board into scalable businesses, they need plenty of investment. Fortunately, there's currently plenty of investment to be found, from private venture capital (VC) firms to automaker corporate VCs seeking out exciting ideas that can be nurtured and grown.

VC portfolios work on a two-thirds/one-third assumption, explained Jim Adler of Toyota AI Ventures, with the larger share of the portfolio struggling to return capital, supported by the success of the companies in the smaller share. To succeed in the fast-moving future mobility field, then, companies need to stand out from the crowd–to be the black sheep, if you like. And then they might be closer to making the connection between sick, scooters, start-ups and sheep.

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> ## Motion sickness—or kinetosis—is a make-or-break issue for AVs

Does the connected car pose a threat to a connected life?

With more on-demand mobility services than ever at the tap of a smartphone, the old adage of 'more connections, more risks' has never been more accurate. By Freddie Holmes

Consumers today are happy to share a significant amount of personal data with connected devices in order to make the service more functional and convenient. The same applies to new cars and mobility solutions, and in future, autonomous shuttles. However, the consequences of losing control to a hacker may not simply be inconvenient or embarrassing, but potentially life threatening.

"We are putting more information out there and more trust in these vehicles, but it is important to bear in mind that the information we are sharing is personal," said Chuck Brokish, Director of Automotive Business Development at Green Hills Software. "Users today are revealing their location, where and when they travel and which services they use. All of that information essentially tracks us as individuals."

The risks have already been made clear. In 2016, a UK-based Nissan Leaf was hacked all the way from Australia. At the time, the NissanConnect smartphone app only required a car's vehicle identification number (VIN) to take control, and by copy and pasting URL codes into an Internet brwiser, the researcher was able to access details such as where and when the car had recently been driven. Hacks such as this may not lead to the vehicle causing

" Imagine how horrible it would be if you ride-hailed and a couple of days later found out that your bank accounts had been drained

havoc on the road, but it could result in your home being burgled while you're at work, or even a coordinated hijacking.

It is not only location information or personal preferences on offer. In order to unlock a shared e-scooter or pay for a ride-hailing service, personal financial information must be accessed. Industry stakeholders are also pushing for new vehicles to feature an 'e-wallet' to pay for services such as tolls and fuel seamlessly.

"At this point, you are frankly looking at the risk of identity theft," warned Brokish. "Imagine how horrible it would be if you ride-

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> It is not just about securing our personal information, it is about securing our life

hailed and a couple of days later found out that your bank accounts had been drained."

Autonomous vehicles

Consumers are taking greater risks with mobile devices in general, observed Brokish, and that mind set is spreading to new vehicles as well. But as elements of automated driving make their way onto the road, concerns around cyber security are amplified exponentially.

"As more autonomous capabilities become available, we will not be putting our lives in the hands of a driver, but in the car itself," he said. "As such, we need to make sure no one can alter the path of that vehicle, or the functionality of critical driving functions. It is not just about securing our personal information, it is about securing our life."

Indeed, the risks associated with an unsecured smartphone are relatively minor. A hacker may be able to access your contact list or browser history, but there is no immediate safety threat. With an autonomous vehicle travelling upwards of 60 miles per hour through busy towns, the lives of its passengers, other road users and pedestrians are at stake. The now infamous hack that left Wired journalist Andy Greenberg stranded on a St. Louis highway after the brakes and steering had been hacked remotely by researchers is testament so.

"The autonomous vehicle has your life in its hands," said Brokish. "Each step in automation means the need to keep that mobility device secure grows exponentially. It is vital that applications in the vehicle are properly separated and have freedom from interference. That will require mandatory access control, so we can manage who has access to what and when."

A threat to society

Sharing all this data creates a pleasing user experience, but it does come at a risk. As more services and features enter a mobile device, consumers will naturally become more reliant on it. The panic of a lost phone today only underlines the issue: the financial value of a smartphone is easily eclipsed by the potential risk of private data falling into the wrong hands.

Despite this, consumers are likely to provide mobility devices with even greater access to their personal information than they do with their smartphone. The fallout of that information being accessed by a hacker extends further than a leaked address book–it could cripple societies.

With private vehicle ownership expected to fall, many will instead depend on reliable and safe mobility services. If those services go down, it could leave consumers isolated.

"For every good that all of these tools bring into our life, we are also becoming more dependent on them," said Brokish. "If we do not have our own vehicles any more, we are relying on mobility to get to work, hospital or play. But if someone shuts the system down, we will be paralysed."

For companies such as California-headquartered Green Hills Software, tackling these challenges is front of mind. "The idea of securing the future of mobility is absolutely critical to our core concerns," affirmed Brokish. "We need to ensure that all aspects of the design are secured. This means every port, every connection and every critical task, because hackers are relentless when it comes to discovering vulnerabilities."

Is the auto industry prepared for the future of mobility?

Automakers have acquired a very particular set of skills—but will expertise in manufacturing be enough? By Freddie Holmes

It is nigh on impossible to raise the subject of future mobility without focussing on four key megatrends: connected, autonomous, shared and electric (CASE).

That acronym has served as a banner for the automotive industry's ambitions for some time now, but as those technologies approach commercialisation, is the industry ready for the changes they may bring? This was the focus of a panel discussion among industry stakeholders at M:bility | California, a two-day event hosted by *Automotive World* in San Jose.

"We have to look at the trends that have affected, and are affecting the automotive industry, and that leads us to those four letters: the CASE trends," said Alexandre Marian, Managing Director, San Francisco at Alix Partners. "For the past ten years, we have seen these trends disrupt the auto industry, and that will surely continue for the next ten to 15 years."

An existential crisis

The role of the automaker is changing. Once the focal point of the industry, the world's leading vehicle manufacturers are now working with a wide array of partners to make CASE technologies viable. In some cases, competitors are even working hand-in-hand to survive.

"I don't want to say there is consolidation, because that has a negative undertone. But there are certainly ecosystems forming around mobility," said Martta Lystila, Senior Director

> "
> I think everyone is realising that this meal is too big for anyone to cook alone

of Zenuity's Silicon Valley Tech Hub. "Automakers and Tier 1s are coming together and forming different alliances–I think everyone is realising that this meal is too big for anyone to cook alone."

The partnership between Daimler and BMW is a case in point, with the German automakers recently combining their mobility services through a joint venture. Clearly, even the big names need to adapt their core business to keep up with start-ups. "Automakers used to be at the centre of that ecosystem, with everybody else following their lead," said Marian. "They were the ones selling cars and owning the brands, but that dynamic is changing dramatically as a result of the CASE trends."

Automakers have a very particular set of skills– skills that have been built up over a significant period of time. Vehicle design and assembly, along with system integration, is the bread and butter of the established automaker, but software competency and fleet operations are areas where they may struggle. This, said Marian, does not leave them well positioned when it comes to

tackling mobility as a service (MaaS). "The challenge of going from a hardware mindset to a software mindset is a big deal," he affirmed.

"There will be some automakers that do really well, but others are really going to struggle," added Daniel Florence, Chief Operating Officer at Sixt USA.

Over the air

Automakers are used to developing products gradually, often over a period of several years, before launching to the public. However, in the world of software, even a year is considered a lifetime, and vehicle manufacturers run the risk of releasing vehicles that feel out of date.

"Car makers are used to a linear development cycle, but in software, it is about continuous improvement," explained Jason Stinson, Co-Founder and Chief Technical Officer at Renovo. "They need to get used to continuously making the product better. It cannot be the case that you leave the service centre and your car is immediately out of date."

It may take time for the industry to become comfortable with this new way of working, but the awareness is there at least. "I think the new entrants have woken up the incumbents," said Lystila. "They have created a buzz, and issued a real wake-up call."

Zenuity, she added, is trying to mirror the working style of an 'agile software company.' The company was formed out of a joint venture between Volvo Cars and Autoliv in January 2017 to develop advanced driver assistance and autonomous driving software.

A case for profitability

Electrified, connected and autonomous vehicle technologies are all key components to a wider aspiration: shared mobility. Most major automakers by now have created some form of mobility service offering, but the list of success stories remains extremely brief. Ford's closure of Chariot may be the best example of the struggles in making money from the mobility business today. Part of the issue, said Marian, may be due to the fact that there is a focus on revenue and not profitability.

"The service operators have two main stakeholders to manage: the drivers and the users. However, the pricing equation at the moment does not make sense," he explained. "But will robo-taxis capture that lost revenue because there is no requirement for a driver? Or will they find a path to profitability before that–this really needs to be sorted out."

"The focus for all of those companies right now is not on profitability, it's on growth," agreed Stinson. "But once you take the driver out and achieve cost parity, the growth numbers make sense."

There is also the elephant in the room to address: the cost of the car. Robotaxis may remove the need for a driver, but with all of that hardware on board they will be significantly more expensive to launch. "With all of those sensors, you have a much higher CAPEX," said Lystila.

Arguably positioned as a world-leading test bed for autonomous driving programmes, Marian believes California is "completely focussed" on crafting the future of driverless vehicles. However, he suggested that there are more pressing megatrends to address. "Right now, the trend that is mostly affecting automakers is electrification," he explained.

Is society ready?

All of this raises another question: is society ready for the changes these technologies may bring? Most consumers will only be vaguely aware of CASE mobility, and adoption of robo-taxis may prove a very gradual process. "It will take time to get the consumer comfortable in that kind of space," said Lystila.

The panel recognised that ultimately, the future of mobility will have far wider implications than the automotive industry. As Florence put it: "We believe all of this will be a bigger sea change for society than the introduction of the Internet."

Poised and prepared: proactive sensor cleaning is a must

For automated vehicles, connectivity could mean the end of mucky sensors. By Freddie Holmes

While some sensors are sheltered from the elements by the windscreen, others sit around the 'belt line' of the car. While this may be the ideal viewing point for vision sensors, it is also the dirtiest. Research from fluid management and sensor cleaning specialist dlhBOWLES has found that even in normal road conditions, camera sensors located around the belt line can be almost fully obscured within just 15 minutes of driving.

The importance of ensuring that those sensors are clean when the car sets off is clear. However, they must also stay clean whilst in transit. Maryland-based dlhBOWLES believes its sensor cleaning technology can be paired with a range of connected services to help vehicles 'prep' certain sensors depending on what is coming up ahead.

The idea is to help avoid a scenario where a sensor is obscured when it is required to navigate a turn or another manoeuvre. What's more, if there is no human driver available to apply some elbow grease, such vehicles run the risk of being incapacitated mid-way through a drive–or worse.

"Sensor availability is vital to autonomous vehicles (AVs)," says Russell Hester, Director of Business Development at dlhBOWLES. "Many of us take for granted that when we open our eyes or look in a new direction we can see;

> " Even in normal road conditions, camera sensors located around the belt line can be almost fully obscured within just 15 minutes of driving

imagine the concern if every time you looked to your left, you were blind."

While this may seem dramatic, the reality is that AVs rely on their sensors to operate–if they are blocked, the car cannot see. "If sensors are obscured or otherwise not fully functional when needed, an AV will need to take countermeasures to keep their passengers safe," Hester explained. In such a case, he suggests, the vehicle could cautiously pull over to the side of the road–"like when we slowly fumble around in the dark with our hands"– but this is far from ideal. There must be a better solution, or preferably, a preventative measure.

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> If a driverless vehicle's GPS system knows that the vehicle will soon take a right-hand turn, it can perform a system check to ensure the necessary sensors are good to go
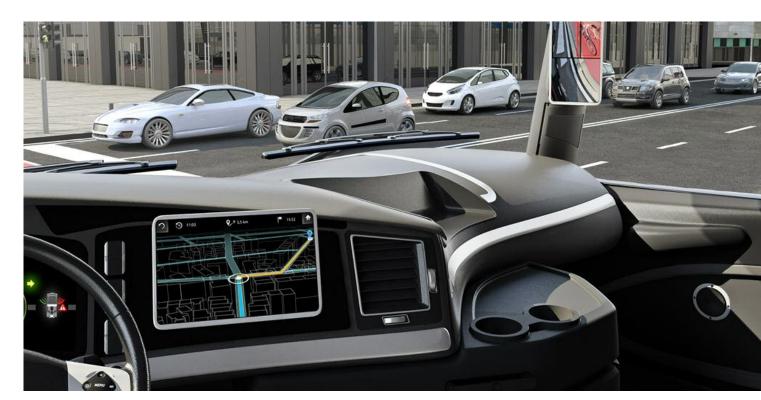
ADAS

The technology at hand is fairly straightforward and is borne out of the company's decades of experience in windshield washers. To keep sensors clean, one of the most effective ways is to spray a special mix of fluid to remove that grime.

Sensors can become blocked surprisingly quickly, and even in seemingly clear conditions. It's not just mud and road dust to consider; in the snow and muck of a harsh Michigan winter, things are even worse. "Under normal autumn or winter conditions in the US it is not uncommon for sensors to become dirtied to a point of ineffectiveness in as few as

ten miles," said Hester. "While our data from test vehicles in Michigan or Ohio–known for bad winter road conditions– was not surprising, this corroborating result in the Southern state of Maryland was unexpected."

While the problem is certainly more pronounced for driverless vehicles in future, the challenge is also relevant to cars on the road today. Advanced driver assistance systems (ADAS) are no longer reserved for upmarket marques; features such as automatic emergency braking (AEB) and lane-keep assist (LKA) are commonplace even on entry-level vehicles, and many rely only on a forward-facing camera sensor. If that becomes blocked, the driver can be met by a barrage of

When sensors are required to safely make a turn, they must be clean in advance

warnings–in some cases advising that he or she pull over and sort things out.

Hester has concerns that this could hamper the industry's effort to make automated functions more attractive to prospective buyers. "Present ADAS features are mostly related to convenience functions like cruise control and can be substituted by manual driving," he said. "Having these features unavailable on a vehicle becomes a nuisance for the owner. As ADAS features evolve into more and more safety-critical functions then there should be a concern of sensor availability."

By extension, that would likely make robotaxis more of a hard sell in future. "Intermittent availability of ADAS features on today's vehicles do present a risk to the adoption of AVs," he continued. "Reliability and comfort with the use and operation of today's ADAS functions, their related hardware and dependability, is establishing a foundation of trust in the technology whether we like it or not. Any apprehension the common driver may experience in their vehicle today will influence their faith in tomorrow's AV."

Mission-critical

There are a variety of instances where sensor availability comes into play. Sensors could clean themselves whilst parked 'valet style', for example. However, this would require predetermined spots to be set up. Self-cleaning sensors could make a mess of a home garage, but outdoor areas with appropriate drainage would reduce the environmental impact of any cleaning products.

Even reversing cameras require a once-over before setting off, advised Hester. "It is best to clean the camera when you pull in to your parking spot at work at the beginning of the work day–before the vehicle's next 'mission'. Waiting until the end of the work day when the driver is about to back out of the parking spot reveals that the soiling from the morning's commute has dried on the lens, rendering the camera useless and unsafe. This forces the driver to rely on traditional visual checks," he warned.

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> If sensors are obscured or otherwise not fully functional when needed, an AV will need to take countermeasures to keep their passengers safe

Critical driving functions that rely on a clear view of the road may require the introduction of connectivity. If a driverless vehicle's GPS system knows that the vehicle will soon take a right-hand turn, it can perform a system check to ensure the necessary sensors are good to go. "Sensor availability can be validated in time for a safe execution of that right-hand turn," explained Hester. "If a required sensor is determined to be dirty, the vehicle can perform a pre-emptive clean."

Join the conversation

Sensor availability is one of many niche elements to vehicle automation that the industry will need to consider. Ensuring that sensors are poised and prepared for every eventuality will help to eliminate any consumer frustration when using driver-assist features today. It will also be vital when those sensors become the vehicle's primary means of navigating complex road situations safely.

While the topic may appear to have been overlooked, Hester advised that it is a major talking point behind closed doors. "Many of our customers and technology partners in the industry are actively exploring this matter," he concluded. "As every month passes more simulations are being run, hardware and software is being tweaked and on-road miles are accumulated. A number of automakers are implementing sensor cleaning systems on current ADAS features."

What role will AI play in the cockpit of the future?

Voice control is likely to dominate the user experience, and Affectiva believes that requires the introduction of human perception artificial intelligence. By Freddie Holmes

The cockpit of today is becoming increasingly digital, but drivers remain in control of the vehicle and its creature comforts. In a driverless future, artificial intelligence (AI) will be required to shape the user experience (UX) and ensure the ride is as enjoyable as ever.

To this end, Boston-headquartered Affectiva is developing what it calls Emotion AI, which measures facial expressions using computer vision, as well as vocal analysis through speech science, to recognise the emotional and cognitive state of human drivers and passengers.

An early use case will be to reduce driver distraction, highlighting when a driver is looking at his or her phone behind the wheel, or misusing a semi-autonomous driving feature. Numerous incidents have already occurred where drivers have abused highway pilot systems, and the start-up believes that Emotion AI could help encourage drivers to pay attention. The technology is also being honed for fully driverless vehicles of the future.

The system works by identifying, isolating and tracking a human face. Vision-based algorithms then analyse and categorise facial expressions to judge human emotions and states. Future iterations will also be able to detect objects such as smartphones. Affectiva does not develop its

> " The HMI in the cabin will become significantly smarter within the next few years, but it also has to become more conversational, sophisticated and intuitive

own cameras or microphones to provide developers the freedom to integrate the technology within their vehicles as they see fit.

A little more conversation

While early use cases are certainly promising, Affectiva also has a keen eye on the future. The company aims to improve the in-vehicle UX in a world where drivers become passengers, and thus voice control becomes the norm.

"We believe that the human-machine interface (HMI) in the cabin will become significantly smarter within the next few years, but it also has to become more conversational,

sophisticated and intuitive," said Abdo Mahmoud, Senior Product Manager at Affectiva. "You can draw parallels with the changes that have taken place with smartphones; they used to be simple devices to make calls, but are now very advanced machines."

A future of voice control would be a far cry from today. Despite the best intentions of many automakers, voice recognition is rarely favoured over physical switches and buttons. That being said, the technology has come on leaps and bounds of late, even to a point where the system can interpret casual language and make relevant suggestions–"I'm hungry" can be understood as "find me a restaurant nearby that is open now and suits my preferences."
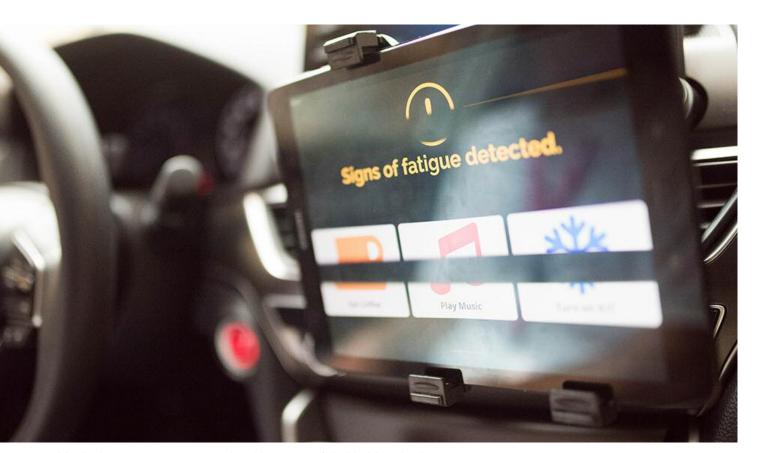
But if drivers no longer have control of the vehicle themselves–and are even sharing a robotaxi with strangers–what role can advanced Human Perception AI play? "The cabin experience within the vehicle will become more of a critical differentiator across different brands," Mahmoud suggested. "In

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> Many people experience nausea in AV test cars, and facial and vocal expressions can help developers to adapt the way the car drives

robotaxis, the cabin can provide information that is critical to their operations."

For example, it is useful for the vehicle to know where people are sitting, whether they have their seat belt on and whether they are using a smartphone. The technology could also be used to alert a passenger that he or she has left their wallet behind. All this information can help to ensure that passengers feel comfortable in the

Monitoring systems can ensure that drivers are safe behind the wheel

vehicle–it will give the impression that it understands exactly what is going on, and may even come across as helpful and friendly. That is a big plus for AV service operators, which will initially have to win over sceptics or scared first-time riders.

The AI should also be able to recognise how passengers are feeling. "A good example is if you get into a robotaxi and fall asleep," said Mahmoud. "The car should recognise that, wake you up before you reach your destination and ensure you exited the ride safely with all your belongings."

Acts such as this will help the car to build a rapport with users over time. Consider the wave of relief when another passenger passes over the wallet that had slipped out of your pocket by accident, or the taxi driver that advises the destination is just a few minutes away. It's the little things that make all the difference, but digitising those micro-interactions is a sizeable task.

Public opinion

Numerous AV developers have prototype vehicles running on public roads today. In August 2019, more than 60 players held a permit to test with a safety driver in California alone. The vast majority of AV pilots do not take members of the public along, but a small handful do. In this case, Emotion AI can play a useful role.

For example, Waymo's Early Rider programme in Phoenix may have a safety driver behind the wheel, but it also has willing volunteers in the back seat. Footage of each ride can show how passengers react to certain events whilst the car was driving, and how the experience can be tweaked. Mahmoud explained that Affectiva's Emotion AI technology can help developers to sift through hours of AV test footage and catalogue emotions.

"We can use data from the vehicle in order to understand their experience, as well as how they react to the operation of the vehicle itself. A good example is that many people experience nausea in AV test cars, and facial and vocal expressions can help developers to adapt the way the car drives," he explained. While the technology has not been trained to recognise a passenger physically vomiting just yet, recognising that a passenger feels sick in advance of such a situation–and driving more gently as a result–is a bonus for all involved.

The smart cabin of the future

Somewhat fuelled by millennial demands for on-demand mobility, the next generation of shared vehicles will focus less on driving dynamics and more on usability and comfort. That naturally places a greater emphasis on how passengers interact with devices in the cabin, and further in the future, how the car interacts with its passengers.

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> We are building the next-generation of AI-based systems for the smart cabin of the future

Mahmoud believes that smart in-vehicle communication is the next frontier for vehicle HMI, with Affectiva nicely positioned to reap the benefits. Indeed, the start-up recently secured an additional round of funding to the tune of US$26m, led by Tier 1 AV specialist Aptiv and several venture capital firms.

"We are in somewhat of a unique position, having built similar systems in another vertical for years. In automotive, we are building the next-generation of AI-based systems for the smart cabin of the future," he concluded. "That holistic system will understand not only where the driver is looking, but also how they are feeling and which objects they are interacting with. And not only for the driver, but for all passengers in the vehicle."

Can Luxembourg become a future mobility tech hub?

With access to key European markets and a cross-border test bed for automated and connected vehicles, Luxembourg aims to become the 'digital heart' of Europe. By Freddie Holmes

The concept of future mobility is a step change for the incumbent automotive industry, and has led to a wave of investments and partnerships between existing players and new entrants. Technology innovation continues at a rapid pace, and the pressure is on to secure a workforce that can help shape a future of connected, autonomous, shared and electric (CASE) mobility.

All of this may well require players to look outside of the box and expand into new territory. Luxinnovation, the national innovation agency of Luxembourg, believes the country is well placed to serve the wave of new mobility start-ups cropping up across Europe, and act as a useful testing ground for CASE technologies.

In partnership with the Luxembourg Ministry of Economy and the Chamber of Commerce, Luxinnovation's aim is to not only encourage start-ups and entrepreneurs to set up shop in the city-state, but also to secure foreign investment from established players. The non-profit agency works with a wide range of industries, from clean tech and finance to logistics and maritime. In 2018, 220 companies received tailor-made and individualised support as a result of Luxinnovation's work, and led to the launch of more than 50 R&D projects.

> " Players should not necessarily come for Luxembourg's internal market, but there are business opportunities in Europe that can be well served from Luxembourg

Moving forward, the organisation is making a concerted push to become a tech hub for the mobility sector.

Europe's next tech hub?

Luxembourg may not be the most obvious location for a mobility tech hub, but it has a number of key attributes in its favour. It is well served with graduates in software and computer science from the universities of Luxembourg and nearby Saarbrücken, and boasts close ties with surrounding

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> ## Luxembourg can become a tech hub for software fields related to autonomous driving and connectivity

regions of France and Germany to allow for cross-border testing of 5G and autonomous driving. "We are particularly looking at the companies that fill the gaps of innovation in Europe," explained Joost Ortjens, Head of International Business Development–Automotive at Luxinnovation.

Given Luxembourg's diminutive size–home to around 600,000 people–the agency is not necessarily encouraging automakers to set up manufacturing hubs, however. Instead, it could house R&D headquarters or technical support facilities to serve European customers. "Players should not necessarily come for Luxembourg's

internal market," said Ortjens. Typical locations for such facilities would be the Netherlands, Belgium, Germany or France, but Luxinnovation believes Luxembourg should also be on that list. "It is very small, but there are business opportunities in Europe that can be well served from Luxembourg."

One of the areas on which the agency intends to focus is software-based technology that is relevant to autonomous driving. It may come as a surprise, given the number of big name suppliers present in Germany and France, such as Continental, ZF and Valeo, not to mention the premium automakers.

Luxembourg could prove attractive for players looking to tap into the wider European market

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> A highway network of more than 130 miles of public roads means that drivers can easily pass through France, Germany and Luxembourg

Indeed, Ortjens is quick to point out that "autonomous driving in general is not considered to be a weakness in Europe," but conceded that software development, artificial intelligence (AI) and testing and accreditation appear to be slightly stronger in the US. The Bay Area of California is particularly flush with talent, but that's not to say Europe cannot catch up. "On the software side, there is a lot of potential for us to bring many of these US-based companies from the Bay Area into Europe via Luxembourg," Ortjens affirmed. "Luxembourg can become a tech hub for software fields related to autonomous driving and connectivity."

5G and AVs

Luxembourg is part of Europe's largest cross-border automotive network that is made up of more than 500 companies, and spans across six regions. Geographically, Luxembourg sits at the centre of this hub between Belgium, France and Germany. In Luxinnovation's words, it acts as 'the digital heart of Europe', and is looking to further strengthen that position.

Given its location, the country provides access to a cross-border test bed for autonomous and connected driving. A highway network of more than 130 miles of public roads means that drivers can easily pass through France, Germany and Luxembourg in a triangle. The highway is being outfitted with 5G antennas through a partnership between Deutsche Telekom in Germany, Orange in France and POST Luxembourg, the country's national telecoms provider. The 5GCroCo trial–in which numerous players including PSA, Renault, Volkswagen and Volvo Cars are taking part– began in 2018 and will run to the end of 2021.

This cross-border highway allows developers to test how 5G connectivity fluctuates when passing through different countries, which is highly common for European drivers. "If your connection drops out when crossing a border, it is annoying, but nothing more than that," said Ortjens. "But if an autonomous vehicle is using data from outside of the vehicle that relates to safety applications, it is vital that the data stream is reliable and uninterrupted."

Thanks to this 'digital highway', developers can also attain permits to test autonomous vehicles in all three countries. Then there is the Mobility Innovation Campus, a dedicated site for R&D facilities that already hosts a number of global Tier 1s.

Every little counts

There are also practical reasons to establish a presence in Luxembourg; its natives speak German, French and English, which makes networking with companies in the surrounding area more straightforward. "It's easy for a company to build up an organisation with German and French expertise," explained Otjens.

Then there is the country's favourable taxation policy which may prove attractive for larger companies, "especially when making a strategic decision about where to be located in Europe," Ortjens added. "As Luxinnovation, we bring in the knowledge of innovative businesses in Luxembourg and Europe, and can leverage the position that our companies play in the fields of research and development for the future mobility space."