

The Future of the Car

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Combustion era goes up in smoke

Tomorrow's vehicles will be defined by new technology and the sharing economy, writes *Peter Campbell*

Evolution, rather than revolution, has been the watchword of the global car industry for decades. Engine tweaks and fresh designs mask one important fact: that the cars driven by more than a billion consumers today are broadly the same as those that trundled along the roads half a century ago.

But revolution — with a capital R — may be on the way.

Traditional automakers find their business models under attack from a host of assailants. This report will identify these problems, how they threaten carmakers and how the world's motor companies are rallying their international and financial might to respond.

The rise of electric vehicles, supported by emissions regulation and championed by the likes of Tesla's Elon Musk, is expected to eat away at demand for combustion engines.

Diesel has a black cloud hanging over it following the industry-shaking revelations from Volkswagen in 2015 that it installed devices in 11m vehicles worldwide designed to cheat emissions tests.

Other emissions investigations all over the world have implicated others, from Mitsubishi to Daimler.

The probes cast a shadow over the integrity of the sector, says Stuart Pearson, auto analyst at Exane BNP Paribas. "Consumers won't know who they can trust."

The unstoppable march of technology has seen cars become increasingly connected, partly in an attempt to make them attractive to young drivers more concerned with being online all the time than with horsepower. With internet access comes the risk of online troublemakers causing havoc. The dangers of cyber attacks that could result in fatalities is the stuff of nightmares for auto executives (see story below).

Technology brings fresh competition. The shadows of Apple and Google loom over motor manufacturers that are steeped in history.

Others are preparing to enter the market. Samsung has developed vehicle-tracking telematics with UK technology group Tantalum and is reported to be developing its own driverless car.

These brands are well known — are even loved — and such technical challenges threaten to upset older companies for whom customer trust is everything.

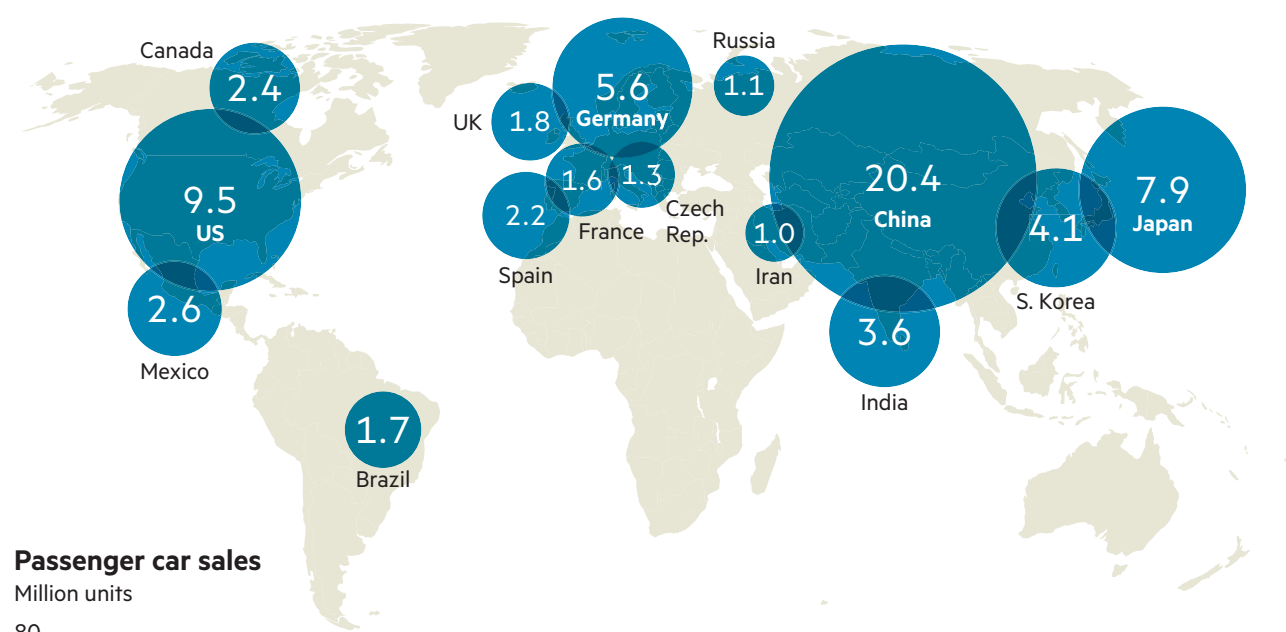
At this year's Davos summit, Mary Barra, the chief executive of General Motors, said: "We are moving from an industry that, for 100 years, has relied on vehicles that are standalone, mechanically controlled and petroleum fuelled, to ones that will soon be inter-



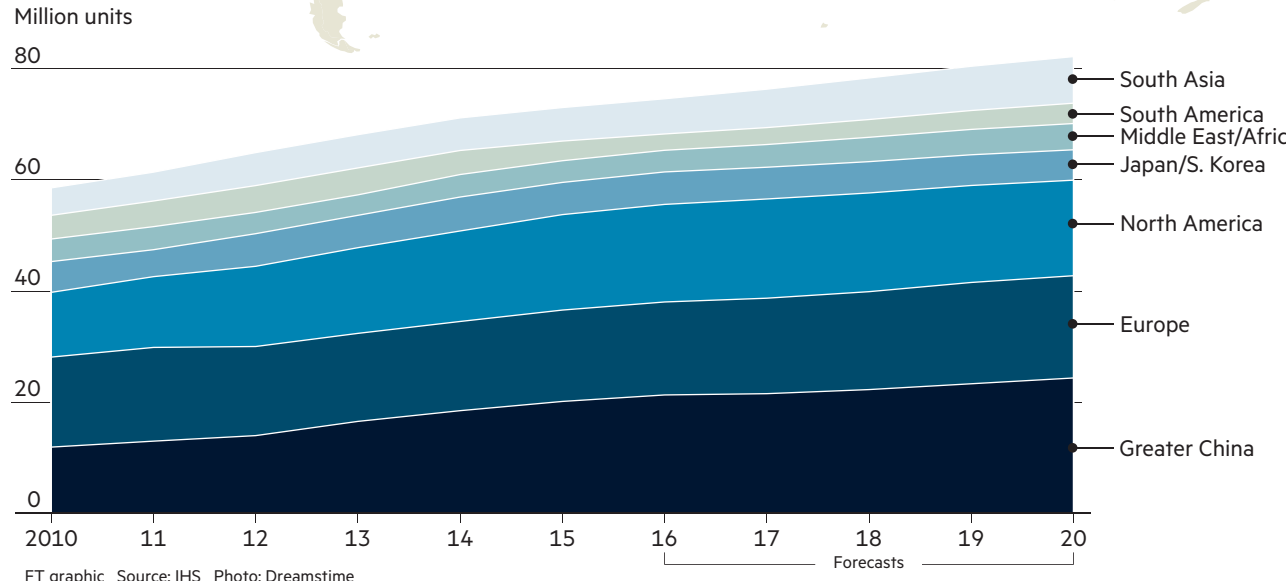
Shifting landscape

Carmakers will face a changing world as new technologies, competition and consumer habits challenge their traditional business models.

Passenger car production
Top 15 countries, million units (2016)



Passenger car sales



FT graphic. Source: IHS. Photo: Dreamstime

The future of diesel has a black cloud hanging over it after the revelations from Volkswagen

connected, electronically controlled and fuelled by a range of energy sources.

"I believe the auto industry will change more in the next five to 10 years than it has in the last 50."

Older manufacturers are responding to these challenges. For many, the question is not how to make an electric motor run or how to get a sensor to activate the brake, but how to make these technologies affordable enough to put in family cars, rather than being gadgets for the rich.

But one form of disruption — a Silicon Valley term that for once is unusually apt — threatens to undermine car sales: the sharing economy, embodied by the likes of ride-sharing company Uber.

In future years, so the thinking goes, no one will own a car. Driving — or "mobility" — will be an on-demand service, activated at the tap of a smartphone, a service Uber already offers.

One great fear of carmakers is that ownership is falling among younger generations, and there are worries that

individual cars will go the way of the horse and cart.

"What we want from our cars is changing," says Tim Lawrence, manufacturing specialist with PA Consulting Group. He adds: "Younger customers care less about actually owning the car. Car sharing and hiring are back on the agenda."

"That means [established companies] need to be looking at alternative business models and using the potential of new connected technologies to meet a wider range of mobility needs in different ways."

Of particular worry are millennials, people in their 20s-30s, among whom car ownership may be dwindling. A study from the University of Michigan this year found 69 per cent of 19-year-olds in the US had licences in 2014, compared with 87 per cent in 1983.

But other evidence suggests these fears may be unfounded. In 2014 in the US, the world's second-largest car market, people aged roughly 21-38 bought 4m cars or trucks, making the generation second only to baby boomers (those born from 1946-1964) for vehicle sales, according to research group JD Power. Customers under the age of 34 account for a fifth of GM's sales, a figure that has increased by 5 per cent since the start of the decade.

The fears are based on the idea that lower rates of car ownership will mean falling sales for the manufacturers. However, analysis from Deutsche Bank suggests that, contrary to this view, sales may actually rise as the fall in vehicle numbers will be offset by more frequent replacements because shared cars will wear out more quickly.

"US sales nonetheless increase under every scenario we've examined," wrote Deutsche Bank analysts. Reports of the death of carmakers may therefore be greatly exaggerated as well as premature.

BMW offers DriveNow, its car-sharing scheme which is available in London and Europe as well as the US, while Mercedes-Benz owner Daimler has its car2go service. Audi is launching a car-sharing scheme called Audi at home and General Motors has taken a share in Lyft, Uber's US rival.

New entrants in this market face significant problems. As well as lack of brand recognition, they must have sufficient scale to rival car ownership. Building this from scratch means either drivers deliver cars to customers or there are sufficient pick-up points to make the service workable, something that will require significant outlay in big cities where demand will be highest.

Young people in cities can use metros or Uber and many do not have off-street parking. This adds to the hassle of owning an asset that research suggests will sit unused for more than 90 per cent of its life.

Successfully tapping into that unused vehicle time will be the step that prevents today's big names from becoming tomorrow's dinosaurs.

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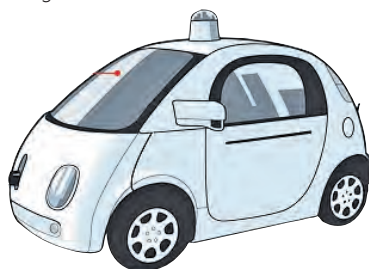
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FT Special Report The Future of Cities

Read it in the FT and online on June 1

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Data-hungry cyber hackers turn gaze to connected autos

Security

Vital information housed in vehicles will be the target for technology-savvy criminals, reports *Peter Campbell*

When hackers took control of a Jeep Cherokee, assuming charge of its steering, braking and even stopping the car on a highway, they confirmed industry fears that connected vehicles could be subject to the whims of online menaces.

The incident, an experiment that took place last summer in the US, was a "watershed moment", according to Martin Borrett, chief technology officer for IBM's European security division.

"A lot of people thought you had to have physical access," he says. "This proved them wrong."

The risks of cyber attacks are rising as carmakers cram connected technology into their vehicles.

The Jeep incident, which prompted the recall of 1.4m vehicles, raised fears that this increased connectivity goes hand in hand with greater vulnerability. The simulated attack was the result of two years of work by hackers who

owned the Jeep and had access to its hardware before they gained entry to its systems remotely, says Eric Friedberg, founder of cyber consultancy Stroz Friedberg.

"Hacking the car itself is quite hard," he notes. "The bar is pretty high."

Once hackers are inside, however, the scale of harm could be quite huge because they are able to move around the car's digital infrastructure with relative ease. That said, do not expect a spate of cars to be halted on motorways as teenage bedroom tinkers run amok, Mr Friedberg says. The real value is in the data that the vehicles contain.

"Intellectual property theft has always been a threat in an industry that has high levels of technology," he says. "The car industry is no different."

As vehicles become more connected, consumers will add more personal data to the car, from payments for apps or film downloads to passwords for Spotify accounts. It is the potential for stealing and reselling data that holds the real financial allure of hacking into vehicles.

"Getting someone's car to crash isn't a good way of making money," says Andy Davis, research director at cyber security group NCC. "There's only going to be a very small percentage of attackers who are interested in that kind of thing."

This means cars are no different from any other device connected by the so-called internet of things, ordinary objects hooked up to share information over the internet.

If all the items in your household are linked, your Tesla might as well be your toaster as far as a hacker is concerned.

This requires a change in the mindset from companies that have mostly been preoccupied with passenger safety.

"The challenge for car manufacturers is they have to shift from a manufacturing discipline to an IT discipline," says Mr Borrett at IBM.

"You have crash systems and safety glass but the same hasn't been done in the IT side of the discipline. A car is now a data centre on wheels and the bad guys only have to be right once."

As awareness of the possibilities of hacking become more prominent, those who could profit from it are listening just as keenly as worried consumers.

Mr Borrett adds: "What we have seen so far is well-intentioned good guys showing what can be done. What we need to be worried about is criminal organisations."

"The level of effort is pretty high. But once they have [your details], people sell this on the dark web — with guarantees of your money back if it doesn't



A car crash waiting to happen: researcher Charlie Miller with the Jeep Cherokee he hacked in the US last summer — Bill O'Leary/The Washington Post/Getty Images

work. It's a commercial shadow economy."

Carmakers are responding by investing billions in research and bulking up cyber security teams. IBM believes the issue is so important for consumers that it can foresee a time when having a good security provider could become a strong reason for buying a vehicle.

It is not just criminal organisations that will profit from the explosion of interest in car security. Companies that provide the chips that power

internal computers are rubbing their hands with glee.

Richard York, a vice-president for embedded marketing at FTSE 100 chip designer ARM, says the car security sector could provide the company's "third wave" of growth after it enjoyed booms thanks to smartphones and network equipment. "A cell phone is one thing with a few chips in it but a vehicle is a completely different problem," he says.

Not only will better-connected cars need more chips, but consumers and car

companies will demand that those chips offer better security, a potential double win for chipmakers.

The car industry has also recognised that — based the cyber adage that you can never build walls that are high enough — it cannot always keep hackers out. "Rather than thinking you've got to make [things] watertight, which won't happen, you've got to plan for attacks," Mr York says.

One benefit to the industry is that over-the-air software updates would allow car companies to fix any potential or real problems in their systems within hours rather than days. This would avoid the current situation over vehicle recalls, where many consumers refuse to take their cars back to dealerships.

However, many of the computers currently in cars are "rudimentary", with "very, very low" security, Mr York adds.

As a result, chip designers expect the market to double in value in the next six years as on-board computers become more complex and better protected.

"Most of the [security] technology exists, [carmakers] just have to get outside of the auto world and they will find it," notes Mr York. A year ago companies were in denial about the security risks they faced, he adds. "They're certainly not in denial now."

The Future of the Car



Smog warning: Beijing has pledged to improve air quality in China and has introduced measures to boost sales of electric vehicles — Lintao Zhang/Getty Images

Cloud over diesel and petrol as emission deadlines loom

Regulation Carmakers may find big changes simply unavoidable, writes Peter Campbell

The phrase “high octane” is often used to describe blockbuster action films or rollercoaster rides. It is a term rooted in chemistry, where the octane levels of a substance translate directly into its power output and efficiency when burnt.

The words are much spouted by those who say ethanol is a way of reducing car pollution. The biofuel, which has a higher octane level than petrol or diesel, joins the list of technologies vying to answer the question that has dogged the car industry, namely how to reduce emissions (see story below).

Electric motors, advances in battery technology, hybrid vehicles and hydrogen fuel cells all clamour for market share in a future being ushered in with speed by regulators who are introducing tougher emissions targets for car manufacturers.

By the end of the decade, the US, the EU and China will have brought in rules that it will be impossible for car manufacturers to comply with unless they embrace new technologies.

This follows the Volkswagen fuel emissions scandal, in which the com-

pany last year admitted it equipped cars with software that understated emissions when the cars were being tested. As a result, fossil fuels’ century-long grip on carmakers is slipping.

“If the EU misses the opportunity that the transport decarbonisation strategy gives us, Europe will not achieve its greenhouse gas targets,” says Carlos Calvo Ambel, an analyst at Transport & Environment, the green lobby group.

Carmakers face deadlines for average fleet performance relating to nitrogen oxide emissions (NOx) in the US and fuel efficiency and carbon dioxide (CO₂) in the EU. European targets are for CO₂ emissions of 95 grams per kilometre by

‘If the EU misses this opportunity, Europe will not achieve its greenhouse gas targets’

2021, compared to a 2015 level of 130g for each km. US targets are for NOx emissions of 58 milligrams per mile by 2021, compared to 86mg a mile in 2017.

This discrepancy is one of the reasons why diesel use has grown rapidly in Europe and remained stubbornly low in the US. Diesel engines on average produce 20 per cent less CO₂ than their petrol equivalents, one of the reasons carmakers were so keen to promote them.

Of the 11m VWs around the world affected by the scandal, about 500,000 are in the US and 8.5m are in Europe.

Automakers are now looking to move away from diesel, although this is driven by regulations that were in place before the emissions scandal started.

In a note published at the start of 2015, more than seven months before VW’s admissions, analysts at Exane BNP Paribas said diesel was “facing extinction from air quality regulation”.

Euro emissions limits had aimed to cut NOx from new diesel cars by 85 per cent between 2000 and 2014. Discrepancies in testing, however, where cars pollute more on the roads than in laboratories, meant that the reductions have been lower in practice.

As a result, carmakers have even more ground to make up to hit the next round of targets. They are responding by increasing production of hybrid and electric cars to lower the average emissions of their total fleets by the time the new regulations take effect.

Some manufacturers have released fully electric models, such as the BMW i3. This year Hyundai began offering its Ioniq model in different fuel formats.

In order to reduce average emissions, carmakers will have to persuade consumers to buy more of the new models.

This is a particular problem for the luxury brands with their larger – and thirstier – vehicles.

For now, inner-city electric car

projects are springing up. In London, the French company Bolloré has designed its own lithium-polymer metal battery and built its own cars in an attempt to start an electric car-sharing scheme called Bluecity.

The group already operates similar schemes in Paris, Lyon and Bordeaux. The project will use the Bluepoint London charging network, which is owned by the same company.

In China, where Beijing has pledged to improve air quality, electric vehicle sales are sluggish despite tax breaks intended to garner public support.

Furthermore, calculations from the brokerage Bernstein suggest that a very significant proportion of all electric sales involve the Chinese government.

In December 2015, electric vehicle registrations hit 83,200 units – almost as many as were sold during the rest of the year.

Robin Zhu, an analyst at Bernstein, has calculated that direct purchases by government, including ministries and state-owned enterprises, “account for almost half of annual volumes”.

To predict the death of diesel may be overstating the rise of new technologies, some analysts say.

“The diesel engine is a good technology,” says Daniel Hirsch, automotive expert at PA Consulting. Alternative fuels might affect its sales over the next few years a little bit, “but I am quite sure it will recover.”

Manufacturers face a bumpy road to electric success

EVs

Automakers dither over how to raise young buyers’ interest as new rivals enter market, reports Leo Lewis

At last October’s Tokyo Motor Show, Nissan – Japan’s second-biggest automaker and cumulatively the world’s biggest seller of electric vehicles – launched its showcase concept car with a frank admission: millennials do not love cars the way their parents did.

To win their custom, Nissan says, will require something like its Teatro for Dayz – an all-electric concept vehicle that keeps its passengers in a constant state of “online connectivity, creativity and shared experience”. Such slogans are vague but Nissan’s message is not: the cars that inspire the next generation of drivers to be buyers will be battery-powered electric vehicles (EVs).

By the time the Auto China show opened its doors in Beijing in April, carmakers were desperate to illustrate that they had an electric, plug-in hybrid or fuel cell strategy in place, even if tricky questions of fundamental design, battery efficiency, battery pricing and driving range remained unresolved.

The global auto industry’s uncoordinated approach to a battery-driven future has given brokerages such as Asia’s CLSA the chance to produce rankings that rate the strength and future prospects of each company’s EV strategy. The disrupters, such as Tesla, Apple and Google, are coming to the industry with new rules and threats.

Companies that have not yet laid out their electric car strategies or who, like Toyota, have gone for an alternative fuel cell technology, are looking exposed to such rivals. The problem, as Nissan has discovered, is that there still remains a difference between making an electric car people will buy and making money.

Right now, say analysts, it makes

‘Do we start with the battery or the fuel cell, or do we start with a chassis? Neither, you start with the vision’

sense for the giants to exploit their existing supply chain and the significant cost savings these produce.

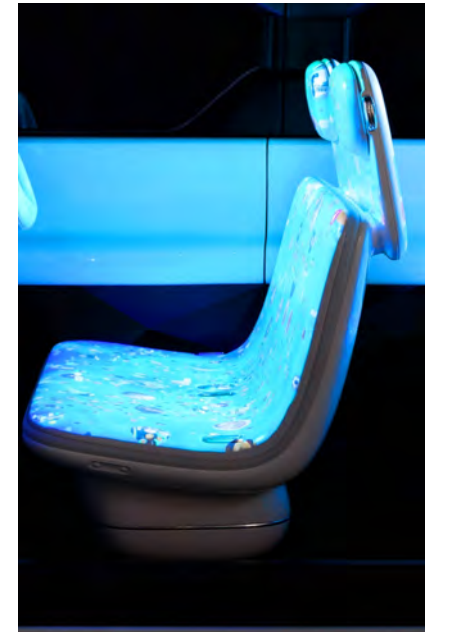
“Among the volume automakers right now, if you want to develop an EV you are going to be taking a combustion engine chassis and working around that,” says Christopher Richter, an autos analyst at CLSA in Tokyo. “That’s what Nissan did with the Leaf, and cost issues continue to dictate that.”

So incumbent carmakers base EVs on a chassis and other features that already exist for their combustion engine marques. This is what has allowed Nissan to bring the price of its all-electric Leaf down to \$21,500 from the 2011 price of \$35,430. Despite this, Nissan’s global EV sales, which were overwhelmingly driven by the Leaf, were down 9.8 per cent in 2015.

However, sticking to this route, the same analysts say, could potentially sacrifice substantial efficiencies that may be achieved by redesigning electric cars from scratch.

The dilemma facing battery EV carmakers, and the time it will take to resolve, could even provide a chance for costly hydrogen fuel cell vehicles (FCEVs) to establish a foothold.

“Recently there has been an increasing focus on battery electric vehicles and battery technology but FCEVs could also play a key role in zero-carbon mobility,” says Ben Scott, senior analyst with IHS Automotive.



On show: Nissan’s Teatro for Dayz is packed with display screens

“We are now in the third wave of FCEVs... more hydrogen refuelling infrastructure is beginning to be rolled out. This could be a ‘now or never’ situation for FCEVs in mass-market mobility.”

Mr Richter says sales volumes and the incentive to design electric cars from new fundamental principles are linked. Until electric car sales increase considerably, mass-market automakers face a choice between competing technologies (battery electric, plug-in hybrid, fuel cell) and competing design strategies.

The most important catalyst for achieving the necessary sales volumes, say engineers from both the battery and the incumbent auto industry, will be the point at which a 60 kilowatt per hour battery can be made small enough and produced at a cost low enough to put the overall price of the car at about \$30,000.

When an electric or a fuel cell car sells about 250,000 units worldwide a year, Mr Richter says, “that is when things start to get very interesting in terms of the major carmakers taking a ground-up approach to the chassis and other aspects of an electric vehicle”.

However, a handful of carmakers, such as Kyoto-based start-up GLM, which casts itself as Japan’s answer to Tesla, has devised ways to adapt no matter what the technology outcomes. This is by creating interchangeable vehicle “platforms” that can be tweaked to support whatever buyers finally want.

GLM, which makes a high-performance electric sports car and is planning an initial public offering this year, does not see the market in the same way as the analysts do.

The company takes the view that the next generation of cars must be designed from the battery or fuel cell up. Doing so, say its founders, allows the company to use any powertrain technology – which connects the engine to axles – while the market decides which it likes best.

Sota Nagano, GLM’s chief financial officer and co-founder, does not see a direct correlation between falling battery prices and a general lowering of the entry threshold to rivals from Silicon Valley, China and elsewhere. They will, he says, enter the market anyway because the whole concept of how cars are built and supply chains are established is effectively up for grabs.

The car GLM has in the showrooms of Kyoto and Osaka, he says, is mostly a showcase for the creation of vehicle-making platforms that will allow multiple varieties of powertrains and other technologies to be used in its vehicles.

These, Mr Nagano believes, will turn its car into a magnet for innovation.

“Do we start with the battery or the fuel cell, or do we start with a chassis? Neither, you start with the vision,” says Mr Nagano. “That is what the big car companies are slowly realising.”

Fuel replacements jostle on start line

Alternative power supplies

Peter Campbell assesses the pros and cons of the main runners in the dash to replace old favourites

Petrol and diesel will be supplanted eventually as the fuels that power our vehicles. Among the alternative technologies that may replace them are:

Lithium-ion batteries Found in laptops and mobile phones, this is the dominant technology in the electric car battery market. Prices have been falling, allowing General Motors and Tesla to unveil cars expected to cost \$30,000-\$35,000 and capable of driving more than 200 miles at a time, an improvement on cost and distance over previous models.

But the batteries pose difficulties. They are highly flammable, need to be isolated from water and require cooling when being transported. They are chunky, so the car base has to be built around them, and there are concerns about how much more powerful they can become. To overcome such limits, Tesla adds more batteries, which is why its Model X SUV weighs almost 3 tonnes.

Lithium-air batteries Non-flammable lithium-air batteries solve several of the problems of their lithium-ion cousins. They can operate at any temperature, do not catch fire and have a theoretically high energy density.

Exposure of their electrodes to the air brings problems, such as reduced performance in humid climates. They are behind lithium-ion in development.

Solid-state batteries Often called the “holy grail” of batteries, solid-state technology offers the potential for high-energy output with flexible battery size.

Unlike liquid-based batteries, they can be small and divided into even smaller elements, making it much easier to integrate them into existing car designs. Harnessing the technology is difficult because of the low levels of current passing through the battery.

Last year, Dyson, the vacuum cleaner maker, bought Sakti3, a solid state battery business, for \$90m saying the acquisition had “developed a breakthrough in battery technology”. Dyson aims to use the batteries in cordless vacuum cleaners. According to documents accidentally disclosed by the UK government this year, the company is building an electric car of its own.

Hydrogen fuel cell Running cars on the planet’s most abundant element would be sustainable. Rather than using a battery to power an electric motor, hydrogen is mixed with oxygen to create a full cell that runs the motor.

A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. Unlike a battery that needs recharging but does not need its core ingredients resupplied, a fuel cell will never lose its charge as long as a constant supply of hydrogen is available.

Toyota, which has launched a



Battery power: Tesla’s Model X SUV — Peter Campbell

hydrogen-powered vehicle, says the technology “can help us contribute to the next 100 years of the automobile”.

While charging infrastructure for electric vehicles is limited, rolling it out is inexpensive compared with hydrogen. Electric cars only have to be plugged into a power supply but setting up hydrogen pit stops requires expensive pressurised tanks to be sunk into the ground at each station.

Although hydrogen may be the future, it is far from being practical.

Ethanol This works with existing internal combustion engines, rather than replacing them. Mixing ethanol with other fuels reduces harmful emissions while increasing power output and it acts as a cooling agent in the engine.

There are concerns over the sustainability of ethanol, which is powered by crops critics say should be used for food.

Supporters say unused land is used to grow the crops ethanol is derived from. However, much of it is produced in South America and flown across the world, reducing its green credentials.

Ethanol advocates say it has not been

rendered obsolete by electrification, and add there will always be demand for hybrid or petrol-driven vehicles.

Hybrid There are three main types of hybrid that use both batteries and fuel-driven engines.

Full hybrids use batteries that drive the car up to certain speeds. The engine then kicks in and is used both to drive the car and recharge the battery.

In mild hybrids, the battery runs with the engine to reduce emissions by making the engine work more efficiently.

The cheapest version, 48V hybrids, are small, which means 11 turbo engines can power large saloon cars.

It is possible to get 70 per cent of the propulsion from a full hybrid engine for 30 per cent of the cost, according to Delphi Automotive, a car-parts maker.

Overall, hybrid engines are expensive as they require a battery and an internal combustion engine. But they can cut carbon emissions by 10 per cent compared with non-hybrid engines, while increasing the torque – the wheel-turning measure loved by adrenaline-seeking motor enthusiasts – by 25 per cent.

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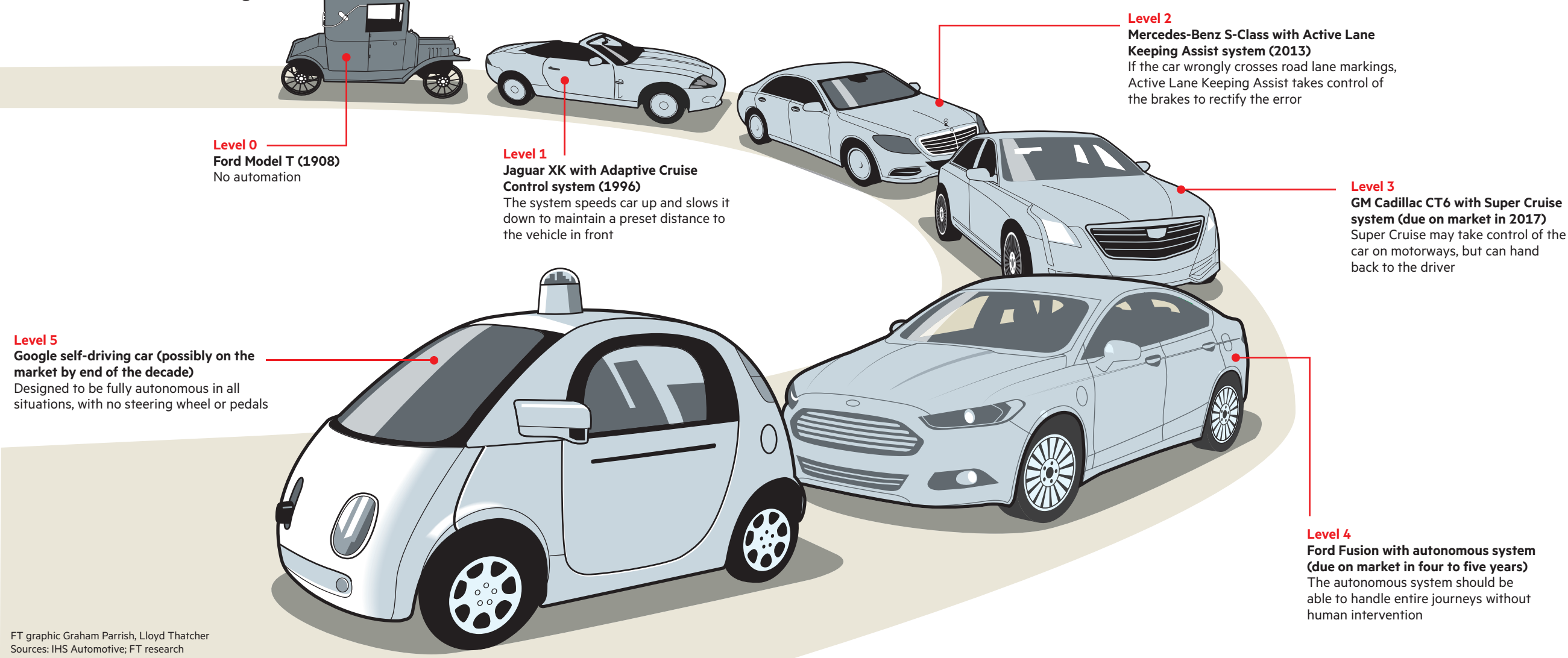
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The Future of the Car

The road to the self-driving car



Expect orders to wake up and smell the coffee

Safety New systems will target driver distraction to reduce accident numbers, reports Jane Bird

Drivers whose attention wandered off the road caused 3,179 deaths in the US in 2014 and injured a further 431,000 people, according to the Department of Transportation. The percentage of people sending texts or manipulating handheld devices at the wheel increased from 1.7 per cent in 2013 to 2.2 per cent in 2014, the National Highway Traffic Safety Administration says.

UK road deaths rose by 3 per cent, in the year to September 2015, to 1,780, the Department for Transport said. Safety campaigners say drivers being distracted by messages and data on mobile phones or on-board electronic information systems is a big cause of accidents.

In response, the industry is looking at how smartphones and driver assistance systems can be integrated to help people assimilate complex information more quickly and easily. Glen De Vos, vice-president of engineering at Delphi, an automotive technology supplier, says: "As your car becomes more connected it will act seamlessly with your mobile devices to understand where you want to go, automatically find the best route and warn of traffic delays so you can plan ahead, leave on time, get there and find a place to park."

All this will happen without the driver being distracted by giving instructions to the on-board computer system and will probably involve development of technologies such as Apple CarPlay and Android Auto. These let motorists use steering wheel switches or touchscreens to control their phones while driving.

That is only a first step, says Mr De Vos, because there are still lots of things that can divert a driver's attention.

Research is focused on technologies like gesture and voice recognition, eye tracking, touch controls and augmented reality. The approach is "multimodal" says Mr De Vos, "to give as many options as possible and make interacting with the vehicle simple, intuitive and safe".

Gesture control is available on BMW's 7 Series, allowing hand movements to control radios. This will gradually become available on cheaper models.

Voice recognition systems are available but Mr De Vos says they struggle to understand what people say without using specific commands. Developers are working on infrared cameras that track the position of the driver's head or eyes and check if they are watching the road or being distracted. These will likely be on sale in the next two years.

Facial scanning and head and eye tracking can tell if a driver is upset, angry or tired and can raise an alert to concentrate more on the road or take a coffee break. The technology needs to give the driver the right information at the right time, says Alexander Klotz, head of research and development for interior electronics solutions at Hanover-based Continental, an automotive technology company.

Continental is developing a system to

take into account the state of the driver and that of the traffic ahead. The driver's line of vision is analysed before a collision warning sounds. If the driver is paying attention, the warning can be suppressed until the situation becomes critical. If the driver is distracted the warning can be immediate.

Drivers will be able to forget about controls for windscreen wipers and fog lights because adaptive systems will automate their use based on individual preferences. "But we will have to look carefully at which functions we automate," says Mr Klotz. "Seat heating could cause drivers to become drowsy, so we have to keep them in the right state. Personalisation is key."

Continental is also working on touch technology, or "haptic feedback", such as an accelerator pedal that gives counter pressure if the driver is going too fast. The company is building dashboard screens that use pulses to simulate the feel of real mechanical buttons to the finger. "All our research is aimed at keeping the smartphone out of the hands of the driver," says Mr Klotz.

Some vehicles, such as the BMW Series 7, project information on to the windscreen in the driver's field of vision. BMW foresees the end of the road for dashboards. The windscreen would serve as "one giant augmented reality display", BMW says, adding it has the ability to create fully autonomous cars. But regulatory change is needed before such vehicles can be produced. Manufacturers will be liable if the technology causes accidents, says Daniel Hirsch, automotive expert at PA Consulting.

"The regulation is in a mess at the moment and there are problems with variations between countries," Mr Hirsch adds. "People don't want their cars to behave differently just because they crossed a border."

Drivers will also need to be able to override automatic systems in an emergency, Mr Hirsch says.

Perhaps most importantly, Continental's Mr Klotz says, automatic systems need to help drivers and not add to the possible distractions: "Otherwise people will resist them and turn them off."



Trouble ahead: the BMW augmented reality display at work

Advanced Materials that drive the future

TORAY
Innovation by Chemistry



We don't build cars. We build hope.
With advanced materials,
we are giving shape
to the next generation of eco-friendly cars.
Pictured here: the new concept
Toray EV TEEWAVE™.



The Material of Hope. Toray

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The Future of the Car

Automation revolution puts focus on 'soft skills'

Careers Books do not teach what bosses seek, reports *Patrick McGee*

Auto engineering students are learning that future-proofing their jobs means broadening their horizons beyond the confines of their subjects and into technology, communications and design.

Take the carmakers who sponsor the graduate programme at the Clemson University International Center for Automotive Research in Greenville, South Carolina. They no longer want mechanical, chemical or computer engineers — they look for recruits who have all of these skills and can integrate thinking from each.

"We need engineers that link across disciplines," says Paul Venhovens, BMW endowed chair in automotive systems integration at the university.

The jargon is "T-shaped" graduates: the vertical line represents depth of expertise, while the horizontal is an ability to communicate across technological and cultural barriers to spur innovation, so-called "soft skills". Mr Venhovens says these will become increasingly important, adding: "I cannot teach that from a textbook."

His solution to these changing demands was to ask students to conceive, design and build a concept car from scratch within two years. The latest vehicle to emerge from the programme is the Deep Orange 6, unveiled in April. The Toyota-sponsored vehicle achieved weight savings by using ultra-thin carbon fibre wherever possible.

The prototype is a youth-oriented, multifunctional vehicle that aims to do more than go from point A to B. Seats can be reconfigured to carry passengers, deliver cargo, or become a mobile office, while its electric powertrain — the mechanism between the engine and the axle — can serve as a power source for electronic devices or tools.

The concept car underlines how technology is transforming the industry. What powers a car, how it is built and who the buyer will be are all being



Welding power: automation is likely to affect the prospects of middle-skilled workers
Matthew Busch/Bloomberg

re-evaluated. In the short term, this should be a boon for jobs as carmakers and suppliers boost spending on research and development.

"Everybody's hiring," says David Riemenschneider, a director at Hambleton Partners in London, a mergers and acquisitions company focused on technology. "All the tier-one suppliers are trying to outmanoeuvre everyone else."

Mr Riemenschneider says General Motors aims to buy its way into the new era, taking a \$500m stake in car-sharing service Lyft and paying more than \$1bn to buy an autonomous vehicle start-up. Ford has been building its own technology in Detroit. "It's like the wild west. Everyone is doing their own thing."

In the US, automotive jobs have been steadily increasing since mid-2009, rising from 623,000 to 920,000, according to the Bureau of Labor Statistics. Near-term production is expected to rise, supporting more jobs.

"The US is near a cyclical peak but globally demand is still rising and China is under-penetrated," says Efraim Levy, equity analyst at S&P Global Market Intelligence.

Even if robots increasingly take over manufacturing roles, there should be a net increase in global production for the next five to 10 years, he adds.

The longer-term outlook is less comforting. The move towards automation will tend to force down the wages of the

low skilled and "impinge on the employment prospects of middle-skilled workers", warns research from bank UBS.

Demand for adaptable workers will increase, as BMW showed this year when it revealed that software engineers would make up half of its 30,000 research and development team within five years, up from a fifth today. But UBS says robots and clever software would replace costly labour-intensive jobs.

Michael Brecht, chairman of Daimler's general works council, has called for "a new humanisation policy" to ensure that machines work hand-in-hand with people, not instead of them. New jobs such as "robot consultant" or "data artist" could be the result.

'There are going to be massive job losses in the making of the vehicle'

Materials vie for pole position in the lightweighting stakes

Manufacturing

There is no single answer to the problem of how to make vehicles weigh less, reports *Michael Pooler*

The fight against climate change is driving automakers into a race to make their entire fleets lighter, because one of the main ways of lowering emissions is by slimming vehicles down. "Every gram has to have a purpose in the car, otherwise it's waste and needs to come out," says Sandra Walker, engineering group manager at General Motors.

With fuel economy standards tightening in Europe and the US, this involves ensuring structural safety while keeping production costs low. It is an engineering challenge not only to carmakers, but also to component manufacturers and raw material suppliers. Materials used to reduce weight include:

Aluminium Producers of aluminium say its low density can lead to weight savings of up to 50 per cent and that its corrosion resistance makes it suitable for body panels. But its cost, about three times more than steel as a raw material, means it has been mostly associated with premium products like sports cars.

So Ford's decision in 2014 to use an aluminium body for its F-150 pickup truck was a sea change. It was the brand's first all-aluminium bodied vehicle and the best-selling vehicle in the US for more than three decades. It weighed 700lb less than its steel predecessor, evidence of the metal's weight advantages.

The UK's Jaguar Land Rover has helped to develop high-strength aluminium alloys over the past two decades. Aluminium is used in engine block casting, wheels, hoods and fenders.

Charlie Klein, an executive director at GM, says a key application is suspension, where lightweighting can make springs and shock absorbers more effective.

Compared with steel, however, aluminium is difficult to join and repair. In 2012, GM developed a breakthrough welding technique for the metal, used on its Cadillac CT6, which it says can eliminate nearly two pounds of rivets.

Another obstacle to adoption is the need to reconfigure supply chains, factory tooling and retrain workers. This



Metal trade: rolls of aluminium in a factory in Russia

requires large capital outlays that must be justified by a decent return. The metal's use "will continue to rise but perhaps not as much as the aluminium industry had expected", says Michael Robinet, managing director at research company IHS Automotive.

Steel As the predominant material of choice for carmakers, steel is stronger, stiffer, cheaper, easier to repair and more soundproof than aluminium.

Since the F-150 went aluminium, ArcelorMittal, the world's biggest steelmaker, has concentrated on developing new high-strength grades. This year

'Every gram has to have a purpose in the car, otherwise it is waste and needs to come out'

aims to unveil varieties with tensile strengths of about a third higher than the best steels available and more than three times as strong as leading automotive aluminium alloys.

"It doesn't mean a tonne of steel will weigh less, but the amount of steel used [in a car] will be lower," says Gregory Ludkovsky, head of research and development at ArcelorMittal.

In the past decade, press hardening —

where high-strength steel is heated to 950C and stamped into shapes — has become a key lightweighting technique. This greatly reduces the "spring-back", or deforming, of high-strength steels while being made into complex shapes.

About 40 per cent of the body weight of Volvo's XC90 is press-hardened steel — the most in any vehicle — and industry figures expect other brands to increase their usage. However, as with aluminium, start-up costs of installing manufacturing plant are high.

"Many carmakers will stand back and say if I need to do hot stamping, can I do the same with aluminium?" says Mr Robinet of IHS.

Composites These combine two or more materials to create one with different characteristics and are, for some, the great hope of car lightweighting.

While fibreglass has been used for decades in boats and sports car bodies, it is carbon fibre-reinforced polymers that experts say have most potential because of their high strength-to-weight ratios, corrosion resistance and workability.

Well established in aerospace and motorsports, composites' biggest hurdle is cost, which can be more than 10 times that of aluminium, says Professor Richard Dashwood of Coventry University. This is less problematic for high-value niche brands produced on low volumes, such as Aston Martin. But adoption for mainstream models is not yet economic because composites take longer to make.

Christophe Aufrère, chief technical officer at Faurecia, one of Europe's top automotive components suppliers, believes carbon fibre for mainstream vehicles will arrive by 2025 and that up to half of structural components could be made from it: "If you do a complete car floor with composites, the weight today is 50kg and you could save 25kg."

The French company has developed a bio-based plastic composite with hemp fibres to add stability.

This has led to weight reductions of up to 20-25 per cent compared to traditional parts and reduces overall environmental impact by 20-25 per cent.

Cars of the future will probably be based on a variety of materials, depending on suitability, cost and market segment.

"Our big picture is a mixed material strategy," says Mr Klein of GM. "There isn't one that will answer it all".

