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Building Trust in Automated Vehicles – The Role of Fenced Test Sites

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Abstract

One of the primary benefits from automated/autonomous vehicles (AV) is the promise of increased road safety through reductions in the number of driver error-induced accidents, where an often-cited statistic is that around 90% of all motor vehicle crashes are caused by human error[1]. The flip-side of this is that one of the greatest barriers to the widespread uptake of AV is the need to prove to the public that AV are 'safe'. Hence, whilst accumulating operational experience is necessary, it is insufficient to make people feel comfortable about the idea of robot vehicles roaming the streets. This paradox can be addressed by developing testing processes and protocols that generate empirical data that proves reliability alongside more intangible evidence needed if we are to build confidence and trust. To this end we have opened-up the Culham Science Centre campus[2] as a 'fenced test facility' where AV routinely operate alongside over 2,000 site users.

Keywords: AUTOMATED VEHICLES, AUTONOMOUS VEHICLES, TESTING, TESTBED, RISK MANAGEMENT

1. Background

UKAEA has over 30 years' experience in developing, testing and deploying sophisticated robotic and autonomous systems primarily for remote handling in challenging environments[3]. Before we use these, we go through a comprehensive process of testing and validation to build our trust in these systems. At its heart we use advanced science and engineering to demonstrate robustness, reliability and safe operation which gives objective measures of predictability and reliability, UKAEA, as the user, needs to have trust in complex systems that dynamically combine technology, user and application. Key to our philosophy is the recognition that building trust is not like flicking a switch where one day people do not trust you and the next day they do. We build trust through a structured process of testing 'in silico, in vitro and in vivo' that builds our confidence in the technology and its safe and reliably function.

We are applying the same principles to the testing of AV on our site. Indeed, we have been hosting such trials for 30 months, with level 4 AVs having driven over 15,000km on our roads and using the

trust this has built means that the vehicles are now an everyday, unremarked-on presence and the developers have the confidence to drive on the public highway. We recognise that we sit in a niche between testing on private tracks and on the public highway, but it is a niche that can significantly reduce the risks associated with public testing. As a niche site we only offer a fraction of the facilities required to fully prove AV, and hence have aligned ourselves with other AV test centres, notably Millbrook[4], within a coordinated programme of investment designed to position the UK as a global centre for the testing of AV[5].

2. The Prize

The first advanced robot we experience may well be an AV. AV technology has made huge strides in recent years, moving from a mainstay of science fiction to the first forays on public roads. Indeed, AV are almost unique in technology development in so far as estimates of when they will reach market are being brought forward – industry predictions now talk of the majority of new car sales in 2030 being of vehicles with high levels of autonomy[6]. This optimism on early uptake is based on a combination of developments in sensing, data processing, data compression, data storage and machine learning.

The promise in AV stems from a wide range of potential and perceived benefits, the biggest of these is increased road safety through a reduction in the number of driver error-induced accidents – where research shows that around 90% of all motor vehicle crashes are caused, at least in part, by human error (US National Department of Transportation, 2008). There are, however, numerous other benefits including: improved mobility for the disabled and elderly; reduced road congestion via reactive traffic flow control; productive travel time; higher utilisation of individual vehicles reducing the number of vehicles required per capita; and a reduced need for parking, freeing-up space in urban areas. The associated economic impact of the technology is also considerable - with KPMG reporting that the total impact of AV on the UK economy will be £51 billion in 2030 based on AV creating 320,000 additional jobs, avoiding 25,000 serious accidents and saving 2,500 lives between now and 2030[7].

3. The Challenges

The emergence of vehicles able to undertake any end-to-end journeys without any supervision from a driver, will be transformative, but also hugely challenging with technological, social, cultural, political, commercial and legal implications[8]. Not least in terms of how human drivers will interpret the AI-driven decisions of an AV. Hence the need to address questions such as:

- How do you fully prepare AVs for use on open roads without fully characterising their interactions with driven vehicles in all conditions?
- How do you characterise these interactions without exposing the public to AV technology before it is mature enough for it to be safe?
- How will road users behave towards autonomous vehicles?
- Will people give them a wide berth out of fear of them doing something unexpected?
- Or will the public test the limits of the technology under the assumption that the technology

should be smart enough to cope with anything they throw at them?

- How do you start introducing AVs into the roads?
- How will an AV be insured for use?
- How will the public react to further AVs incidents or accidents?

Of themselves these are complex and open-ended questions, but are compounded by the fact that part of the challenge lies in how we transition from roads where all the vehicles are controlled by a mostly predictable human driver to one where all vehicles are computer controlled with hard wired behaviour and responses. While the end scenario of pervasive, connected, fully-integrated autonomous vehicles is relatively easy to imagine, the journey to get there during which driven and driverless cars interact heavily, can look long, treacherous and chaotic.

4. The Response: A fenced urban testbed

The need to meet these challenges means that the emerging AV industry is continually testing and developing its vehicles. Indeed, the UK Department for Transport code of practice for driverless car testing states: "Manufacturers have a responsibility to ensure that highly and fully automated vehicle technologies undergo thorough testing and development before being brought to market. Much of this development can be done in test laboratories or on dedicated test tracks and proving grounds. However, to help ensure that these technologies are capable of safely handling the many varied situations that they may encounter throughout their service life, it is expected that controlled 'real-world' testing will also be necessary"[9].

The transition from closed to open road testing is crucial and as such the lessons learnt from "controlled real-world testing" will have huge relevance to the safe emergence and acceptability of AV. Without "controlled real-world testing" on a substantive, mixed road network where other vehicles, pedestrians, cyclists etc. have free (and random) access within a suitably monitored and supportive environment, there is a risk that the process of gaining 'authority to operate' from the general public could become even more problematic.

UKAEA began exploring the possibility of developing the Culham Science Centre site as such a facility (aka a 'fenced test site') through a feasibility study funded by the UK Centre for Connected and Autonomous Vehicle (CCAV). This study undertook a stakeholder consultation, that was conducted against a backdrop of a gradual introduction of AVs on to the site road network.

This consultation[10] concluded that whilst it is largely accepted (59% of respondents) that the roads would be safer with AV local stakeholders were significantly more positive towards the concept of AV (81%) than members of the UK public (54%) indicating that whilst there is much to do address public perception of the technology, Culham site users are more welcoming.

All respondents highlighted concerns about security, standards and whether any technology could be truly prepared for all eventualities. Again, members of the public were found to feel significantly less positive (49%) here than stakeholder groups (80%) reinforcing the work required to give the public the same level of confidence as those connected to the field. Stakeholders are aware of this and described how they believe "public perception of safety concerns to be a major barrier to the acceptance of fully automated vehicles, and how new technologies would need to be gradually introduced to navigate this." As important as it is to understand public perceptions towards AV and how they differ to stakeholder perceptions, it is possible that the differing views of these groups on how AV should react in complex real-world situations could trigger hostile responses on the part of the human driver. This work contextualises a paradox of AV: the main barrier to uptake is the need to prove safe operation, whilst the main benefit is an improvement in safety. This initial characterisation of perception allows us to anchor technology verification work into a socio-technical context.

5. The Response: A risk-oriented operating regime

At the engineering level we require that all AV be roadworthy, carry a location tracker and have on-board a dedicated Vehicle Safety Operator who is able to take control of the vehicle at all times. We require vehicles to demonstrate an appropriate degree of safe and reliable operation before allowing them full access to our road network. Permission to operate is granted to the autonomous system, being the combination of both vehicle type and software. If a new operating system is installed in an existing vehicle or a new vehicle is fitted with an existing operating system it will be required to re-qualify.

Our access regime splits into 3 tiers:

- **Fenced Test Area**. The vehicle needs to demonstrate its basic competence through monitored operation on a suitably configured area where pedestrians etc. are not permitted. We have such an area at Culham, but also allow for this test to be undertaken at our partner's site at Millbrook[11]. Progression to the next tier requires the AV to demonstrate its ability to:
    - Drive in a straight line.
    - Turn at junctions and roundabouts.
    - Avoid a collision with an object in its path.
    - Demonstrate hand over process to the Vehicle Safety Operators.
    - Demonstrate request for Vehicle Safety Operator take over.

  The order in which these manoeuvres happen is (randomly) set by our Facility Manager and the test must be successfully completed within a defined time period. A time stamped data set covering this trial must be made available.
- **Northern Loop**. Once basic control has been demonstrated vehicles are allowed access to our 'Northern test Loop', which is a c.3km circuit comprising roads with relatively low utilisation. Operation on this loop is monitored from our track control centre and accrued experience assessed before the AVs are allowed unfettered access to the broader site road network.

- **Full site access**. Vehicles will be eligible to progress once they have accumulated a minimum of 50km of safe autonomous driving on the Northern Test Loop and demonstrated safe operation in full compliance with our conditions of use, to our Facility Manager

6. Next Steps for our Site[12]

By the summer of 2019 we expect to have completed the first phase of a major upgrade in the facilities and services that are available to the developers of AV and related technology. This investment will deliver tangible benefits to an industry keen to exploit new test infrastructure to speed up development and gain a competitive advantage. Key to this is our partnership with Millbrook that allows us to offer a fusion of real-world and simulated environments and real-time connectivity to challenge software, sensors, cyber security systems and telecoms developers.

In practical terms this means that we are putting in place the physical infrastructure essential for supporting efficient and safe development of autonomous driving aids. As a result, we are able to offer innovators everything from roads to real-time connectivity through to reference vehicles and simulation facilities. Specifically, we are:

- Investing in dedicated Long-Term Evolution (LTE) and Dedicated Short-Range Communication (DSRC) capabilities, and associated street furniture, to provide a common, seamless and connected experience for users across the two sites. The capability is enabling accurate location and connectivity Vehicle-to-everything (V2X) trials with possibilities for (localized) network disruption and simulated connectivity issues as shown in Figure 1.

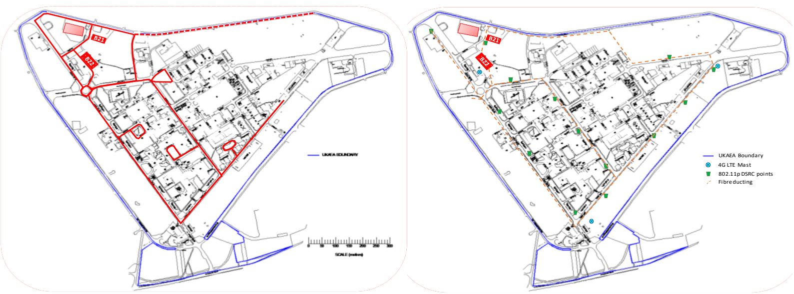

Figure 1: Culham Science Centre showing (a) accessible roads (b) LTE/DSRC infrastructure

- Sourcing a number of 'mule' and open source reference vehicles. These can be programmed to simulate traffic, be controlled autonomously or remotely, and/or test autonomous driving software. They can be given different steering, braking and acceleration characteristics to emulate a range of vehicles without the need to bypass the CANBUS, speeding up valuable

experimentation and development time.

- Developing a virtual proving ground model encompassing both locations. Both sites have been digitally modelled with 1mm surface accuracy and the first simulator installed (at Millbrook). This will enable customers to test their software across physical environments and their associated digital twins. We are also working with developers of new simulation and modelling techniques[13] to increase the number, and capabilities, of our digital siblings.

7. Conclusions

The process of building public trust in AV is rooted in testing. The move from testing on closed test tracks to testing in the public highway involves a huge increase in both the scale and range of risks. Managing this risk by accumulating mileage on motorways and trunk roads where vehicles and pedestrians are largely segregated represents a mechanism for mitigating such risks, but arguably does little to build trust.

In the UK we are developing an alternative mechanism for building trust - the use of a fenced site. At the Culham Science Centre site we are able to operate AV alongside the scientists, engineers, office and support staff who work here and move around the site (on foot and in vehicles) as part of their normal business. Such testing does not allow developers to readily accumulate millions of miles of 'experience' but instead allows them to test at a location where the operation of AV is an everyday, and unremarked, occurrence. The combination of this with simulators and digital twins represents a novel approach to risk mitigation.

References

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[2] The Culham Science Centre is an 80ha site with a 10km private road network that is used by commercial/passenger vehicles, pedestrians and cyclists

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[13] See https://www.latentlogic.com/latent-logic-to-lead-omnicav-project/ for links to project details