ROYAL ACADEMY OF ENGINEERING

Innovation in automotive

Summary of a meeting held on Tuesday 29 January 2013 at the Royal Academy of Engineering

The Royal Academy of Engineering
Prince Philip House
3 Carlton House Terrace
London SW1Y 5DG

Tel: 020 7766 0600
Fax: 020 7930 1549
www.raeng.org.uk

Registered Charity Number: 293074

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Foreword

The Royal Academy of Engineering has run a series of seminars to highlight cutting edge innovations in different engineering sectors that have the potential for growth and global reach, and to identify the opportunities and challenges that they present. On 29 January 2013, a half-day conference on Innovation in automotive brought together leading engineers and businesspeople from the automotive industry and beyond to discuss issues and trends in innovation.

The conference heard presentations from automotive original equipment manufacturers (OEMs), technology advisers and motorsports groups. It discussed innovation and research processes both within individual companies and in collaborations between industry and academia. It explored some of the current complexities in the automotive landscape, where the future trajectories of core technologies such as powertrain and materials are very much open questions. The innovation challenges that face the industry were set within the wider social and political context, highlighting the external pressures and changes that are forcing the industry to adapt.

This report highlights some of the issues raised at the conference, and seeks to contribute to further discussion of innovation in the automotive sector, both within the Royal Academy of Engineering and beyond.

In 2012, the output of cars rose to its highest levels since the recession began, exporting 81% of total vehicles to over 100 markets worldwide

1. The UK automotive industry

The UK's automotive industry is a manufacturing and exporting success and the figures prove it. In 2012, the output of cars rose to its highest levels since the recession began, exporting 81% of total vehicles to over 100 markets worldwide (Society of Motor Manufacturers and Traders, *Motor Industry Facts*, February 2013).

The UK industry has made a successful transition in the era of global automotive groups, and is an important manufacturing location for nearly all the major players – supplying vehicles into the rest of the European Union and beyond from modern plants with productivity that matches the world leaders. But the UK is far more than just a manufacturing base for the world's automotive industry, fostering corporate research and development centres and industry-academia collaboration. Important global automotive groups such as Nissan, Toyota and Honda have long-established research centres in the UK, and now companies from newer automotive superpowers such as China and India are setting up bases in the UK to tap into the font of excellence in innovation that the UK represents.

International groups are drawn to the UK because of the track record of innovation and the infrastructure supporting engineering research and education. But increasingly, according to Lord Drayson FREng, former UK science minister turned motorsport entrepreneur and passionate advocate of electric vehicles, new innovation partnerships will model themselves on those in the IT and pharmaceutical industries which encourage the involvement of small companies and which are "porous to new technologies from outside".

This kind of 'open innovation ecosystem' is particularly suited to electric vehicle development, he believes, and the growth of a low carbon and electric vehicle industry in the UK might also in itself be a boost to the promotion of science and engineering in Britain: a virtuous cycle.

NISSAN

Nissan was the first of the new global automotive OEMs to invest in UK manufacturing, and its plant at Sunderland has since set the benchmark in terms of European automotive productivity through innovative processes and automation. The company also brought important elements of its research and development to the UK with the establishment of its Nissan Technical Centre alongside Cranfield University. The extent to which UK operations are seen as a leading innovation within Nissan is demonstrated by the fact that the Sunderland plant will be a lead supplier of the Leaf, the group's pioneering venture into electric vehicles.

Nissan, explained Jerry Hardcastle, Global Chief Marketability Engineer and Technical Director for Global Motorsports, "is about innovation that excites". As a group, he said, it was not afraid to challenge the accepted wisdom, as seen in its adoption of the innovative Deltawing concept developed by a very small company.

But innovation for a global group like Nissan was a means to an end: the big target for the group worldwide was set in a strategy called Power 88, which challenged the group to achieve 8% of global market share and an 8% consolidated profit rate by 2016. To do this required innovation in both product and process, and Nissan was committed to introduce 51 new models between 2011 and 2016 and adopt 90 new technologies inside the vehicle and in its own production facilities over the same period. These targets require Nissan to employ more than 18,000 people in research and development worldwide and to collaborate extensively with academic and other research institutes, as well as with smaller companies.

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JLR is also developing its innovative capacity through investment in its research facilities and through links with university and innovation centres

JLR

Jaguar Land Rover is in the middle of the UK automotive industry's single biggest investment programme perhaps of all time: a radical expansion and upgrading of facilities and products that will take the manufacturer of upmarket cars and off-road vehicles into the world league.

The investment by Jaguar Land Rover's parent group Tata includes a £350 million plant on a new site near Wolverhampton which will see Jaguar supply its own engines for the first time and end the dependence on its former owner Ford. But JLR is also developing its innovative capacity through investment in its research facilities and through links with university and innovation centres.

> ...the research councils have brought focus to innovation by setting up new centres of excellence that combine the work of several universities

2. Industry-academia research collaboration

Influential reports by the engineer and inventor Sir James Dyson FREng and by the entrepreneur Dr Hermann Hauser FREng identified a possible gap in the innovation infrastructure in the UK which might go some way to explaining the long-held belief that UK engineering is good at producing inventions that others outside the UK then exploit and make money from.

The concept that these two reports brought into wider discussion was the idea of 'technology readiness levels' or TRLs, a scale from one to nine used by US government departments and by some industries to rate the maturity of technologies on the basis of their preparedness for markets. What the Dyson and Hauser reports suggested was that research in UK universities was in many cases excellent at TRLs one to three, where fundamental science was put together with engineering to create innovative ideas. Where the UK system was lacking in many areas was in the middle of the scale – TRLs four to six – where technologies are developed and demonstrated before being brought to market by commercial concerns at TRLs seven to nine.

Successive governments have sought to tailor their support for innovation into the creation of new structures that will help to bridge this apparent gap. In particular, a recommendation of the Hauser report was for the establishment of what were termed 'technology and innovation centres': new organisations to build on academic research and to coordinate different projects. The first of these 'Catapult' centres, are now underway. Automotive research and automotive companies are involved in several of them, with a Transport Systems Catapult covering automotive and other forms of transport currently being set up (Technology Strategy Board, June 2012).

Outside this network, other initiatives through the research councils have brought focus to innovation by setting up new centres of excellence that combine the work of several universities. And even the tax regime has been changed to encourage the exploitation of UK inventiveness, with the Patent Box tax relief scheme offering lower tax rates on profits from patented ideas.

WMG

WMG, (formerly Warwick Manufacturing Group) is to be the site for a new £92 million national automotive innovation campus, which will continue the link between Jaguar Land Rover's research centre at WMG's International Digital Laboratory and the Tata Motors European Technical Centre, also on the University of Warwick campus. The aim is to research and develop technologies, particularly vehicles, that will reduce dependence on fossil fuels and cut carbon dioxide emissions.

Professor Richard Dashwood, Chief Technology Officer of WMG centre High Value Manufacturing Catapult, saw strength in UK academic research. He saw the new landscape of research infrastructure and funding, of which the Catapult centres and the automotive campus were a part, as a way to bridge the "funding valley of death" between academic research and commercial exploitation.

But he warned that there were still issues in automotive industry innovation: the difficulty of matching the longer timescales of academic research with the industry's short cycle planning, for example, and the decline over many years of UK-owned Tier One suppliers. There were differences too in the way that universities and industry work and how they manage issues of intellectual property. Professor Dashwood believed that the automotive R&D landscape in the UK was "extremely strong" with many opportunities for further partnership.

> ...the potential for the motorsport engineering sector to act as a testbed for mainstream automotive developments remains largely untapped

3. Racecars and roadcars

Aerodynamics, braking systems, lightweight materials - there is a long list of innovations that motorsport has fed through to the mainstream automotive industry. But in practice over the past 10 to 20 years, the two industries, both very strong in the UK, have pursued relatively separate tracks, though there have been moves in recent years to align them through technology roadmaps.

The difference between the two sectors is in numbers and in the acceptability of high cost: what is suitable for a single vehicle, where time and money are almost no object, is very different from the demands of a production vehicle.

Dick Glover, McLaren Automotive Research Director, cited as an example carbon fibre as a structural material, which was introduced into Formula One in the 1980s. Even now, more than 20 years on, he said, road cars using structural carbon fibre have been limited to maximum production numbers of around 2,000. The time to produce components had reduced tenfold in 20 years, he said, but was still too long for volume production. However, there are some promising uses beyond formula One, with carbon fibre and active suspension bridging the divide, and now being seen on supercars such as the McLaren 12C and the BMW's i3 electric vehicle, to be introduced later this year, which features a horizontal-split variant of the LifeDrive concept. The Drive module provides the solid foundations for the Life cell, which is simply mounted on to accommodate the large battery.

The disconnect between motorsport and the wider automotive industry has been the subject of study over the past year. In 2012, the Motorsport Industry Association commissioned the automotive consultancy Ricardo to plot a future technology roadmap for the motorsport sector, covering likely developments in powertrain, structures, materials and other factors through to 2025.

The exercise was deliberately based on a similar technology roadmap exercise, also done by Ricardo, for the wider automotive industry in the new automotive innovation and growth team that reported to the UK Government in 2009 under the chairmanship of the former Ford engineering chief Richard Parry-Jones - though the level of detail is much greater in the motorsport version.

The intention, said Ricardo's Global Market Sector Director for High Performance Vehicles and Motorsport, Steve Sapsford, was at least in part to identify crossover points where product or process technology used in motorsports might have "road relevance". Areas such as improved performance of internal combustion engines, aerodynamics and drag/weight reduction all offered potential. One technology where changes in motorsport regulations had already successfully resulted in wider automotive and other applications, he said, had been in KERS, or kinetic energy recovery systems, and specifically flywheel technology.

But the potential for the motorsport engineering sector to act as a testbed for mainstream automotive developments remains largely untapped. Richard Parry-Jones said that it was good that the agendas of the two sectors were now becoming more connected, as they had been in the distant past, "but there does seem to have been a lost decade in which motorsport decoupled from road cars".

FORMULA E

Former government minister and motorsports entrepreneur Lord Drayson believes that electric vehicles (EVs) may be one area where innovation in racecars may be able to answer questions that will help the technology developed for roadcars. Drayson Racing has been appointed technical adviser to the Formula E electric vehicle series which will start a grand prix-style format on city centre circuits from 2014.

Issues facing electric racecars include the fundamentals of range and battery chemistry and configuration that are among the core technical factors that could influence the degree to which EVs are taken up more widely in everyday motoring. "The transfer of innovative technologies will accelerate between the two," Lord Drayson said.

"But," he added, "we also need to be innovative in marketing." Electric vehicle motorsport has the potential to change public perceptions of EVs and to bring excitement, and UK strength in racing and roadcar technology meant that "we have the conditions to lead the electrification of vehicles that will take place".

These broad issues include health and safety, environmental concerns and pollution control, climate change, and the potential or actual scarcity of resources

4. Automotive technology issues

Drivers for change and technology development in the automotive industry are in many cases subsets of much wider issues that affect not only the automotive industry but other activities and businesses. These broad issues include health and safety, environmental concerns and pollution control, climate change, and the potential or actual scarcity of resources. The degree to which one or other of these issues takes priority varies over time.

Lord Drayson, as an example, said that while the automotive industry appeared principally focused on measures that would combat climate change, issues related to controlling the pollution from vehicle emissions for health reasons could very quickly demand attention and create a shift in priorities. Legislation can be seen as driving technology and investment and can change the attractiveness of technical options.

In this case, there are both environmental and health benefits from a legislative measure, but in other instances, the broader drivers of automotive innovation can be seen to be in conflict, and engineering is frequently the art of balancing these different or even conflicting aims to reach an optimal solution. Pollution control technology, for example, often adds weight to vehicles; extra weight decreases fuel efficiency and that potentially increases pollution.

It means, said Steve Sapsford of Ricardo, author of the UK Automotive Council industry roadmaps, that in terms of technology and innovation "there are usually no clear winners

and certainly no silver bullets" - no panaceas that would solve a range of different problems. This is all very far removed from the early days of the automotive industry, when innovation and technology development were geared to answering some fairly simple and basic questions about vehicle performance to make the car go faster, further, or more reliably. Now, he said, it was quite possible that there would be a wide range of different technologies in use in low- and high-performance vehicles.

EMISSIONS

The need to cut automotive emissions as part of the war on pollution and on climate change is established in targets which the industry has broadly managed to achieve, despite initial protests that the targets were unreasonable. Further progress towards even lower emissions becomes ever more challenging, however, which is why so much automotive industry attention is being put on alternative powertrains and energy storage systems.

In these areas, said Steve Sapsford of Ricardo, there is no "obvious" single technology that meets the current requirements in the same way that the internal combustion engine met the automotive demands of a simpler age. Even lithium-ion, the most advanced of the new battery technologies and the one that Sapsford considers is likely to dominate innovation in short-term electric vehicle development, has question marks over its provenance and sustainability.

Other energy storage options, from different kinds of batteries through supercapacitors and flywheels to liquid nitrogen and compressed air systems, appear either to need a lot more research or to have - currently, at least - limited or partial application. The path to innovation is not short of options, but is far from straightforward.

> Jaguar Land Rover, had set itself a target for a current 2,000kg car to be reduced in weight to 1,500kg

MATERIALS

Mark White, Chief Technical Specialist for body engineering at Jaguar Land Rover, is leading the group's work on weight-saving for new vehicles. This is not just a bodywork issue: "It's the complete vehicle weight," he said. Weight is an area where a lot of the different external and internal drivers for innovation can come into focus. It is patently part of the drive towards greater fuel efficiency and lower carbon emissions, and while commodity prices are high, reducing materials potentially brings cost savings too. There are also broader trends towards blurring the distinctions between different classes of vehicle, with small premium cars and car-like SUVs, and global economic factors are also important: growth markets for the automotive industry are in places such as India, China and Latin America.

Jaguar Land Rover, said Mark White, had set itself a target for a current 2,000kg car to be reduced in weight to 1,500kg: "At this level, a petrol car would be as efficient as a current diesel, and a diesel as efficient as a current hybrid."

While bodywork is not the whole answer, it is a good starting place, accounting for around 400kg of steel in current cars. Almost immediately, however, the complexity of reducing weight here becomes apparent. Jaguar Land Rover is investigating the use of high-strength steels that give equal performance for lower weight, but this will meet only some of the desired weight-saving, as these materials are not suited to all applications.

So lighter weight materials such as aluminium and magnesium are under scrutiny, but weight cannot be looked at in isolation and these materials introduce cost implications – and composite materials such as carbon fibre reinforced plastics are even more expensive. Other considerations include recyclability, where there are legal requirements under EU legislation, and critical safety standards. Changes in materials demand changes in manufacturing processes too. And whole-life analysis of energy use in material refining and recycling has to be considered too. The new Range Rover, 420kg lighter than the model it replaces, proves weight can be saved. But innovation in this area is no simple matter.

> Issues such as congested roads, inner cities with limited parking spaces and the sheer cost of running your own car are social factors that are likely to have a significant bearing on future vehicle development

5. Automotive in society

The issues that weigh on automotive innovation come from the technology of the vehicles themselves and from wider aspects such as environment and safety where the products of the auto industry fit into bigger debates. But the ways that we use vehicles, and the things that we do while we are in them, are also changing. As elsewhere, some of these changes are, or could be, the subject of regulation: taxation, for example, is already to a degree based on environmental performance but might in future also be based on usage, with road tolls.

Many of the changes that will demand innovation in terms of the vehicles that we use, however, are to do with lifestyle choices and personal convenience. Issues such as congested roads, inner cities with limited parking spaces and the sheer cost of running your own car are social factors that are likely to have a significant bearing on future vehicle development. Potentially, automotive industry customers of the future will be buying mobility rather than a car as such: the vehicle may be – indeed, for a lot of people already is – just one of several options to get from A to B, and may not be the most flexible of those options.

At the same time, the technology revolution of the internet and mobile devices has also had an impact on automotive innovation. Drivers accustomed to being constantly connected with friends, family, colleagues and world events in their daily lives outside the vehicle are likely to be unimpressed by a vehicle that isolates them from the wider world, and that also makes limited connections with the environment in which it operates – the road system, other vehicles, the places it travels to.

Models of future automotive innovation that see only straight-line extrapolations from past vehicle usage and ownership patterns may be well off the mark, with the potential for disruptive technologies on the horizon.

SMART SERVICES AND SEAMLESS MOBILE EXPERIENCE

BMW will introduce its first series production carbon-fibre-bodied electric vehicles later this year and designs new ways in which the users will interact with the vehicles. Tony Douglas, head of marketing and sales for BMW Mobility Services, called it "a greenfield project" which was redefining the relationship between the vehicle and the user.

Central to that is the adoption by the vehicle's communications network of many of the features more commonly found in mobile phones. For example, apps that can direct the vehicle to a pre-booked parking space (Park@MyHouse.com) or to a city-centre charging point (ChargeNow) are built into the network. In a trial on a hire fleet in California the vehicles, the parking and charging infrastructure and the customers themselves were all networked. Links through to wider systems mean all transactions can be done without cash and without paper tickets.

An important innovation aspect in this, according to Tony Douglas, is that many of the developers of these technologies are small start-up companies, now selling into an industry where it is difficult for small companies, even with innovative ideas, to make an impact. It also changes the business for BMW, he said: "We're now in the business of mobility services."

ALTERNATIVES TO OWNERSHIP

BMW Mobility Services is based on the premise that car ownership by individuals, seen for the past few generations as fairly high on many people's lists of aspirations, is just one of a number of models for future vehicle supply. Other models include hiring, sharing and car clubs, with Mark Walker, UK general manager of Zipcar, explaining that the heart of what the automotive sector is doing is providing a service rather than a specific product.

Zipcar provides cars to rent by the hour or the day, from locations close to where people live and work. A key market for this is younger city dwellers, for whom the cost savings and convenience of car sharing outweigh the benefits associated with car ownership. Walker also identified a market in the form of companies that have traditionally maintained their own fleets of company cars. "People use Zipcar when they need a vehicle and they pay nothing when they don't!," he said. The 'collaborative consumption' business model can be applied much wider than just vehicles and was already a multi-billion pound industry worldwide.

6. Further information

The **Innovation in automotive** event on 29 January 2013 was the third in a series of conferences held at the Royal Academy of Engineering on innovation in sectors that are important to UK engineering and that offer potential for growth locally and globally.

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Chairs

Sir John Parker GBE FREng
President, Royal Academy of Engineering

Professor Richard Parry-Jones CBE FREng
Co-chairman, Automotive Council

Speakers

Professor Richard Dashwood
Academic Director, Warwick Manufacturing Group

Tony Douglas
General Manager Sales and Marketing Mobility Services, BMW Group

Lord Paul Drayson PC FREng
Managing Partner, Drayson Technologies LLP

Dick Glover
Research Director, McLaren Automotive

Jerry Hardcastle OBE
Global Chief Marketability Engineer and Technical Director Global Motorsports, Nissan

Steve Sapsford
Global Market Sector Director High Performance Vehicles and Motorsport, Ricardo

Mark White
Chief Technical Specialist, Jaguar Land Rover

Mark Walker
UK General Manager, Zipcar

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Drive faster and more balanced economic growth

Foster better education and skills

Lead the profession

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Royal Academy of Engineering
Prince Philip House
3 Carlton House Terrace
London SW1Y 5DG

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