The Impact of Motoring

The Future & Epilogue

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Cover images: The Old Mill, Bourton-on-the-Water, today home to the Cotswold Motoring Museum and Toy Collection and cars associated with the museum.

Source of right hand image above: Metropolia University of Applied Sciences, Helsinki, Finland.
http://green.autoblog.com/2013/05/30/biofore-concept-car-is-a-plant-laden-sustainable-ride/

The Future

Introduction

Within some of the preceding chapters, a view has been offered of what the future may bring. For example, wearable satnav was the parting shot in the satnav chapter. The 'airless tyre' was one vision of the future. Telematics services were the potential consequence of mandatory Emergency Call (E-call), enabled by widespread car-to-car communications and a suggestion was offered that the second half of the 21^{st} century may herald the widespread adoption of hydrogen as the fuel of choice for our cars.

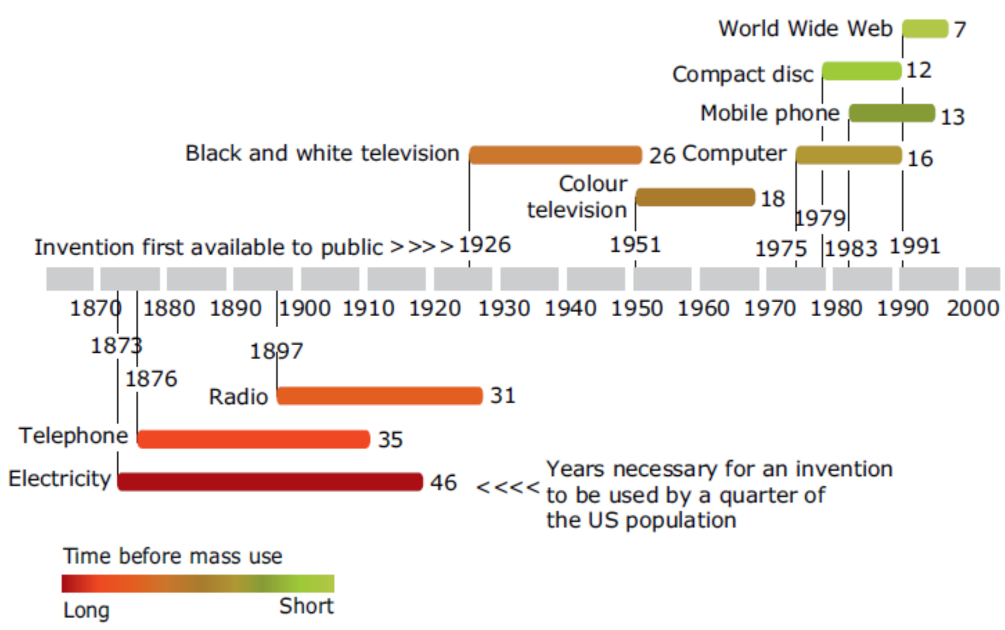
In terms of the car performance, the influence of Formula One Racing has been mentioned in the context of Energy Recovery Systems and their relevance to future hybrid car powertrain design. Formula One also has blazed a trail in terms of vehicle safety with the use of carbon fibre materials capable of withstanding impacts that would otherwise result in death or serious injury to the occupants.

As previously noted, land speed records have been held by both steam and battery powered cars before the records set by internal combustion engine cars powering the road wheels. More recent records have been established by jet and rocket powered cars and the next UK attempt on the record, with a target of 1000mph, is to be made with a car, Bloodhound, powered by internal combustion (to pump fuel), a jet engine and a rocket motor. Whilst the land speed record is one of the objectives of Bloodhound, the main objective is to encourage an enthusiasm of science, technology, engineering and maths amongst the current generation of schoolchildren. Without their skills, none of the possibilities presented in the remainder of this concluding chapter will come to fruition.

Historically, there are occasions when the developed world has been saved from the folly of its own actions through a fortunate change in the direction of technology that conveniently removes a looming problem. It was argued in the chapter on the Internal Combustion Engine that its invention was an example of one such 'disruptive technology'. And the problem it avoided? In 1894, the Times of London estimated that every street in the city would be buried under 9ft of horse manure by 1950! This was not as far-fetched as it may seem today. Urban populations were increasing and rail transport exacerbated the problem as horses were used for the final leg of passenger and goods transport. (Is there a modern day parallel here with internet and white-van deliveries adding to urban pollution of a different sort?). The private car was hailed as an environmental saviour which, in less than two decades removed an urban planning nightmare that, to the majority of the population, had no foreseeable solution. Will hydrogen power be the next such technology? More shortly!

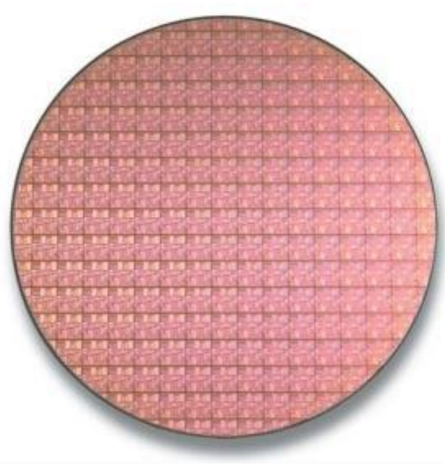
Before looking at specific topics, it is also instructive to look at the evidence that supports what many of us sense; namely that the *rate* of adoption of new technology is increasing. The figure below is based on the talk "The Accelerating Power of Technology" in which Ray Kurzweil suggests that technological advances proceed exponentially and not linearly. His figure below was reproduced in "The European Environment – State and Outlook 2010" and needs little additional explanation.

Figure 4.1 Shortening time lapse before mass adoption of new technologies



So, what else might be waiting around the next technological corner?

Back to basics



As already discussed in the chapter on the Electronic Control Unit, the value of electronics and software in the car is set to increase still further if the legislation on vehicle emissions and 'zero fatality' targets are to be met and the concept of the 'connected car' becomes ever more familiar. Fundamentally, the reason that electronics can be used to achieve these objectives is due to the ever-increasing packing density and power reduction of modern electronics.

In the mid-1980s the target, subsequently the state-of-the-art, lithography in semiconductor processing was to achieve a sub-micron - ie less than 1000 nanometres[1] (nm) - level of detail. This meant that semiconductor masks used in fabricating devices, for example a transistor, on a wafer of silicon would have sub-micron features and this in turn would determine the number of devices that could be grown on a wafer of typically 50mm diameter. Today, the modern home PC and smartphone are running processors with sub-30nm geometry.

At this level of detail, the features of the device are already shorter than the wavelength of the light used to illuminate the photosensitive resist that forms the etch mask overlaying the semiconductor material. Extreme ultraviolet illumination sources may reduce device geometry by a further (small) factor, three dimensional structures may increase packing density and increased use of parallel processing will increase speed. High device density reduces power consumption, improving cooling, enables more powerful and faster processors, results in a high production yield on wafers of up to 300mm diameter and ultimately delivers lower unit cost.

It is possible that the next major breakthrough however will be away from purely mineral-based electronics: germanium, silicon, gallium arsenide, indium phosphide and so on. Biological-based electronics may well provide that next breakthrough.

Researchers working on lithium air batteries have successfully used a bio-engineered virus coating to increase the electrode area of the battery with the potential for increasing capacity and hence the range of electric vehicles, with no associated weight increase. Flow batteries, using an organic electrolyte, are one possible solution to smoothing the flow of renewable energy generators such as solar, wind and wave. With brine as the electrolyte, they may even have a role as a future power source for electric cars. More generally, bioelectronics as the basis of future computers took a step forward when scientists at Stanford University published their results of a transistor based on DNA and RNA dubbed a 'transcriptor'.

Innovation in how the computational power of the day is used is also likely to enhance future vehicle applications. Artificial neural networks have been around for many decades but their affordable implementation has had to await low cost, high-speed processors and vast, affordable memory. Neural networks are particularly good at analysing complex situations. In a facial recognition application, the 'system' is taught to recognise the face of the subject under different lighting, different profiles, with / without glasses, facial hair, headgear etc. When deployed to spot a face in the crowd, identification of the subject is based on the learned knowledge and the identification is typically expressed with an associated probability. Over 97% correct recognition rates have been achieved; virtually equalling the performance of a human being set the same challenge.

In the automotive world, the role for artificial neural networks is as one input to an autonomous vehicle navigation application. The images captured from on-board sensors and cameras under different lighting and road conditions, different traffic densities, different lane markings and different weather conditions would all be built into the learning phase with the neural network 'decision' being one input to the navigation system.

[1] A nanometre is one millionth of a millimetre or 10^{-9}m

In short, on-going developments in the world of electronic devices will enable ever more applications, which hitherto may have been unaffordable or impractical to implement, to find their way into the car of the future.

Vehicle trends

As outlined above and in the chapter of the Electronic Control Unit (ECU), electronic hardware and lines of programming code comprising the embedded software, dominate a modern vehicle. In the ever-increasing drive to reduce vehicle weight and hence improve fuel economy, this trend is sure to continue.

For most modern vehicles, depressing the right foot on the throttle pedal no longer moves a heavy metal Bowden cable that owes its origins to the world of early 20th century cycling. The action of depressing the throttle pedal slides a potentiometer providing a variable voltage signal to the appropriate ECU(s) where it is converted into a digital signal. This throttle position sensor is used with other sensor inputs such as air temperature, engine coolant temperature, manifold vacuum, crankshaft position, vehicle speed and emissions related data (and, for an automatic gearbox, selected gear ratio) to control the amount of fuel injected into the cylinders.

Continuing the trend, the abandonment of direct linkages to steering, brakes (including the parking brake / hand brake) and clutch, in the on-going quest to reduce vehicle weight, is simply a continuation of the 'drive-by-wire' theme. The Infiniti Q50 is one of the first cars to adopt electronic steering (although the mechanical steering column remains in the event of an electronic failure). Electronics enables the steering ratio to be adjusted as the car's speed increases and allows feedback from the road surface to be varied to suit the driver's preference. Drive-by-wire is an essential, enabling technology if the process of driving is to become ever more automated.

Electronics used in the aid of improved safety take many forms. Included in the safety enhancement features are:

- the provision of information to make en-route decisions on congestion avoidance
- on-board cameras – potentially reducing ambiguity over insurance claims and maybe reducing premiums - as well as enhancing the drivers view in vehicle blind spots
- lane keeping alerts
- emergency brake assistance
- automatic cruise control – responding to the speed of surrounding traffic – with or without the aid of car-to-car communications.

Technically, the feasibility of an autonomous car has already been demonstrated and, following adoption of relevant legislation, some cars fitted with after-market adaptions could be on US and UK roads by 2015 with Google predicting 2017 to 2020 for mass production.

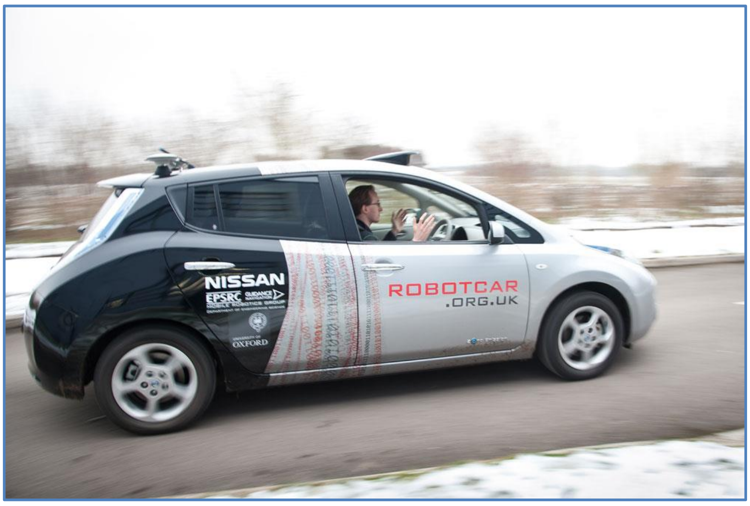
The Autonomous Vehicle

Already, adaptive cruise control and automatic parallel and perpendicular parking are options on mid-range, mass-market cars such as the 2015 Ford Focus. It is certainly a performance leap to go from these features to a fully autonomous car but, given the hundreds of millions of dollars being invested in the concept, there is little doubt that this will become increasingly common within the next decade or two.

The Institution of Engineering and Technology published one view on autonomous vehicles on UK roads in a submission to the government Transport Select Committee, and states:

“Highly or fully automated road transport will improve traffic safety, reduce congestion and provide both financial and environmental benefits. Vehicle automation will reduce the driver’s workload, reduce accidents, increase vehicle density, minimise speed variations in urban areas and on motorways and reduce vehicle emissions and fuel consumption”.

In 2013, Rt Hon David Willetts MP identified autonomous vehicles and robotics as one of the eight great technology challenges of the future. Government funding, via the Environmental and Physical Science Research Council has helped the University of Oxford with the Robotcar project. Collaborating with Nissan and MIRA, the focus of the research is on an infrastructure-free solution to vehicle autonomy. Using on-board sensors and a training / learning routine, the car interprets a fusion of data from the sensors to recognise its surroundings and navigate accordingly. Pedestrians, cyclists and other variables in its surroundings are detected up to 50m ahead through video and laser sensors scanning at a rate of 13 times per second.



In contrast, the Google project to build a fleet of autonomous cars does take information from the infrastructure, namely GPS information and uses this to map-match the car’s location: just as described in the satnav chapter of this book. In addition, scanning laser rangefinders, video cameras and radar for obstacle detection provide other inputs to the steering wheel-free car.

Of the current mainstream motor manufacturers, BMW have a road-going 5-Series prototype capable of autonomously navigating the autobahn whilst recognising and responding to surrounding traffic. Sensors again include map-matched GPS location, stereo video, radar and forward-looking scanning laser rangefinders along with all round ultrasonic sensors: the same technology used on current cars for parking sensors.

Whether known as ‘autonomous driving’ or, maybe less emotively ‘assisted driving’, the capabilities outlined above seem certain to become ever more pervasive over the next decade, offering increased mobility to the elderly as well as smoothing traffic flow with the associated environmental benefits and offering a major step towards the 'zero fatalities' target. Legislation and public acceptance may have to catch up with the technical progress.

Motive Power

So, whether autonomous or not, what will be powering the cars of the future?

Adverse effects on human health, including in the extreme, premature death, for which air pollution is responsible, have already been outlined. The corresponding financial cost has been addressed in a report from the Organisation for Economic Cooperation and Development (OECD). It estimates that air pollution costs the OECD countries $1.7 trillion per year in healthcare cost with half of this attributable to road transport. Since the most harmful emissions come from diesel vehicles, the OECD wants governments to remove incentives to buy them. Nitrogen dioxide (NO_2) levels in London's Oxford Street, predominantly from diesel powered buses and taxis, have been recorded at peaks of ten times the recommended average EU safe level.

With this concern over NO_2 levels from diesel taxis, buses and cars, even with ever-finer diesel particulate filters, has the peak of diesel-powered cars been reached? More efficient petrol engine cars come onto the market each year, complying with ever-tougher emissions legislation and reflecting customer demand for more affordable and environmentally friendly cars suitable for predominantly urban use.

This momentum behind the development of the internal combustion engine and progress in recent years however has been spectacular. For example, the entry level 2015 Ford Mondeo will use a turbo-charged one litre, 3-cylinder petrol engine with CO_2 emissions under 130g/km and fuel consumption of around 70 mpg on a motorway. Compared with the 2 litre, 1997 Mondeo, the 2015 model will travel 20 miles further on a gallon of petrol and have a 7% power improvement over the 1997 model.

Soon after the launch of the 2015 model Ford Mondeo, it is reported that Ford will introduce a petrol / electric hybrid, at *around the same price* as the diesel and producing around 100g/km of CO_2. To date, the hybrid has been sufficiently more expensive than its petrol powered equivalent, even with a subsidy, to act as a deterrent to purchasers who like the concept but not the price differential.

It seems highly probable that there will be a long-term role for the battery electric vehicle (BEV). Users who make frequent short trips, who have access to recharging points at home or their place of work and who want to enjoy low running costs (excluding depreciation) would find this an ideal solution. All the while the market remains small however, and prices high, take-up is likely to remain low. Extended-range electric vehicles (E-REV), some of which may also be plug-in, eliminate the anxiety associated with the 100 mile 'fair-weather' range of the BEV, with the on-board charging offering a range similar to many of today's petrol engine cars.

Increasing gas production by fracking is reducing gas prices in those parts of the world where fracking is gaining ground: the USA and China for example. Powering commercial vehicles and possibly cars on liquefied natural gas (LNG) then becomes affordable. The gas however, that holds the greatest hope for the future of low emission motoring is hydrogen. The potential for hydrogen and air used with a fuel cell to generate electricity to power the car has been mentioned in the Electric Vehicle chapter. The challenges facing this potentially carbon-free motive power are associated with the production and distribution of hydrogen. Nonetheless, as a mid-21st century solution, this has to be a strong contender as a replacement for fossil fuel derived motive power.

Picture Captions and Credits

Page 3: Bloodhound. http://www.bloodhoundssc.com/news-events/press-and-media/media-library
Page 4: A wafer of silicon with multiple semiconductor devices prior to being scribed into individual dice. Source unknown.
Page 7: Robotcar. http://www.epsrc.ac.uk/newsevents/news/selfdrivecar/
Page 7: Google Car. http://blog.caranddriver.com/wp-content/uploads/2014/05/Google-Autonomous-Car.png

Epilogue

For the last couple of decades, developing countries such as Brazil, Russia, India and China have aspired to catch up with the living standards of the developed world. Intensified global competition for natural resources has occurred and this trend is unlikely to reverse in the short term. Fossil fuels will remain the most important energy source, at least until 2030, and the use of oil, gas and coal is expected to grow in volume over this period. As the sources of easily accessible oil decrease, production costs rise due to the expanding share of deep-water exploitation and unconventional sources (eg biofuels) in the total supply.

In motoring, as in the wider uses of energy, there are no easy answers but those actions that can be taken include:

- *Use less of the Earth's raw materials*. Ultimately, if we are to keep the effect of manmade air and sea pollution to a level where we ensure future generations can enjoy the quality of life experienced in the developed world at the start of the 21st century, the energy use per head of population has to fall[2].

  Whether driven purely by environmental concerns or economic necessity, in the world of motoring there are encouraging signs. Average annual car mileage in the UK is falling, the number of cars on the road, whilst still rising, appears to be flattening and of those that are being purchased, smaller, lower emission cars predominate. Amongst young people in the UK, Germany, the USA, Australia and Japan, those learning to drive are doing so at a later age and car ownership is seen as less important than good, smartphone internet access. Increased urban living may also be a factor in this age group[3].

- *Reuse more*. For more than a decade, EU directives have covered the end-of-life disposal of vehicles: they are now built to be recycled rather than sent to landfill. The average age of cars on the UK roads is at its highest for over 20 years but even so, the average life is still just 7.9 years. The CO_2 produced during manufacture and scappage can be a significant percentage of that emitted by a car during its lifetime: anything from 15% to 50%, depending on the age of the car and assumptions made in the calculation, so it makes sense to maximise the use of our cars. One trend that will help is that away from personal ownership to membership of instant sharing schemes: again, particularly relevant in urban areas. Technically, software upgrades to existing hardware are likely to extend the useful life of the ever-more connected car.

- *Innovate alternative solutions*. Europe is relatively resource poor and imports many of the resources it requires. With a dependence on non-European suppliers, with their associated political uncertainties, there is every incentive to develop European solutions to energy generation, transportation and food production. Many areas of innovation in car transport have been covered in this book. One, clearly on the mind of a major manufacturer and highlighted by Bill

[2] David J C MacKay: "Sustainable Energy without the hot air"
[3] Eric Sanderson: "Terra Nova: The New World after Oil, Cars and Suburbs"

Ford, Executive Chairman of the Ford Motor Company, is that of networked cars leading, by 2025, to autonomous cars bringing their benefits of lower emissions, less gridlock and lower casualty figures.

Perhaps the biggest challenge will be that of fuelling the car of the future whilst keeping the harmful emissions of the car, when in use and during manufacture, to levels that produce no further degradation to the planet's atmosphere.

Whilst trying to avoid producing proscriptive lists, a significant part of this book has focused on what the individual motorist can do to minimise his or her impact of motoring on our environment. A discussion of how we might better plan our journeys to avoid congestion, avoid becoming lost, select our new or used car and prolong the life of that car has been presented. It is encouraging that there must be a significant number of motorist who are already changing their habits (or not even going down the route of car ownership) since for reasons of cost, population growth - especially in our cities - or environmental concerns, there are trends that suggest the impact of motoring may yet be something that our planet will survive.

The Cotswold Motoring Museum and Toy Collection is not just about cars. Toys that our parents and grandparents played with as children, everyday artefacts from the Victorian and Edwardian era plus an insight into the social history of the village of Bourton-on-the-Water and much more can be found in the Old Mill, alongside the River Windrush.