A focus on the latest in technology, innovation and sustainability

Ricardo Quarterly Review

Q2 2018

Interview
Peter Moelgg
GKN’s head of electric drives

Vehicle fleet electrification
Guiding corporate strategy for introducing hybrids and electrics

Airports and the environment
Ricardo teams steer operators towards low-impact expansion

AUTONOMOUS VEHICLES: Are they still the future?

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The task of RQ is to highlight the latest thinking in global engineering and technology in the transportation and clean energy sectors and related industries. We aim to achieve this by presenting an up-to-date mix of news, profiles and interviews with top business leaders, as well as in-depth features on programmes – both from within Ricardo and other leading companies.

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Political and public pressure on diesel has never been higher, but German producers are continuing to champion it, particularly for larger cars, with VW’s outgoing CEO even predicting a “renaissance” for the fuel. And now, a new development from the world’s largest automotive supplier, Bosch, gives some credence to the idea of a diesel comeback.

Promising to “put a stop, once and for all, to the debate about the demise of diesel technology,” Bosch CEO Volkmar Denner explained how new developments could enable vehicle manufacturers to reduce emissions of nitrogen oxides (NOx) so drastically that cars will already be able to comply with 2020 limits – even real driving emissions (RDe) values.

Vehicles incorporating the new development could achieve as low as 13 µg per km NOx, with an average of 40 µg; the 2020 limit is 120µg. The new technology does not require any new components but achieves its reductions by dealing with the NOx spikes that come with ‘dynamic’ acceleration. The key, says Bosch, is in highly responsive airflow management and a turbo that reacts more quickly than conventional units. Also important is sophisticated thermal management to keep exhaust temperatures above 200 Celsius, especially in urban driving, to maintain optimum NOx conversion.

Is this the answer for diesel?

As Hamburg becomes the first German city to ban older diesels and the European Commission begins referring EU states to the court of justice for air quality infringements, governments around the world are looking further ahead and weighing up complete bans on the sale of combustion-engined passenger cars.

Paris, Madrid, Athens and Mexico City are all excluding older diesels from their streets by 2025, while Norway and the Netherlands plan to outlaw the sale of new combustion-engined cars by the same date, though some uncertainty still surrounds the fate of hybrids. The same applies to combustion-engine exclusions announced by India and China for 2030, and ‘total’ gasoline and diesel bans in the UK and France for 2040 are still awaiting ministerial clarification. UK Environment Secretary Michael Gove has hinted that, post-2040, the only hybrids permitted will be those capable of more than 50 miles (80 km) on battery power alone. This would exclude almost all of today’s hybrids and plug-in models.

The reactions from industry and the markets have been swift. April diesel sales in Germany plunged by 13 percent year on year, to just one third of overall registrations, the lowest since 2001: diesel’s Europe-wide share slumped to below 37 percent, with electrified models jumping to a 5.5 percent high.

Manufacturers have responded, too, with Nissan and Volvo announcing a phase-out of diesel in passenger cars, joining the ranks of Toyota and Fiat-Chrysler earlier this year. Almost all major automakers have followed Volvo’s lead last summer and committed themselves to electrified versions of their main model lines, and the new S60 will be Volvo’s first sedan without a diesel option.

Filling stations: will these be a rare sight in 20 years’ time? Will they be replaced by rapid chargers and hydrogen dispensers?

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Rulemakers call time on gasoline and diesel

Photo: Shell

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INDUSTRY NEWS

The latest in technology, innovation and sustainability across world industries

Rulemakers call time on gasoline and diesel

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Marine emissions cut

The International Maritime Organization (IMO) has agreed to a 50 percent cut in shipping’s CO2 emissions by 2050, slightly less ambitious than the 70 percent the EU had been pushing for, but significant nevertheless. Shipping accounts for 2.5 percent of global GHG emissions, and the shift to cleaner and less carbon-intensive propulsion is expected to lead to a collapse in the market for low-grade bunker fuels.

Carbon rise threatens Paris hopes

After having levelled off between 2014 and 2016, global carbon emissions began to rise again in 2017. Figures from the International Energy Agency (IEA) show a 1.4 percent growth in CO2 output in 2017, and 2016, global carbon emissions began to rise again in 2017. After having levelled off between 2014 and 2016, global carbon emissions began to rise again in 2017. The Trump administration’s assertion that the US auto industry would welcome a slackening of standards was countered by GM CEO Mary Barra, who said in a letter to GM employees that: “General Motors supports establishing one national set of fuel efficiency requirements, with flexibilities that take into consideration recent industry developments such as vehicle sharing and self-driving electric vehicles.”

“We are not asking the administration for a rollback,” said Bill Ford, chairman of Ford Motor Co., at a recent automaker meeting, according to Bloomberg News. “We want California at the table, and we want one national standard.”

However, the automakers’ task in meeting future CAFE standards is being made harder by the sustained upswing in sales of heavy and inefficient SUVs and trucks, prompted by low fuel prices.

Lithium from metal-organic membrane

Researchers from Monash and Texas Universities are claiming a win-win for a new metal-organic membrane that mimics the filtering process found in organic cells. The membrane, which connects metal ion nodes with organic linkers in a crystalline structure, has the largest internal surface area per unit volume of any known material and is capable of allowing some atoms through and stopping others. By changing the node and linking materials, different substances can be filtered out. The membrane is said to have potential for low-energy water desalination and can even filter out lithium from liquids.
EU clampdown on truck emissions

In a rare display of unity between business and regulator, leading European companies are pressing the EU for tighter, rather than weaker, standards for road freight emissions. To this end, major operators including IKEA, Carrefour, Nestlé and Unilever have signed a letter to the European Commission and, as reported in the Financial Times.

The companies, along with other groups and trade associations, are calling for a 24 percent cut in truck fuel consumption by 2024, along with mandatory quotas for the introduction of zero-emission commercial vehicles. “If Europe wants to deliver on its Paris commitments and own 2030 targets, transport and truck emissions need to be curbed urgently,” the CEOs stated.

The move would save operators some €5700 per vehicle per year, said the signatories of the letter.

Truck CO2 emissions limits are already in force in the US, Canada, China and Japan, and it is believed that the EU will propose a reduction of 30 percent by 2030. Both this target, and the industry consortium’s figure, are significantly more ambitious than the norms preferred by the European automakers’ association ACEA – a 16 percent reduction in consumption by 2030, with an interim target of seven percent by 2025.

Low-carbon trucks

Shell and the AirFlow Truck Company have collaborated to demonstrate the fuel economy improvements possible with a conventional diesel-powered Class 8 heavy truck. The Shell AirFlow Starship is a 25-metre tractor-trailer combination powered by a 15-litre Cummins diesel rated at 400 hp and 2500 Nm torque. Driving through an 18-speed AMT to a downspeeded axle, the engine’s power is supplemented by an electric axle when climbing grades; added electrical energy is provided by a 5 Kw solar array covering the trailer roof area, and extensive use is made of 48-volt electrics. The hyper-efficient carbon fibre streamliner will undertake a 3800 km coast-to-coast run across the US to show its economy potential: AirFlow’s earlier Bullet Truck managed 13.4 mpg at a GVW of 65,000 lbs (29.48 Tonnes) on a similar exercise in 2011.

Electric cars: the big push begins

Competition is intensifying among the world’s automakers not just in the showrooms and on the race tracks, but also when it comes to electric cars and how many they expect to sell in the future.

Volvo set the ball rolling last year when it promised that from 2019 every new vehicle it launched would be electrified in some way. By 2025, says Volvo, half of all its vehicle sales will be pure electric, the other half being hybrids. Nissan has gone one better, with a commitment to eight new pure EVs, inspired by the Leaf, and annual sales of a million electric vehicles by 2022. Volkswagen will kick off its electric initiative next year with a 48-volt mild hybrid version of the eighth-generation Golf, along with the all-electric I.D. series; gradually, every vehicle in the group’s huge range will be electrified in some way. All future models from PSA’s premium brand DS will be hybrid or fully electric, beginning with a pure electric SUV this autumn, and Audi promises annual sales of 800,000 pure electric and plug-in hybrid cars by 2025; for Porsche, having abandoned diesel, half of all its sales will be electrified by 2025 – including the iconic 911 and 718 Boxster/Cayman sports cars. BMW’s mid-size i4 electric sedan will be a volume seller from 2020, dropping the costly carbon fibre construction of the i3 and slotting in with the next 3-Series at the company’s main production plant in Munich.

Electrification will make its mark on the top premium sector, too, with numerous ultra-fast battery-powered sports cars, Lagonda turning itself into a luxury electric brand, and even Winnebago offering battery-powered versions of its eponymous large camper trucks. UBS forecasts that by 2025 some 16 percent of global vehicle sales will be pure battery electric models.

Following the lead set by the Jaguar I-Pace, the German premium brands are squaring up to each other in the new market for electric crossovers. The Audi e-tron Sportback (pictured) will be built at the VW group’s carbon-neutral Brussels plant from 2019, and will face competition from Mercedes-Benz’s EQ sub-brand, Porsche’s Mission E and BMW’s i-series models.
Renewable hydrogen cheaper than gas

The fast-falling costs of renewable energy mean that solar and wind power can now undercut both gas and nuclear energy – in Europe, at least. And hydrogen could prove a valuable complement to battery and other forms of energy storage used to smooth out the intermittency of some renewable sources.

Already, a plant in northern Germany is producing hydrogen from renewable energy when there is a surplus, and a new study by Berlin’s Energy Brainpool predicts that this hydrogen may soon be cheaper than natural gas; the mass production of electrolyzers would further reduce the cost, says the study. Not only would the hydrogen be an important energy vector in its own right, it would also be a viable alternative to batteries or costly interconnectors to absorb peaks in renewable energy generation.

The study refers to International Energy Agency (IEA) forecasts that natural gas prices will more than double from €0.017/kWh in 2020 to €0.041/kWh in 2040. At the same time, hydrogen generated from wind power could fall from “about €0.18/kWh” to between €0.021 and €0.032/kWh in 2040, the study is quoted as saying.

Denmark and Belgium are investing heavily in more wind power, the latter committing itself to abandoning nuclear power by 2025, and Saudi Arabia has joined with Japan’s SoftBank in a massive $200 billion programme for 200 GW of solar power. In France, pressure is building on nuclear as EDF pushes strongly into solar

EU’s safety stimulus

The auto industry has given its support to a wide-ranging array of new safety measures proposed by the European Commission and set to become mandatory on all new cars within three years.

If the proposals go through, by 2021 all new cars will have to feature automatic emergency braking and lane-keeping assistance, as well as intelligent speed limiters, drowsiness detectors, reversing cameras and pre-wiring for accident data recorders and alcohol interlocks. Other measures will improve protection for children, pedestrians and cyclists. Trucks will require detection systems, and larger windscreen and side windows to improve visibility of cyclists. Other measures are aimed at crash testing, driver behaviour and infrastructure improvement.

The European automakers’ association ACEA has given a guarded welcome to the raft of measures, though advising against unnecessary doubling up of additional systems with parallel functions.

How science-based targets can help multinational companies achieve reductions in GHG emissions

Christine St John Cox – Ricardo Energy & Environment associate director for Sustainable Business

Arising from the 2015 Paris agreement, the Science Based Targets Initiative (SBTi) has over 300 companies committed to developing targets aligned to climate goals. The concept of science-based targets is that they encourage companies to take the mindset that over an agreed period of time, they will implement actions that respond to market changes and the risks associated with climate change. To achieve a fully recognized target signed off by the initiative, the targets need to follow an agreed methodology and be approved at the top level of an organization, which is great because it means that there is a commitment by the decision makers to ensure these targets are met.

How can we make science-based targets even better?

Before signing off on targets, it is important that the company knows just how much investment will be required and how the objectives are going to be met. At the moment, this isn’t included in the process for SBTi approval – but should it be? We think so, and this is why.

For decades we at Ricardo have helped companies, and indeed countries, to set targets and think about what they will need to do to meet them. In many cases we’ve helped to identify cost-effective ways to achieve these ambitions and to use advances in technology and supply chain development to deliver long term savings and greater security for their businesses. But, just as importantly, we have helped reveal where ambitions may not be achievable without companies incurring significant and in some cases unsustainable costs.

Knowing your three scopes

Companies should set three targets in such a way that allows reasonable progress to be tracked in each of the three ‘scopes’ used for greenhouse gas (GHG) accounting and reporting. Emissions are split into three categories. Scope 1 represents those GHG emissions that are directly attributable to the operations and processes of the company, and within its control. Scope 2 represents indirect emissions such as those arising from the grid electricity provided to the company by external generators, where the emissions physically occur remotely at the power station. Finally, Scope 3 represents all other indirect sources of GHG emissions attributable to the activities of the company.

With Scope 2 offering two reporting routes (market or location-based), care should be taken to adopt the appropriate route to represent relevant changes in the company’s activities, not just the energy that is procured. As technology developments, alternative forms of power supply and smart grids continue to become more available, companies will be able to see the benefit. Selecting an inappropriate Scope 2 reporting option will add little value and could mislead stakeholders on progress. Perhaps unsurprisingly, Scope 3 is generally where the larger proportion of emissions lie. It is also where future resource risks lie, so understanding exactly what the challenges will be and what needs to be done is essential. We’ve been working with a new approach to product life cycle assessment (LCA) to help identify cost-effective and sustainable ways to achieve these ambitions and to use advances in technology and supply chain development.

We’ve helped to identify cost-effective ways to achieve these ambitions and to use advances in technology and supply chain development and Scope 3 that allows a company to do both at the same time. Not only does this provide a much better understanding of your Scope 3, it also allows you to see where the resource risks and increased cost per product line are for the future.

So, in summary, science-based targets are great, and we encourage multinational companies to think about adopting them to achieve GHG emissions reduction targets that are aligned with current climate goals. But to make them more robust, they must be matched to a company’s need, and be followed by an understanding of how they are going to be met. To do so a company must consider its choices of Scope 2 and 3 appropriately.
Market projections indicate that the electrified sector will grow from $18.4bn in 2017 to $63.3bn by 2025. Do you recognize those figures?

Yes, they are in this region – all industry forecasts predict that by 2025, some 40 percent of the total fleet is going to be electrified in one way or the other. And with car sales of about 110 million per annum, it comes to these kinds of numbers. Clearly, for us the value add that we’re bringing to the market is changing. Previously, a set of side shafts were worth $100-$150 per vehicle; now, with an electric drive system, it can go to $1500 to $2000 per vehicle. Therefore, for us the importance of electric drivetrains will definitely increase. I think all car ranges will have an e-axle option. The numbers we have seen today are significant, and it’s a huge market success – every customer has come back to us asking for increased capacity because of the success in the market.

Which type of e-axle will be the most popular?

We believe that, for the money, the so-called P4 e-axes give you the best benefit in the vehicle because they have a broad impact. You reduce CO2 emissions radically, you convert the car to a plug-in hybrid and you achieve full electric drive. Technical developments like the eTwinster permit an electrified powertrain to allow torque vectoring and off-road capabilities as well. We believe P4 systems are the most efficient use of electric energy for mobility. That’s important for electric axles so you can get the maximum range on a given battery. With smaller batteries and reduced system weight, the car gets lighter and costs are reduced.

On the environmental agenda: if an OEM needs to be under 90 g/km CO2 on a combustion engine they need to do something different. You reduce CO2 emissions radically, you convert the car to a plug-in hybrid and you achieve full electric drive. Technical developments like the eTwinster permit an electrified powertrain to allow torque vectoring and off-road capabilities as well. We believe P4 systems are the most efficient use of electric energy for mobility. That’s important for electric axles so you can get the maximum range on a given battery. With smaller batteries and reduced system weight, the car gets lighter and costs are reduced.

Some automakers are predicting that EVs will only account for about 25 percent of the market by the middle of the next decade, and that sales will be very localized – the US West Coast, China’s mega-cities, European metropolises. Would you agree?

Yes, those are the numbers that we see and that will include vehicles that allow some electric drive as well as the combustion engine. We believe that BEVs will have a lot of penetration, at first, especially in China. But I think it will be broken down into different sectors: city cars will be predominantly BEVs because you have a lot of short-range commuting where you can plug the car in at the start and finish of the journey. Then there is high speed autobahn driving, and there’s a lot of technology being developed to further improve the combustion engine. I don’t think combustion engines will disappear in the next 20 to 25 years: it is not an ‘either/or’, but both electric and combustion engines going forward.

Are weight and cost the two biggest challenges you face?

Batteries are the heaviest components we have to deal with, but other systems such as the eTwinsterX, from a power density point of view, is one of the most efficient on the market. It weighs only about 80 kg and, with a torque output of 4300 Nm, it beats a Ferrari’s power-to-weight ratio. At present we remain battery agnostic, although we do co-operate with the manufacturers who work closely with the OEMs.

Will e-axes eventually replace conventional mechanical four-wheel drive systems?

I think the time will come when e-axes will erode this market. We distinguish between four-wheel drive and all-wheel drive. The traditional heavy duty four-wheel drive for trucks might be out there for longer, but all-wheel drive systems for passenger cars, which are predominantly there as safety systems, will develop into e-axes with their torque vectoring and traction control. From GKN’s standpoint we came with a profound knowledge and understanding of mechanical four-wheel drive systems, so it was relatively easy for us to develop electric versions from that base, and that engineering heritage has been fundamental to our successful development of e-axes. I wouldn’t exclude any vehicle as a potential application for e-axes – from light commercial vehicles, where we already have a programme with the German Bundespost for electrified delivery vans, through to heavy goods vehicles and earth-moving equipment.

There’s quite a debate as to how many ratios an e-axle or electric motor should have for maximum performance and efficiency. Where do you stand?

This can be a question of philosophy. In the early applications, most of them were single speed, but with the latest e-motors you end up with something like 200 kW and they need larger batteries. But when you bring into the equation a two-step gearbox, then first gear can provide high torque and the second
ratio gives efficiency. By applying this logic, you can use a smaller e-motor which reduces the energy consumption to increase the range. The bottom line is that with an extra gearset you improve electrical efficiency by up to 13 percent. If you add a third gear the improvement is only a few percent: the big gain is adding a second gear, and that’s why we are pushing very hard with a two-step gearbox.

What impact is artificial intelligence having on these systems you’re developing?
With mechanical systems you were always working with clutches in order to gain or maintain traction: now on an e-axle like the Twinster you just lock the axle and control the e-motor. The systems are becoming much more digital and techniques such as using recuperation for vehicle braking mean that future strategies will be totally different and more sophisticated than those in the past or even those in use today. A few years ago we had a handful of software engineers: now we have hundreds and it’s still growing. It’s absolutely vital for us to develop these electronic capabilities.

What’s happened with the flywheel technology you acquired from Williams Engineering in 2014?
We’ve been having lengthy discussions as to what GKN’s focus should be, and part of that is exploring different technologies. For instance, we have looked into 48 volts and the flywheel. The flywheel is basically a mechanical battery that has some very distinctive benefits, but we don’t believe it will go into series production for cars. It has helped us gain knowledge and make us focus on specific areas of technology. There’s no company in the world that can do everything at once. We needed to grow from a purely mechanical engineering company into one that is developing software, and from that to technical differentiation.

We can manage and master flywheel technology, but is it on the radar for the near future? No, but it gave us very valuable experience on the way to developing what we’re now doing. For example, energy storage levels in a flywheel aren’t that big, at the end of the day it delivers 170 kW for 25 to 30 seconds, and that’s very difficult to deploy in a normal car. In a race car where you accelerate to 300 km/h, brake to 50 and then accelerate to 300 again it’s a huge source of instant energy and acceleration such as when Audi used the system to win Le Mans in 2014. Energy recuperation by e-motors and batteries is much more efficient and delivers better benefits. I think people were ever optimistic when it came to the flywheel’s potential for energy storage. In the meantime, batteries have evolved much more than flywheel technology, and with better management and cooling systems they have come on by leaps and bounds compared to flywheels which have, essentially, remained unchanged.

How will the recent takeover of GKN affect these programmes?
The expertise and support from Melrose plc will help us to develop further and will have a strong positive impact to our businesses and programmes. For us, this represents a good upside in our current business development.

Peter Moelgg, GKN CEO for AWD and e-Drive
Peter Moelgg has been with GKN since 1979, holding a range of senior roles across GKN divisions. He was appointed to his most recent role in April 2016, having previously been president of Engineering for GKN’s Automotive divisions for 16 months. He is based in Bruneck, Italy. He holds a diploma in mechanical engineering and is executive sponsor for cross-divisional technology development programmes.

“I wouldn’t exclude any vehicle as a potential application for e-axles – from light commercial vehicles, where we already have a programme with the German Bundespost for electrified delivery vans, through to heavy goods vehicles and earth-moving equipment”
Car drivers are often conservative and it can be a challenge to get them to consider changing to another type of powertrain. However, as vehicle manufacturers introduce more models powered by batteries instead of the familiar internal combustion engine, the decision to switch is becoming more attractive for many. Electric vehicles (EVs) have come a long way in a relatively short space of time but, especially for fleets, making such a transition is a major commitment that requires careful planning.

Thankfully Ricardo, within its sustainable transport and electricity networks teams, has experience of working with fleets who are considering EVs: Ricardo believes that approaching the decision to switch to electric vehicles in an informed way can help companies make a successful transition and benefit their overall business.

“Whether they like it or not, companies will at some point in the future have to electrify their fleets,” says N.H. Hill, the knowledge leader in sustainable transport technology and fuels in Ricardo’s Energy & Environment division. “Right now, they have a choice: they can either do nothing and have electrification effectively imposed on them and possibly suffer unforeseen costs or discomforts, or they can act now and plan ahead.”

“What we do,” continues Hill, “is look at the individual fleet and see which roles could be carried out by an electric vehicle,
and what suitable vehicles are coming onto the market in the next few years. We work out how this switch can best work for a company by way of a cost-benefit analysis based on fleet usage data.”

The need to go electric
Ricardo researchers have identified three main drivers for fleet electrification: health, including corporate CSR; compliance with national and local policy directed at reducing CO2 and air pollution, and total cost of ownership (TCO). The last point is arguably the most important one for fleets as any changes to fleets link back to the commercially important factors of financial sustainability and market competitiveness.

“In 2010 and 2011 we were looking at EVs with real-world ranges of 70 to 80 miles,” says Hill, “but the change over the last few years has been quicker than expected, and with improved batteries we are now in the region of 200 or more miles for the likes of the Tesla Model S and, increasingly, some more mainstream models.”

The longer vehicle ranges have helped to reduce range anxiety, and engineering development has also meant the cost of the battery has fallen. “There has been a more than twofold decrease in the cost of batteries in the five years to 2015 and we are expecting costs to halve again in the five-year period to 2020, and even further going forward,” reveals Hill.

One of the reasons Ricardo is often approached by clients stems from its long-standing relationship with automotive OEMs, nurtured through working with them on previous projects and early trials and evaluations of electric vehicles. Dan Clarke, Ricardo’s fleet electrification lead, explains: “We have insights from manufacturers as to what electric vehicle models are coming and when – and we have also done a lot of work with conventional vehicles and can see how they are improving. So, we can advise on both sides, not just the electrification”.

“Part of our job is to let people know that things are changing rapidly,” adds Clarke. “Even if the right vehicles for an organization aren’t yet available, or the infrastructure hasn’t reached the required level of maturity, it won’t take long, so fleet operators need to be thinking about what’s next. Our job is to help customers understand the landscape and work out a plan for what they need to do and when.”

Oxford aims for zero emissions
One of the emission-control areas Clarke refers to is Oxford, which is working towards the introduction of a zero-emission zone by 2020. This goes one stage further than the clean air zones, of which there are many around the UK.

“Although Oxford’s zone is smaller than some others, it is also an important one,” says Hill. BMW’s stand at the 2017 Frankfurt motor show with (centre) the battery-powered C-Evolution luxury scooter and the iVision Dynamics concept car, precursor to a volume production electric model in 2021.
he says. “Oxford is a historic city, so the topography and tall buildings mean there is a specific air quality issue – especially on certain streets. This situation has driven the council to look at air quality in more detail, because they see an opportunity to improve it through cleaner vehicles. They are already working with bus companies and are using that relationship to try and move the initiative forward, and Oxford is ahead of the national curve for deployment of zero emissions vehicles in fleets. It will start on a small scale and then, from 2025, it will expand to a wider area before growing again to cover more of the city from 2030.”

As part of the Oxford project, Ricardo modelled air quality and emissions around the city, based on actual available data, to set a baseline; it then modelled possible air quality improvements as a result of the introduction of the zone. It also carried out a cost benefit analysis for resident businesses that are included in the zone. Oxford is one of a number of cities which are looking at similar clean air zone schemes and Ricardo is playing a part in many of them.

“The original UK government air quality plan identified five cities breaching the air quality emission levels and which would need to implement changes,” Clarke explains. “The initiative evolved into Clean Air Zones and we are already working with Leeds, Nottingham, Derby, Southampton and others. They might not all result in zero emission zones, but are likely to include requirements for cleaner vehicles. This acts as a trigger for fleets to start thinking about electrification of their vehicles.”

With the number of electric vehicles on the road growing month by month, the demand for places to charge these vehicles – and on the energy networks to supply the power – is on the rise too. Ricardo also works with charging providers to help them plan and deploy charging schemes. In fact, Ricardo’s work crosses many boundaries, covering a range from vehicle-based assessment, charging infrastructure and electricity networks, to impact assessment and cost-benefit analysis. This approach enables Ricardo to identify effective solutions for the organizations it works with.

Aside from home charging units, the EV charging infrastructure around the UK is typically limited to parking bays at sites such as retail outlets, service stations and car parks; however, a more coherent ‘charging ecosystem’ approach may be required in the mid- to long-term if EV numbers continue increasing at the current rate. Ricardo has undertaken studies based around the ability of towns and cities to have their own charging network, such as the project with Pebble Power in Brighton (see panel story). Here, several charging solutions were considered, including on-street charging.
“Environmental offers when it comes to growing number of possibilities that the options available.”

Recharge your vehicles. There are lots of ways to invest and how quickly you need to consider – which option you go for depends on how much money you want to put in. Naberezhnykh. “All options need to be considered – which option you go for depends on how much money you want to invest and how quickly you need to recharge your vehicles. There are lots of options available.”

Naberezhnykh, a strong advocate of electrification, also highlights the growing number of possibilities that the environment offers when it comes to vehicle charging. “We are involved in work around smart charging and the ability to manage charging – turning it off or on, depending on the grid demand. One project we’re involved with, called Smart Hubs, is building hubs of car parks with solar panels generating renewable energy to charge the electric vehicles in the car park.”

Naberezhnykh says the project, led by Ricardo’s electricity networks team, has helped prompt the question as to exactly what a charging infrastructure is. "Do you think it is just a plug, or do you begin to start having discussions with operators who are interested in providing grid services and potentially looking at it as a revenue stream? If you are going to be investing in infrastructure, why not sell the stored energy to other users or back to the grid stream? If you are going to be investing in infrastructure, why not sell the stored energy to other users or back to the grid stream?"

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Outlook

Despite the reservations and scepticism of some, electric vehicles have made big strides over the past decade and will continue to do so in the years to come. Ricardo sees itself as ideally placed as an informed partner on all areas of the business.

“There are other providers in the market offering fleet assessment services and whose primary aim is to sell vehicles,” says Nik Hill. "What we do is look at the data, look at the vehicle and how it matches to the market now and in the next five years, and even beyond this in some cases. Many of the Ricardo team are also EV owners and drivers themselves, so they can add the valuable extra dimension of direct experience. The result is a broader based and more scientific and objective view than others, and one with a focus on the longer term.”

Brighton’s electric dreams

Pebble Power, which supports people and community causes in Brighton & Hove, has commissioned Ricardo to help guide the development of a plan for an EV charging infrastructure for the city. The area currently has restricted potential for EV take up because there are very high levels of on-street parking in and around the city, meaning traditional home charging systems are not an option.

“We looked at technologies and costs, the objective being to try to lower the barriers for the uptake of EVs across the city,” explains Ricardo’s Dan Clarke. “That approach led us to consider contactless payment methods to remove the need to pre-register or carry a prepayment card (for use of on-street facilities). We talked to suppliers about contactless payments, and then had to balance the technology with the view of lowering barriers to entry and match that to the infrastructure currently in place across the city.”

One of the key considerations regarding the densely populated areas of the city was the electricity demand. With some houses having multiple occupancy, there is already high demand and pressure on the grid network; with the higher population density, the Ricardo team had to look at all types and sources of charging and identify the costs prior to developing a rollout plan.
Once the preserve of the rich and famous, air travel is now something that is not just accessible to the masses, but in many cases represents the most convenient and affordable means of medium and long-distance transportation. This process of democratization was kickstarted by a series of technical developments and pioneering business disruptors to the established model of the airline operations – from Freddie Laker’s Sky Train of the 1980s to the many low-cost carriers operating around the world today on both short- and long-haul routes.

Environmentalists might wish for this period of growth to soon come to an end, with high-speed rail increasingly replacing air travel for journeys of under 800 kilometres. But the uncomfortable truth is that rising incomes and demand from all parts of the world means that air travel is likely to increase significantly over the coming years. According to the International Air Transport Association’s (IATA) forecast published in late 2017, passenger numbers are expected to increase to 7.8 billion in 2036, a near doubling of the 4 billion today. Perhaps even more surprisingly, the UK is expected to remain one of the world’s top five markets [measured in terms of passengers travelling to, from and within] behind China, the United States, India and Indonesia.

Pro-environmental focus
Peter Mulder is business area manager for infrastructure at Ricardo Energy & Environment, and explains the particular challenge facing UK airport operators: “The UK is a densely populated and well-developed part of Europe, so environmental concerns are understandable with any new infrastructure development. Planning regulations and government targets place strict limits on the allowable levels of noise,
years, however, the preference seems to be changing to a greater provision of long-haul point-to-point services, using lower capacity but more fuel-efficient products such as the Boeing Dreamliner and Airbus NEO. An example is the recent launch of the daily non-stop service from London Heathrow to Perth, Australia. In the light of this trend, we are seeing some airlines reconsider their aircraft purchasing strategies while airport operators may need to provide extra runway capacity to support a greater number of both short-haul and point-to-point long-haul flights.”

**Sustainable transport**

The key drivers for sustainable transport for airport operators tend to be the incentives to reduce emissions and to manage the flow of people, services, and cargo to, from and within the airport. At London Heathrow airport, Ricardo co-ordinates and delivers the Clean Vehicle Partnership, an initiative which aims to promote best practice in sustainable fleet management, to provide free advice, guidance and training to reduce emissions, and to facilitate collaborative working and sharing of information amongst Heathrow’s fleet operators. Initiatives recognized under this scheme have been the replacement of escort vehicles and ancillary fleets under 3.5 tonnes with electric vehicles, and the adoption of zero-emission aircraft pushback tugs for short-haul operations.

“Many international airports are exploring initiatives such as these,” continues Mulder. “For example, Amsterdam’s Schiphol airport has already switched to a fully battery-electric fleet of buses for passenger transfers, and many operators already use electric baggage-handling fleets. For the aircraft themselves, one of the low-hanging fruit in terms of emissions reduction is the avoidance of auxiliary power unit (APU) running while on stand. By providing grid power hook-ups, this can provide considerable benefits in terms of both exhaust emissions and noise.”

While the airside vehicle fleet will tend to be within the influence of the airport operator, landside transportation can be a significant limiting factor on an airport’s development. In the absence of adequate and attractive public transport options for passengers and employees, the road network in the vicinity of a growing airport will rapidly become saturated as an airport expands. “With increasing local traffic will come additional emissions, and potential issues of congestion. In exceptional cases – a level where passengers start to miss their flights – the reputational damage to the airport can be self-defeating,” explains Mulder. “Where possible, we help operators examine the strategic options for transportation, ensuring that the flow of passengers and employees to and from the site can be achieved with minimum emissions and congestion.”

Perhaps one of the most intriguing ground transportation issues facing airport operators in the medium term is how to cope with both the increasing use by passengers of electric vehicles, and the changing patterns of vehicle ownership. For many airport operators, the provision of car parking within the airport estate is a substantial source of revenue. For emissions and the carbon intensity of the commercial operation of each airport. As such, there is a clear business incentive to make operations as sustainable as possible, to enable any desired expansion or development to proceed within these limits.”

While Ricardo provides services to airports in many parts of the world, the UK remains currently its largest market. In the UK there is a mix of major international hubs such as London Heathrow and Gatwick, larger airports such as Manchester and Edinburgh, and rapidly developing regional airports serving a range of sectors such as holiday charter flights, and low cost short haul destinations.

With demand growing, almost all operators have ambitions to expand, but in addition to focusing on their own operations they also need to be sensitive to changes affecting air travel more generally. “Until a few years ago, bigger was better in terms of aircraft design,” explains Mulder, “and the major growth in air travel seemed to be driven by the use of high-capacity airliners such as Boeing’s 747-400 and the Airbus 380 to provide hub-to-hub connections, with onward connections provided by smaller planes. In more recent
The UK is a densely populated and well-developed part of Europe, so environmental concerns are understandable with any new infrastructure development.” Peter Mulder, business area manager, Ricardo Energy & Environment

→ the increasing number of electric vehicle owners, a significant consideration in airport preference may be the availability of recharging facilities. This could provide a challenge to airport operators in terms of managing the new electrical demands. However, unlike other parking destinations, an airport knows exactly when a vehicle owner will return, enabling the charging demand to be predictable and manageable, taking advantage of peak avoidance and the availability of on-site renewable sources and off-peak tariffs. Longer term, this might even be extended to a vehicle-to-grid business model, providing grid balancing or energy buffering services.

And while electric vehicle ownership might offer a means of exploiting a new business model for parking-related services, a reduction in personal vehicle ownership arising from an increase in autonomous vehicles, shared ownership and/or ride hailing app use might lead airport operators to reconsider the current business model.

Surface water management
For much of the year, the water that falls onto the buildings and hard surfaces of an airport will be essentially clean other than dust, and it can be discharged without treatment. For that falling on the buildings, there is the opportunity to develop grey water systems to allow the offset of potable water supplies, for example, for use in toilet flushing systems.

However, surface water run-off presents a greater challenge during winter months. Airports are required to prevent the icing of aircraft runways, taxiways and aprons to facilitate safe take-off and landing. Typically, chemicals used for this (‘de-icers’ or ‘anti-icers’), will be applied to hard surfaces in order to prevent the bonding of ice and snow to the ground. In turn, this significantly limits the accumulation of snow and makes it more straightforward to mechanically remove any snow that does build up. In addition, in sub-zero temperatures, the aircraft themselves will require de-icing, which is applied onto nearly all surfaces including wings and flaps.

As de-icing chemicals tend to break down on contact with water, a process which uses oxygen, all of the winter-related run-off from the airport’s runways and other hard surfaces will require some form of treatment before it can be released into river systems. Most airports are equipped with settling ponds, where the water contaminated with de-icer can be stored. Options for disposal include entering into a contract with a local utility company to take the settling pond water to treatment works during the winter months, or retaining the water and aerating the settling ponds to promote the breakdown of contaminants.

Ricardo’s expert advice in this highly specialist area can pay dividends for customers, as Peter Mulder explains: “We recently completed a scheme for an airport that had previously discharged run-off water year-round into a local stream untreated. They needed to move on from this approach for environmental protection compliance and had been quoted several million pounds for a new treatment plant. In addition to its cost, this solution would consume considerable energy and chemicals on an ongoing basis. Instead, we went back to first principles and came up with a list of different options. Our analysis showed that with the local soil structure, a soakaway-based system with appropriate treatment would be significantly more cost effective and would deliver all of the required environmental benefits. We did all of the risk assessments and helped the airport obtain the necessary permits for the scheme, with a substantial capital and operational cost saving. As a result of this project we have had a number of enquiries from other airports to assist with water treatment strategy.”

Renewable energy
Airport terminals represent a significant baseload energy requirement, and in many cases operations can continue more or less around the clock. In effect, airports are like a shopping centre complex and transport hub, surrounded by a large amount of open space.

“Due to their relatively stable base load, airports are ideally placed to benefit from micro-renewable power schemes,” explains Mulder. “Many are subject to accreditations for the pursuit of environmental goals such as reducing the carbon intensity of operations, and any renewable energy generated can be consumed on site. We are working with a number of customers seeking to explore this type of opportunity, as well as implementing other forms of energy saving initiatives such as the adoption of LED lighting and motion sensors.”

Waste and recycling
International flights can generate a substantial volume of waste that should be treated as being potentially hazardous if it is contaminated by food. It is very important to work closely with the entire airport supply chain to treat waste as a resource
and implement practical steps to prevent this contamination from occurring. As an example, some airlines are increasingly designing their in-flight catering supplies so as to avoid contamination of recyclable materials, ideally using cardboard in place of plastics. With the increasing public awareness of the need to avoid single-use plastics, initiatives such as these can make strong commercial sense as well as providing a halo effect to the brand.

But, as Mulder points out, there are initiatives that can be put in place on the ground too: “The changes to airport security in recent years mean that passengers have to dispose of any drinks prior to clearing security, then purchase a fresh drink in another single-use plastic bottle once airside. A comparatively simple means of reducing waste would be to provide a clean water fountain once through security, so that passengers could empty and retain their re-usable bottles, and then re-fill them once airside.”

**Air quality and greenhouse gas emissions**

A theme that cuts across many of the other areas of airport consultancy support is that of air quality, noise and greenhouse gas (GHG) emissions. While the level of focus upon air quality can depend heavily upon the topography of the area – with some in urban locations where this can be a significant issue, while others are located in comparatively remote locations where pollution can disperse quickly – GHG emissions is a universal topic. “Ricardo has been involved in the monitoring of air quality at UK airports for almost 30 years, collecting monitoring data, undertaking modelling, assessment and managing inventories,” explains Mulder. “This can reflect a significant planning challenge to the maintenance and development of commercial operations in some locations, and the monitoring acts as a driver for improvement initiatives in many areas, including ground fleets and aircraft, but also local road networks which may be affected by airport operations or could have an existing background pollutant load. The assessment of GHG inventories to operations will tend to be broad, focusing on all aspects from the aircraft fleet, airport operations and grid power supplies, to indirect emissions associated with other bought-in products and services. With regard to noise, there appears to be a move to quieter aircraft and a building ‘demand’ from airports to have these based at their airport. Overall, there are many opportunities to improve, and with our access to the many specialist consultancy teams across the Ricardo organization, we can provide analysis, advice and support across an extremely broad range of expertise.”

**The Ricardo advantage**

The initiative to create an infrastructure team was taken by Ricardo in response to the realization that many of the specialist business units – including air quality, water, waste and recycling, and energy – all serve the same customer base. Airports are just one of many areas of infrastructure which are subject to significant development, but their complexity plays to the strength of Ricardo’s multi-disciplinary skills base.

As Mulder concludes, it is this, together with the company’s impartiality and objectivity, that provides significant added value for airport operators: “We have a significant depth of skills and expertise across a very wide range of disciplines, and we can bring in additional specialists in all areas from advanced power systems technologies to public transport, spanning everything from electric vehicles to buses, trams and high-speed rail. However, as a consultancy we are completely independent of any particular product, technology or construction solution – so we can provide completely objective recommendations, ensuring that the best advice is provided for both commercial and environmental sustainability.”

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**Ricardo services to airport operators**

Ricardo consultancy support to airport operators embraces a range of themes on which strategic consulting advice can be provided. In addition to those co-ordinated by the infrastructure team and described in this article, highly focused specialist services are also provided. Notable amongst this is the 24/7 support to operators and airlines by Ricardo’s National Chemical Emergencies Centre (NCEC), which helps them manage the chemical risks of spills and the transportation of chemicals, which can cause substantial disruption to airport operations when they occur.

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**Just some of the airside vehicle fleet typical of modern airport operations, offering opportunities for electrification and other initiatives aimed at improving local air quality**
Much of the automotive industry and countless tech companies are working feverishly to bring self-driving vehicles to market, but their work has hit the headlines for all the wrong reasons – the handful of highly publicized accidents that have highlighted the risks involved in early on-the-road testing. Some commentators, perhaps understandably, are beginning to question the wisdom of pushing so fast into this avenue of development.

Indeed, it is worth asking why there is such a sense of urgency. Why are these connected and automated vehicles (CAVs) suddenly top of everyone’s priority list? What are the drivers behind this sudden shift in thinking? These are among the questions addressed in a White Paper just published by Ricardo. Entitled The automation revolution coming to mobility and transport by 2025, the report warns in no uncertain terms that “CAVs are coming a lot faster than many observers expect.”

Drivers for automation
One of the most frequently cited reasons for the promotion of automated vehicles is that of safety. Vehicles driven by computers don’t get tired, distracted or impatient, it is argued. Another potential benefit, more easily demonstrated, is that vehicles under the control of optimized route planning and powertrain efficiency software will be more environmentally friendly than those piloted by erratic humans.

And while in the short term automated vehicles themselves may not do much to relieve inner-city congestion, they will at least allow their drivers to make more productive use of their time in the car.

Longer term, too, widespread automation of the vehicle parc could help speed up journey times by coordinating traffic flows and preventing overloading of particular routes, much as air traffic control networks already do for commercial aviation.

But why is this race for automation happening right now? Again, the
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consensus is that it has been triggered by a combination of simultaneous pressures and developments. Environmental concerns have hastened the arrival of electric vehicles, which are inherently easier to control through their electronics, and the timely maturing of smartphone technology in millions of people’s pockets now offers a ready-made interface for user-friendly consumer access to a wide range of transport options, including cars. Nor need the automated initiative be limited to passenger cars: in fact it is likely to become accepted in other domains first. Everything from trucks and drones to personal mobility devices stands to be drawn into the automated arena and, of these applications, trucks and goods delivery systems could be the first to yield demonstrable economic benefit.

Impacts of automation
If connected and automated vehicles do become as widespread as some are predicting, what will be the consequences for the automotive industry? And how will this impact on the way in which we use the various modes of transportation available to us?

Once again, there is a measure of general agreement that the arrival of CAVs is likely to result in a decline in overall unit sales of vehicles across a variety of categories. Fully robotic taxis would become prevalent within city regions, say the Ricardo paper’s authors: “...and with good coverage the need for personal car ownership could be reduced to the point where it could become redundant.”

In the new mindset of the market, argue some, people will become less intent on owning a vehicle and the focus will shift towards using pooled vehicles as a service; the early stages of this are already evident in the car-share schemes being run by companies such as GM, BMW, Mercedes-Benz and Smart.

The consequences of this shift will be profound at all levels of the supply chain, and some OEMs – especially premium manufacturers – will have to fundamentally realign their business models. Premium manufacturers invest heavily in the status and public standing of their brand names and, as the Ricardo report points out, while vehicle manufacturers are able to enjoy a high value path when selling to consumers, the value path to mobility providers will be of much lower value. Consumers would effectively disappear from the sales equation, and in a future automated scenario the business model of the industry would shift from a B2C to a B2B one, much like the way today’s major airlines deal with aircraft builders and leading companies.

Lowest cost transport
Perhaps counter-intuitively, the study’s authors also contend that automated vehicles could provide highly affordable travel at similar cost levels to public transport. The key here is ride-sharing in robotic vehicles. This is expected to increase significantly in urban areas and will begin to blur the distinction between what is private transport and what is public.

“Mobility with automated driverless ride-sharing will achieve substantial

Some definitions
The Ricardo White Paper purposely steers clear of the description ‘autonomous vehicles’ favoured in the general press and media coverage. Ricardo reasons that it will be many years before vehicles can properly warrant the label “autonomous” and that, instead, in the intervening period the description “connected and automated” is more accurate. The description ties in neatly with the SAE’s published hierarchy of successive steps towards genuinely autonomous driving.

SAE Level 0 means no assistance whatsoever: the driver must perform all tasks at all times. Level 1, found on many vehicles, comprises longitudinal and lateral assistance such as cruise control and lane-keeping systems. Many of today’s vehicles also already meet Level 2 criteria, where the system can take over some steering and acceleration/braking tasks in certain circumstances; at other times the driver must maintain full control.

Level 3 vehicles, of which only a handful are so far available, are able to monitor the driving environment and control steering, acceleration and braking in specific conditions, such as motorway travel; they will hand back control to the driver in situations where their systems do not have the necessary competence.

Level 4, where the description ‘automated’ can be applied, allows programmed driving for the majority of likely traffic environments, but the driver must remain on board to initiate the process.

Level 5, finally, is where the description ‘autonomous’ is fully justified. Level 5 vehicles can operate remotely and without a driver, and must be capable of all tasks involved in initiating and completing a journey, whatever the conditions.

“Even with the significant increase in vehicle purchase costs, the economics for robotic taxis are significantly better than [for] personal car ownership” The automation revolution coming to mobility and transport by 2025 - Ricardo
cost benefits, be highly affordable and comparable to the cost for public transport,” predicts the report, adding that “it is a possible scenario that automated ride-sharing will become the standard mass mobility mode in the future.”

The context of these forecasts is a world of ever-increasing urban populations, with a range of projections suggesting that 80 percent of the world’s 9 billion people by 2050 will be living in urban areas, placing huge demands on city transport systems. “In response to these urban challenges,” suggests the report, “it is anticipated that in urban areas there will be a convergence towards a range of CAVs including buses, robotic taxis, pods and a multitude of smaller two- and three-wheeled vehicles, maximizing the utilization of each mode of transport in a safe, clean and efficient manner.”

**The business case for autonomy**

The robotic taxi that could be key to revolutionizing urban transportation will be a very complex vehicle, capable of at least Level 4 operation or, more likely, fully driverless Level 5 service. Its necessarily sophisticated sensor and connectivity systems, along with its high-efficiency batteries and powertrain, will mean that it costs between three and four times the price of current personal cars. Yet despite this high upfront cost, says the study, the economics of running a fleet of ‘robotaxis’ could provide a strong business case.

Unrestricted by the need to conform to driver hours regulations, robotic taxis will be highly utilized vehicles, running continuously for some 20 hours through each day until they need recharging. The expectation is that they will cover some 400 km each day, equating to 145,000 km per year. Ricardo estimates an 8–10 year lifespan for the complete vehicle, making a convincing economic proposition.

“Even with the significant increase in vehicle purchase costs, the economics for robotic taxis are significantly better than [for] personal car ownership,” predict the authors, adding that “this is without factoring in the ever-increasing parking costs within cities, or the inconvenience of hunting for a parking space.”

The impacts of these seismic shifts on the many value chains within the transportation sphere are impossible to predict, but are sure to be highly significant. But on an environmental level, especially if city centres become barred to all traffic except electric vehicles and CAVs, the benefits stand to be great.

Socially, however, major impacts will be felt within the community of transport professionals: driving jobs at all levels are expected to be at high risk, most notably for those who earn their living from driving taxis, vans, trucks and buses.

**Significant challenges**

Formidable technical obstacles must be overcome before industry and society can fully commit to CAVs. These challenges have been gruesomely highlighted by accidents that have occurred recently on US roads where regulation of testing protocols is comparatively relaxed.

For terrestrial CAVs the road infrastructure and communication networks must be upgraded, and the vehicles themselves will have to progress upwards through the five technology levels identified by the SAE.

One very practical issue is that of gaps in maps. If CAVs are to be truly autonomous, they will need accurate digital maps of wherever they travel: the world has more than 30 million km of roads, the vast majority of which have not yet been digitally mapped. And without a map, an autonomous car is quite literally lost. Filling these gaps is a major task, though researchers from MIT’s Computer Science and Artificial Intelligence Laboratory have created RoadTracer,
Long-distance trucks: ahead of the pack

Cut-throat competition in the road haulage industry means a laser-like focus on operating costs, with every marginal reduction in outlay on fuel, labour, maintenance or capital expenditure able to confer a commercial advantage over rivals. And it is in this sector that automated functions stand to establish themselves first – for the simple reason that they will help save the haulage operator money. Ricardo has already led trials on public roads of convoy or platoon driving, where by locking electronically onto the lead truck, the drivers of following vehicles can relax and potentially gain some exemption from the hours of service (HoS) regulations that govern the haulage business.

Truck fleet operators in the EU report that fuel and labour costs each account for around 30 percent of annual operating costs. Long-distance trucks are expensive assets and their payback is directly dependent on the percentage of time they spend on the road. That in turn depends on driver hours, so it is clear that the greater the degree of autonomy built into the truck, the greater financial returns it will generate.

With a Level 4 platooning system, says the study, scenario modelling has shown that if the driver can take the HoS mandated rest while the truck moves in the platoon, the revenue improvements could approach 35 percent. As well as the 5-15 percent gain from fuel savings through aerodynamics, the improvement is provided by some direct reduction in labour costs and also increased revenues from greater asset utilization.

Remarkably, the Ricardo white paper calculates that full Level 4-5 automation of a long-distance haulage truck could yield savings of approximately 50 percent of the annual operating costs, since the driver’s salary is completely removed in the following truck. In some circumstances, the fully automated truck will not even need to be platooned, operating independently.

### In-vehicle requirements

For CAVs to be deployed at scale and at higher levels of autonomy such as 4 and 5, Ricardo experts have identified four key technology areas that are essential to safe and effective operation. Each of these areas requires significant software and hardware innovation in order to enable the necessary CAV performance, reliability and cost competitiveness.

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<td>Driving</td>
<td>++</td>
<td>N/A</td>
<td>--</td>
<td>$</td>
</tr>
<tr>
<td>L2 Platooning</td>
<td>Driving/Monitoring</td>
<td>+++</td>
<td>N/A</td>
<td>++</td>
<td>$$</td>
</tr>
<tr>
<td>L3 Platooning</td>
<td>Driving</td>
<td>e.g. for highway pilot automated driving on highway, driver available as fallback and as driver for non-highway driving</td>
<td>+++</td>
<td>++</td>
<td>$$$</td>
</tr>
<tr>
<td>L4 Platooning</td>
<td>Driving</td>
<td>LV driver; no FV driver</td>
<td>+++</td>
<td>+++</td>
<td>$$$</td>
</tr>
<tr>
<td>L4/L5 Automated truck</td>
<td>No FV driver</td>
<td>+++</td>
<td>+++++</td>
<td>+++++</td>
<td>$$$$$</td>
</tr>
</tbody>
</table>

LV = Lead Vehicle  
FV = Following Vehicle  
* Level 3 and above: labour cost benefit for Level 3 platooning if the time when the following truck driver isn’t driving can be used for other non-driving activities while in the cab

Platooning, as demonstrated in a European project involving Ricardo (right), is one of the lowest cost steps towards autonomy - trucks are expected to show the greatest returns on investment as automation advances (above)

**Sensors** form the very foundation of how the vehicle sees its surroundings and how it is able to interact with traffic and highway features. In addition to the radars, ultrasonics and stereo cameras currently offered, LiDAR – the equivalent of radar, but using lasers – is the key technology that provides the real-time 3D mapping that the vehicle needs for its spatial awareness. Current LiDARs are bulky and very expensive, and breakthroughs are eagerly awaited.

**Sensor fusion and data processing** is another key area where progress is required. Massively powerful computers bring together the inputs of the various sensors, making sense of the signals to identify and classify surrounding objects so the vehicle can decide how to react. Satellite GPS signals are only accurate to two metres, so six-dimensional high-definition maps are required to enable precise vehicle trajectories on the road.
In addition to the normal axes of latitude, longitude and altitude, these add pitch, yaw and roll so the vehicle can confirm its exact position.

The vehicle must also plan not just its route but its second-by-second positioning on the road, as well as continuously checking this through a feedback loop. All this requires significant data processing power, and the attendant electrical drain of perhaps 500 W is still a worry on a battery powered vehicle.

Under the heading of **reactions** comes a suite of control actuators already familiar from conventional vehicles: steering, braking, acceleration and activation of other electrical circuits for functions such as lighting, signalling and communication. But the big difference with an autonomous vehicle is that these systems must be duplicated or even triplicated – as is the practice in the aerospace industry – to ensure truly fail-safe operation.

**Communication**, too, is a major topic of discussion, especially when vehicles approach Levels 4 and 5 of automation. The volume of mapping and other data exchange required by the vehicle is too large – and probably too slow – to rely on constant flow to and from the cloud. For this reason many of the fast-response functions must be processed on board, with regular updates from outside.

Further levels of complication are added by the vehicle needing to communicate with surrounding traffic, with the roadside infrastructure and with other road users such as pedestrians and cyclists. Hardly surprising, then, that some 300 million lines of code are required: this compares with 100 million for today’s Mercedes-Benz S-Class, one of the most complex models currently on sale. A final obstacle is the thorny question of cybersecurity – potentially a major headache as all vehicles will be interconnected not only with each other but also with the users’ home and office wi-fi and mobile devices.

**Outlook for CAVs**

In their report, Ricardo’s authors summarise the top five [engineering] challenges CAV as a complete ecosystem must solve to achieve the widespread deployment goal of Level 4 capabilities by 2035, as:

1. Developing reliable algorithms for intelligence, learning, sensor fusion and object detection
2. Ensuring safety by design in vehicles with multiple safety-critical functions
3. Achieving robustly validated systems, considering the enormous complexity of the environment
4. Ensuring cybersecurity resilience
5. Reducing costs of all aspects of the systems

But beyond these largely technical tasks there is the much broader question of societal impacts of widespread CAV deployment, as well as the still unresolved behavioural question of how a near-autonomous vehicle can reliably and safely hand back control to the human driver when required.

Picking winners and losers at this stage is also difficult, for so much depends on the way CAV rollout evolves. As an example, one potentially undesirable outcome could involve automated vehicle travel becoming such good value that people migrate away from public transport modes, thus increasing – rather than reducing – congestion on road systems. Yet the White Paper concludes that, as a future scenario, the automated robotic taxi, offering mobility as a service, has the potential to significantly disrupt the traditional vehicle OEM sales model. The growth of this new type of mobility service will result in a far wider and deeper value chain, built up from the necessarily multifaceted businesses that together create the new ecosystem.

In this scenario, the vehicle OEM moves from business-to-consumer sales as it is today to a business-to-business provider, with the attendant lower margins. Then, only the fittest are likely to survive.

But perhaps what is most surprising is the speed at which this revolution – or at least the first four stages of it – is expected to unroll. The report concludes that, as a result of heavy upfront investments, several OEMs and start-ups are promising Level 4 automated vehicles from around 2021; these will offer automated, hands-off, eyes off-capabilities over defined routes and circumstances.

Yet, adds the Ricardo experts, the fully automated vehicle, capable of unrestricted operation anywhere and in any conditions, and akin in skill to a trained human driver (Level 5), is not expected until beyond the late 2030s. However, the big impact will come from automated mobility as a service provision and, in the scenarios investigated in the Ricardo report, this will not require such a high level of automation. Hence, concludes the study, by 2025 widely deployed Level 4 mobility service systems are a realistic possibility. 28

To obtain a copy of this report please visit: https://automotive.ricardo.com/revolution
Helping to build community renewable generation

Ricardo has supported the Awesome Energy project based in the village of Dalavich in Argyll & Bute, Scotland; the project’s name recognizes the local importance of the nearby Loch Awe. The support provided by Ricardo has involved an innovative connection to the local electricity distribution network for the 350 kW hydropower scheme on the River Avich, which is predicted to provide £1.2 million worth of energy benefits to the local community over the next 20 years.

The hydroelectric scheme is underpinned by an innovative private active network management (ANM) system. Ricardo identified this solution and supported each stage of implementation. The ANM overcomes the limitations of connecting to the local electricity network and was instrumental in making the scheme viable for investment. Connection of generators to the grid in Dalavich is restricted to 50 kW until at least 2021. Relying on this connection capacity alone would have restricted the energy output of the hydroelectric plant, which means it would not have generated sufficient income from day one of operation to repay the scheme’s investors.

The private ANM system uses electricity generation monitoring and control technology to identify the times when an existing grid connection is not being fully used by a generator. Unused capacity is then made available to another generator, in this case Awesome Energy’s hydro scheme, so that it can operate without restriction. Compared with traditional capital-intensive efforts to increase grid capacity, implementing the ANM provides a cheaper, quicker and more feasible option to handle the electricity output from the new generator.

"Ricardo provided due diligence, clear and concise technical advice through the options appraisal, and implemented the identified innovative solution to our grid constraint," commented Carol Thomas of Awesome Energy (Dalriada) Ltd. "Without the support and advice from Ricardo’s experts, we would have struggled to deliver this project – they were simply awesome.”

Forbes hat-trick for Ricardo

For the third year in succession, Ricardo Strategic Consulting has been named by Forbes as one of America’s leading management consultants – ranking Ricardo as among the very best of the more than 50,000 firms active within the US market. The Forbes America’s Best Management Consulting Firms 2018 is a list identifying which management consultancies are providing business sectors with the best guidance in assisting their operations.

"On behalf of Ricardo I am pleased to acknowledge the very generous recognition provided to us through our inclusion in Forbes America’s Best Management Consulting Firms 2018, a list that defines the very best within management consulting," commented Derek Schlonsky, president of Ricardo Strategic Consulting. "To be awarded the honour of inclusion in the Forbes list for the third year in succession is testament to the hard work and dedication to customer service of our global team of management consultants and technology specialists.”
Supporting climate action in Africa

Ricardo Energy & Environment experts have collaborated with C40 Cities in the development of an ambitious new programme launched at an event in Lagos, Nigeria, on 15th May. The C40 Cities Climate Leadership Group is a network of the world’s megacities committed to addressing climate change and the programme will support nine sub-Saharan megacities – Accra, Addis Ababa, Cape Town, Dakar, Dar es Salaam, Durban, Johannesburg, Lagos and Tshwane – to deliver bold climate action under the Paris Agreement.

In addition to Ricardo representatives, the launch event was attended by senior national and local officials and Mark Watts, executive director of C40.

C40’s Climate Action Planning Africa Programme will provide direct support to 11 African cities in developing unprecedented, robust and evidence-based long-term climate action plans that align with the ambitious objectives of the Paris Agreement. The support will include a dedicated city advisor based in each city, a series of workshops, and access to expert technical advice as needed. Nairobi and Abidjan have also joined the programme and are expected to submit their climate action commitments soon.

The C40 Climate Action Planning Africa Programme is part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the Bundestag. The programme was designed in collaboration with climate experts from Ricardo Energy & Environment, who will work closely with the cities to develop their action plans and support greater vertical integration between city and national government climate strategies.

Although sub-Saharan African countries are among the lowest emitting in the world, the region is urbanizing faster than any other. With growth of 1.4 percent per annum, 56 percent of the region’s population and 21 percent of the world’s total urban residents will live in cities in sub-Saharan Africa by 2050. Many of the participating cities are investing in infrastructure and setting policies that will impact development pathways for years to come.

The groundbreaking programme aims to use this narrow window of opportunity to embed climate-resilient and sustainable development by mainstreaming climate change into long-term investments and planning decisions.

New manufacturing investment

The recent commissioning of a state-of-the-art £500,000 Gleason GP300ES Gear Shaping Machine marked a key milestone in a strategic multi-year investment programme that aims to consolidate Ricardo’s position as the transmission design and manufacturing partner of choice for the world’s premium motorsports and supercar customers.

The GP300ES incorporates a totally new shaping head featuring a backlash-free direct drive for the cutter spindle. With the appropriate software, additional generating cutter rotational motion required for helical gears can be superimposed electronically on the spindle rotation. This makes it ideally suited for the manufacture of some of the most advanced transmissions systems demanded for motorsport and high-performance supercars.

Ricardo’s strategic investment in its manufacturing capability extends much further than the introduction of new machining centres and their associated production management systems. With over 10,000 process steps active within the manufacturing operation at any one time, the company has also invested in new planning and scheduling software; this was rolled out at the start of 2018. These and other investments aim to drive efficiency and quality benefits for the company’s advanced transmissions customers, including famous luxury, performance and motorsports marques such as Porsche, BMW, Aston Martin, Bugatti, McLaren, Bentley and Ford.

UK emissions reporting success

Ricardo Energy & Environment has been recognized by the United Nations Task Force on Emission Inventories and Projections (TFEIP) for compiling the most complete emissions inventory, coming first in a field of 40. Ricardo gathers and compiles data on greenhouse gas and air pollutant emissions for the UK’s National Atmospheric Emissions Inventory Agency on behalf of the government’s Department of Business, Energy and Industrial Strategy.

This recognition by TFEIP, an organization which supports the international reporting of official air pollutant emissions and projections data, demonstrates the ‘completeness’ of the UK’s inventory. The UK’s inventory reports emissions from a variety of sectors, including waste, industry, agriculture, forestry, and transport, and this data has been delivered in various forms by Ricardo for more than 20 years.

Sean Christiansen, Ricardo director for environmental evidence and data, said: “It is an honour to deliver the UK’s National Atmospheric Emissions Inventory, and we are delighted to see it recognized on the international stage. The award reflects the UK’s commitment to continuously enhancing the breadth and quality of our emissions data and builds on over two decades of service and collaboration with the UK government.”

Ricardo uses advanced data handling and modelling systems, along with its team’s huge depth of expertise, to compile, process, check and quality assure enormous volumes of data, which are then presented in a variety of accessible, user-friendly ways. Researchers and policy makers can access and apply National Atmospheric Emissions Inventory data within air quality modelling.
Ricardo has signed a Memorandum of Understanding (MoU) to facilitate increased and improved collaboration with Enable Inc, based in Kariya, Japan. The Enable organization provides a range of testing and prototype manufacturing services to the Japanese automotive industry. The list includes engine testing, prototype and concept vehicle preparation, the development of test equipment, the manufacture of jigs and prototype parts, and the modification of vehicles for dual-fuel and CNG use. The company is expanding and is in the process of building a new facility with powertrain test beds, which it intends to use for the delivery of calibration services.

Experts from Ricardo’s Utrecht office performed the national certification of the new trainsets in the Netherlands. Ricardo Certification was appointed as Designated Body in 2012 and supported the project through to the conclusion of performance testing in 2017. The team was also responsible for the vehicle’s testing on the Dutch conventional and high-speed network, including the automatic train protection safety system, train detection system, and components such as the pantograph units.

The e320 model – capable of speeds of up to 320 km/h (200 mph) – was specifically designed to be compatible with the entire European high-speed rail network and already operates between London, Paris and Brussels. The use of these new vehicles means that trains will be able to run direct from London to Amsterdam in around three hours and 40 minutes, offering a competitive alternative to the air route between the two cities which, with over four million passengers a year, is one of Europe’s busiest. The fastest London to Brussels journey times will also be reduced to just 1h 48 min.

Ricardo Certification operates as a separate and entirely independent business within Ricardo and is accredited by relevant regulatory authorities to provide assurance services to the rail industry. It is accredited and appointed in multiple regions against the requirements of standards for certification and inspection, EN17020 and EN17065.

Collaboration with Enable in Japan

With the inauguration of the first direct high-speed rail service between London and Amsterdam, Ricardo is proud to have played its part in the certification of the new Siemens Velaro e320 trainsets on which the new route – and other improved Eurostar services – will be based.

The partnership envisaged by the MoU will enable the improved delivery of services to Japanese automotive customers, with benefits including the locally based testing through its own offices in Yokohama, of products being developed internationally by Ricardo, and the delivery of advanced calibration services through Enable facilities.

“Enable and Ricardo share an ethos of providing excellent customer service and the highest standards of quality in engineering and testing,” commented Enable Inc president Yasumasa Matsuda. “We look forward to a mutually beneficial collaboration with Ricardo that will add value for the Japanese customers of both our companies.”

New directions for Eurostar
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