IMPACTS AND BENEFITS

1. **What are the potential applications for autonomous vehicles?**

Beyond self-driving cars, operation in warehouses for order fulfilment, unmanned underwater, aerial, surface platforms for inspection, maintenance and repair of infrastructure (asset integrity management, assurance and certification), assisted living devices for the elderly around the home, other domestic appliances for cleaning, cooking, gardening, agricultural systems for planting and harvesting, other forms of transport including rail and ship for people and goods. In practice, anything that moves, and in some cases things that currently don’t (e.g. mobile table for carehome).

2. **What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

Benefits are increased safety and productivity, reductions in cost of operations, time to perform, energy used. Disadvantages are need for training and up-skilling of staff who use them – autonomy is all about the operator. No formal methods yet for assurance of autonomous systems, especially if learning features built in.

3. **How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

Different in different sectors. They are already used routinely for operations at sea – defence, oil and gas inspection, marine survey, environmental science, so there role and benefit is clear. Amazon and Ocado order fulfilment are already largely using autonomous vehicles. However other markets are less advanced, for example performing physical intervention for asset integrity management or working and collaborating with people in domestic environments. Here there are still technical challenges to overcome, and therefore the extent of when and what of there envisaged uses has still to be established. Nonetheless, the opportunity and potential impact is enormous, on a par with the revolutions of computers, aircraft and motorized transport.

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4. How much is known about public attitudes to autonomous vehicles?

There have been several surveys at different times with different results.

1. Public attitudes towards robots, Special Eurobarometer 382, Sept 2012

Broadly speaking people are interested and intrigued, because of the immediate ways they understand how it will impact their lives (eg drive home from the pub, faster package deliveries with drones). However, they are also concerned about job losses and employment and there is a good deal of media hype on this. Some believe there is a hollowing out of middle class employment coming or here with uneven wealth distribution, others that this is no different to the introduction of looms, cars, or computers. Technology has always created more jobs than it took away:

https://www.theguardian.com/business/2015/aug/17/technology-created-more-jobs-than-destroyed-140-years-data-census

The public are starting to see the difference between the Holywood version of the future and the reality of what’s achievable now. However, they don’t fully understand the limitations on the technology. Greater responsibility and informed-ness in journalistic reporting plus connection of economists and social scientists to engineers is helping to shape better informed messages.

Some useful texts on employment aspects:

10. The effects of technology on employment and implications for public employment services, World Bank Group (May 2015)

5. What is the scale of the market opportunity for autonomous vehicles?

Multi billion dollar cross sector, with trillions of dollars of consequent impact. McKinsey 2013 report is a much quoted source.


The FT has run an excellent set of articles (Q2 2016) filled with data on investment levels, market sizes, global activity, unemployment data that broadly supports these positions and is worth consulting rather than repeating here⁵

CREATING AND ENABLING ENVIRONMENT

Research and development

6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?

No. We have made a start in self driving cars with demonstrations and public interaction in Milton Keynes and Greenwich. However we must do much more across different sectors and quickly to stay ahead of international competition. RAS2020 Strategy lays out the essential domains. Infrastructure test beds for asset integrity management (oil and gas, nuclear, buildings), other urban environments, carehomes, factories and more


7. Is the Government doing enough to fund research and development on autonomous vehicles and to stimulate others to do so? Should it be doing more to coordinate UK actions?

Government has made a promising start with CCAV and underpinning R&D through EPSRC with Centres for Doctoral Training and Capital investments. A concerted effort is now needed to build on this and enable the cross sector innovation pipelines for disruptive new businesses with products and services to really get going in the UK. This requires co-ordination of stakeholders in industry, government, public bodies and research through a

⁵ http://www.ft.com/robot-week
Leadership Council structure, echoing the success of the automotive council. Government as smart procurer and customer helping disruptive innovative companies to become established by working on requirements spiral eg in SBIR type arrangements – long term relationships emerge over many years. Innovation should be embedded in cluster around the main Centres where research is underway, and skilled people are – eg Bristol, Edinburgh, Oxford, Sheffield, Southampton, London. A conventional Catapult may not be the right answer for this translation activity.

8. How effective are Innovate UK and the CCAV in this area?

CCAV is young and so it is early to pass judgement. They are certainly creating activity and interest across the community. Innovate UK have made good progress supporting all. Increased connectivity in planning and acting alongside the research councils and engagement in getting large companies and Government departments to work through smart procurement are opportunities for iUK.

9. Is the environment for small and medium sized enterprises (SMEs) working in this sector sufficiently enabling?

Not yet. Access to investment at scale is lacking, with follow through, to take risk but develop $billion valuation unicorn businesses. Industrial Strategy has the opportunity to signpost routes to growth, by connecting people and oiling the wheels

Real world operation

10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?

Digital infrastructure continually evolves and can continue to do so as autonomous platforms become more ubiquitous. Physical infrastructure can change (e.g. automated parking garages) but much need not – the vehicles are designed to operate in environments adjacent to humans.

11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?

The typical path is a gradual transition of smart autonomous vehicle capability (eg obstacle avoidance, mission planning) to manned vehicles, reducing workload on the driver/operator, freeing them for other tasks, making them more productive. It also gains the operators trust, and de-risks the technology through extensive supervised field testing, ready for the transition to full autonomy mode. This is happening in the car and unmanned underwater vehicle industries. For mass adoption by the public this kind of in-field testing both of the technology and the people is essential. Autonomy is all about the operator.

12. Does the Government have an effective approach on data and cybersecurity in this sector?
The cybersecurity industry has still to focus on this market and topic with the same vigour being applied to other ICT applications eg banking. This was a key finding in the Lloyds Register Foundation Foresight Review of Robotics and Autonomous Systems launched in October 2016


The cybersecurity and RAS research and development communities need to work closely. Some scoping activity could identify the opportunities and the needs in this area, to secure network connected RAS against a variety of classes of intrusion. This may include the need for encryption and the design of efficient approaches, including the role of digital ledger technology for guaranteed transaction records. Such RAS could be publically offered in a hack challenge to test their security.

Ideally, RAS software will be developed to acceptable software integrity level standards, appropriate to the criticality of the application. This is not a cheap endeavor. Identifying and recommending cost-effective ways to do this will encourage adoption by developers and specification by customers. Allied to this is the embedding of fault detection and diagnosis as part of the RAS onboard health management, with acceptably low false alarm rates. Third party vendor software embedded as libraries should also be assured or at least firewalled and jacketed so that the RAS degrades gracefully, predictably and safely in the event of code and other errors.

13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?

The certification and assurance industry could be revolutionised by these platforms – especially where the autonomy includes the ability to self-certify in real time during operations. Regulation about several things including use of cameras and other forms of data privacy could be necessary for public adoption and trust. Regulations on safe use of space (eg roads and airspace) and standards for performance and behaviour where multiple platforms are operating concurrently or even collaboratively will be required. Insurance and ownership models will change, no longer so personalised to an individual. Significant disruption in the insurance industry could ensue, following a more Swedish model, being offered by the manufacturer as part of the platform package. Fewer crashes make this economic and feasible

14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?

- Engineers alone should not be left to programme behaviours into robots that cross ethical boundaries. Nor can machines that learn be similarly empowered. Internationally agreed ethical standards for RAS are needed so that clear guidance and norms evolve, for example for ‘no-win’ decision making. A culture of ethical concern should be encouraged across the international R&D community. This requires an international effort and the evolution of ethical counsels to provide the reference guidelines and
standards. Efforts to develop these should involve engineers, social scientists, lawyers, ethicists, researchers, policy makers and journalists working closely.

Further reading on this:


Wider governance

15. What does the proposed Modern Transport Bill need to deliver?

16. How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?

We will need more autonomous systems skills at all levels in the future, and more people who possess them and are passionate. Teachers need support to lay good foundations in schools, with examples such as Robokid offering good quality distance learning materials and access to maintained equipment.

http://www.robokid.org.uk/

Undergraduate, postgraduate, continued professional development and fellowships all continue to be needed. Secondments for RAS students and researchers into the assurance industry would also provide useful mutual transfer of knowledge and skills.

EPSRC have made a promising start establishing centers for doctoral training and making capital investments in several UK centers. These are generating technology and talent, but there is a requirement for continued expansion as markets and opportunities grow. Technician and modern apprenticeships will also become increasingly important – maintenance of these systems requires different skill sets, including software.

17. Is the Government’s strategy and work in this area sufficiently wide reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?

No. Government has only just scratched the surface. CCAV could be a good role model, and secondment of fast stream civil servants into it from all Government departments will help
create other opportunities in other sectors. This has been the subject of discussion at Cabinet Office Horizon Scanning meetings with Heads of Depts and Chief Scientists pre-Brexit. Momentum should not be lost post Brexit, in fact quite the opposite if UK is to go it alone. In conjunction with a Leadership Council as part of the Industrial Strategy, Government as customer and regulator and supporter of research and innovation can stimulate the research base and the innovation pipeline to create new businesses across all sectors. These will be disruptive in products and services with autonomous vehicle technology, that will make UK more productive and competitive, and gain market share overseas for exports.

18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?

EU research funds and research partnering are an important source of finance and more importantly, ideas in the development of these technologies. It also connects UK researchers and companies with those in Europe, in some cases large manufacturers who can become customers. Post Brexit, some mechanism for UK organizations to continue in new EU consortia and initiatives doing research and innovation is essential, without discrimination, and without a second funding review hurdle to overcome.

For the car industry, there are no very large manufacturers located in the UK, and post Brexit we may lose those we currently have from overseas (eg Nissan). We will have EU competition selling our smart software for autonomous navigation, planning and other services into these EU based manufacturers. We are less likely to win against European competition without close relations, as well as a competitive edge in technology and price.

26 October 2016