UK Atomic Energy Authority

UKAEA-RACE-CP(19) 03

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This paper has been submitted to
13th ITS European Congress, Amsterdam, 3-6 June 2019

Paper number ITS-XXXX

Could Connected and Autonomous Vehicles Transform Asset Inspection?

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Abstract

Whilst Connected and Autonomous Vehicles (CAV) hold the promise of relegating the driver to passenger by transforming vehicles into intelligent platforms able to 'read' and 'sense' their environment. A corollary of this is that not only will these vehicles transform how people get from A-to-B, they will be a major source of information which could have application far beyond enabling the vehicle to navigate safely. Amey and RACE, with support from the UK Centre for Connected and Autonomous Vehicles, have carried out a feasibility study that explored how the regularly updated asset map of roads, footways, verges, vegetation and street furniture that a CAV generates could be integrated into existing service delivery tasks like road-based asset inspection and vegetation maintenance. This paper sets out the initial analysis of the results obtained and shows where, and how, the step change in the quantity of available data could transform asset inspection.

Keywords:

ASSET INSPECTION, AUTOMATION, AUTOMATED VEHICLES, CONNECTED VEHICLES, AUTONOMOUS VEHICLES

1. Context

Whilst Connected and Autonomous Vehicles (CAV) hold the promise of relegating the driver to passenger (or passive vehicle controller) by transforming vehicles into intelligent platforms able to 'read' and 'sense' their environment. A corollary of this is that not only will these vehicles transform how people get from A-to-B, they will be a major source of information which could have application far beyond enabling the vehicle to navigate safely. Amey and RACE, with support from the UK Centre for Connected and Autonomous Vehicles, have carried out a feasibility study that explored potential applications of data derived from CAVs and how this data could be integrated into existing service delivery tasks like road-based asset inspection and vegetation maintenance. The initial evidence suggests that CAV derived data can supplement and complement existing service delivery task processes and deliver potential efficiencies and quality improvements.

The project analysed several potential business areas where the data from autonomous vehicles could be deployed to complete service tasks and identified that road-based asset inspections presented the greatest opportunity for an application delivering real business value. A twin track approach to evaluating how data might impact on current industry practices was used. The first of these explored the potential to import 'CAV data' sets into the Horizons asset inspection system (an industry standard approach developed by Yotta Limited[1]) with the second being to share the data and analysis in interactive workshops with industry practitioners.

The CAV data sets were collected by attaching an external sensor pack (the NABU) to a vehicle. The NABU unit was developed by Oxbotica and is designed to deliver the basic data required by their Selenium autonomous driving system[2]. Matching the NABU derived data to the data required to autonomously drive the vehicle and that required by the Horizons package leads to four possible outcomes as set out in Figure 1.

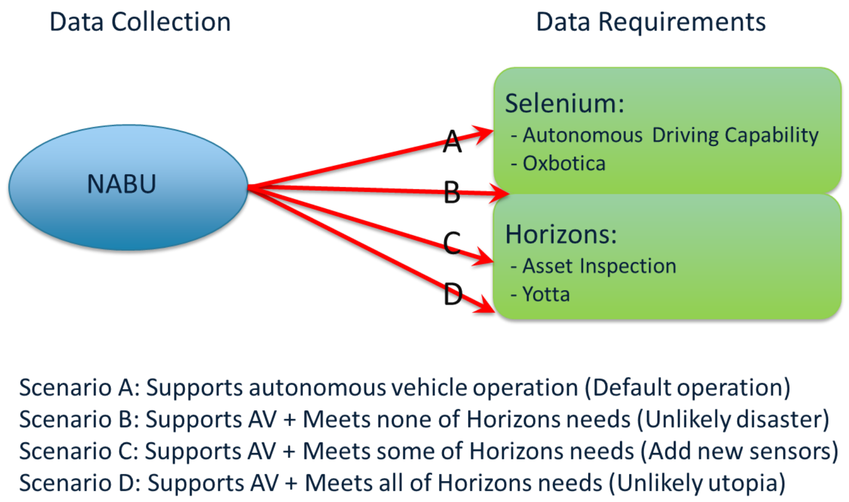

Figure 1: Potential outcomes from the work

2. Methodology

The NABU unit is essentially an externally mountable sensor unit that was developed by Oxbotica to provide the inputs their AV operating system requires. It comprises:

- 2* LiDARs
- 1 * stereo-visual odometry system
- 2 * FireWire cameras
- 1 * GPS (as an external plug-in)
- On-board processing, data storage and wireless communication capability.

This unit was affixed, using an external frame, to a standard road-going vehicle as shown in Figure 2. Data collection was undertaken on a variety of road circuits to ensure that a suitably diverse range of road conditions were experienced. Yotta undertook a full survey of roads on and around the Culham site and equivalent data sets were collected using the NABU. The data collected was processed, using a bespoke module of the NABU, to produce 3D point cloud maps. These maps were used to inform discussion at the practitioner workshops, and samples frames from these are shown in Figure 3.

Figure 2: NABU unit mounted on test vehicle

Figure 3: NABU generated point cloud maps showing a footbridge and a set of traffic signals

The point cloud maps generated are internally consistent with a high degree of accuracy. However, in its current configuration the NABU does not integrate GPS tags in the point cloud maps, but parallel GPS data sets were collected, and this was used to provide basic geolocation validation.

3. Findings

3.1 Integration with Industry Standard Systems

Partial integration of the NABU data with the Horizons system was achieved (i.e. the outcome maps on to Scenario C in Figure 1). In arriving at this conclusion, the following limitations in the NABU output were noted:

- Uniform environments/features, e.g. a segmented tunnel, can occasionally cause incorrect loop closures, as localisation software may struggle to differentiate images if they are too similar.
- NABU generates large data sets (~100mb per km compared to ~300kb per km for Horizons). This significant increase in data presents a challenge for the scalability of surveys.
- The density (fidelity) of the point cloud may limit applicability to pavement surveying.

- As currently configured, data is not fully GPS-referenced.
- Accuracy and density of the point cloud are reduced with increased driving speed and/or significant acceleration.
- Multiple runs of the same road section are necessary to provide meaningful information, and vehicle positioning, speed, etc. must be as consistent as possible across runs.
- A considerable amount of manual post-processing time is currently needed to correct the point cloud, this is a concern for scalability.

Despite these limitations Yotta were of the view that the approach shows promise and could gain initial market traction in pavement condition assessments and asset inventory surveys.

3.1 Connected Vehicle Enabled Services

The workshops with industry practitioners yielded the following insights into the impact that connected vehicles could have on service provision:

Automation of Road Based Asset Inspection

- CASS-DV has demonstrated that data derived from LiDAR has value in terms of automating road-based asset inspections. There is the opportunity to combine LiDAR with other connected vehicle data (accelerometers, cameras) to provide granular data on a regular basis to transport authorities who can monitor their network remotely.
- Potential Impact on Industry: Medium. This will disrupt the traditional industry, resulting in a reduction in personnel required, as well as force current traditional inspection companies to change.

Vegetation management

- The data collected by the vehicles LiDAR is granular enough to pick up surrounding vegetation growth over a period of time. This is of value in relation to verge, tree and hedge cut backs as part of ongoing highways maintenance activities. If the technology can automatically identify where excessive growth has occurred this would reduce the need for inspectors to inspect the route.
- Potential Impact on Industry: Low. Vegetation management is not a high cost item as part of Highways maintenance. Most local authorities are reducing their regular cut schedules as part of cost saving exercises or passing responsibility to community groups.

Air quality monitoring

- There is an emerging trend for vehicles to include additional instrumentation beyond that required to help the vehicle navigate safely. Air quality sensors are likely to be included in future vehicle models, enabling live tracking of air quality in urban and rural areas. A key challenge, however, is the quality of the sensors in comparison to industry leading fixed sensors.
- Potential Impact on Industry: Medium. The impact from a societal perspective will be great as air quality data will enable people to make better decisions about their travel choices. However, from an industry perspective it is difficult to see the value of the granular data as it has yet to be commercialised.

Traffic Management

- Connected vehicles will provide data about where they are and the speed they are moving. This should present opportunities in terms of enabling transport authorities to be able to switch from reactive traffic management to proactive management based on live data, thus being able to improve traffic flow. Based on this data they may choose to tweak traffic signals or actively close key routes.
- Potential Impact on Industry: High. Live traffic data will transform the traffic management industry, enabling the provision of systems which combine this new data with historic data to improve how services are delivered.

Accident Hotspot Management

- Connected vehicles will contain accelerometer sensors as well as location sensors, alongside existing sensors in brakes and steering. Data generated from these sensors can identify deviations from normal patterns, providing data leading up to an accident.
- Potential Impact on Industry: Medium to High. This data is of value to network managers in identifying if a specific road design is contributing to accidents occurring, thus enabling re-design.

Public transport planning

- Connected vehicle location data including origin and destination (and potentially passenger numbers) could help Transport Authorities plan future transport routes based on frequency of journeys between two locations.
- Potential Impact on Industry: Medium to High. The granularity of data could enable demand responsive transport. This data could underpin future mobility models, enabling multiple transport forms to provide alternatives to car travel.

3.2 Autonomous Vehicle Enabled Asset Inspections

The workshops with industry practitioners yielded the following insights into the impact that autonomous vehicles could have on service provision:

Mobility as a Service - People

- Autonomous vehicles will act as taxis, offering first mile - last mile journeys as well as potential rapid mass transit solutions. There is also the possibility of autonomous trains.
- Potential Impact on Industry: High. Autonomous Vehicles will transform the movement of people, generating multiple market opportunities for companies like Amey.

Mobility as a Service - Goods

- The movement of goods using autonomous vehicles. This may take the form of small delivery vans in urban areas or large haulage trucks moving containers in road trains.
- Potential Impact on Industry: High. AVs will transform how goods are transported, delivering considerable savings and generating new opportunities for companies like Amey.

Street Cleansing

- AVs could be deployed as street sweepers, following defined routes. AV could be deployed on small compact sweepers or much larger road sweepers.

- Potential Impact on Industry: Low. AVs will become common to carry out sweeping in the next 10 years, however the market size and opportunities related to it are not that large compared to other emerging markets.

Grounds Maintenance

- AVs have the potential to be deployed to cut grass and trim vegetation (hedges, verges, trees), removing operatives from risk.
- Potential Impact on Industry: Low. Compared to other business opportunities this is quite small in comparison. The size of the market is quite small though the use cases are easy to automate.

Gully Cleansing

- AVs could be deployed to cleanse gullies. They could potentially access hard to reach locations or carry out the clearance of gullies on the highways network.
- Potential Impact on Industry: Low. Although there are multiple saving opportunities these are small compared to other potential opportunity areas.

Waste collection

- Refuse collection vehicles (RCV) could be automated to collect household waste. Due to the complicated nature of the process it is unlikely that everything can be automated, so it is likely that there would need to be one individual as a bare minimum.
- Potential Impact on Industry: High. There is a huge opportunity to automate this service area. Automation will enable services to be offered in a more cost-effective way and potentially as a 24hr service during quieter periods (reducing congestion caused by operating during rush hour).

Litter Picking

- Automation could transform repetitive manual litter picking tasks in parks, on streets and highways verges.
- Potential Impact on Industry: Low. Though the impact on society as result of cleaner streets would be noticeable as autonomous litter picking could run as a 24hr service, the potential commercial opportunities are quite limited compared to other automation opportunities.

Traffic management equipment deployment

- The deployment of traffic management instruments (temporary traffic signals, barriers etc.) is a repetitive task which could be automated, though this is potentially quite complicated due to the number of localised factors (parked cars, location of signals, etc.) when deploying traffic management.
- Potential Impact on Industry: Low. Automation presents opportunities in this area but there are other areas which will likely be a higher priority and are less complicated to automate.

Road/ pavement repair

- AVs have the potential to complete automated tasks like pavement and road repair, if fitted with the correct technical equipment. This could be to fix potholes or developing cracks in the road.
- Potential Impact on Industry: High. Local authorities are constantly looking for more effective ways to carry out pothole and road repair. Automation of the process could transform how this is carried out, enabling 24hr road repair.

Gritting

- Gritting would be simple to automate as the vehicles follow predefined routes. There would be the potential to automate the salt spread rate and radius, whilst also enabling a truly 24hr responsive service as drivers would no longer be required.
- Potential Impact on Industry: Medium. Gritting is an area where Local Authorities are looking to deliver savings as each gritting run can cost tens of thousands. Automation has the potential to transform this service area, removing the driver as a cost.

Cone deployment

- Cone deployment as part of work zone deployment is one of the most dangerous jobs on motorways, resulting in a number of fatalities each year. Automation has the potentially to remove operatives from harm's way.
- Potential Impact on Industry: Medium to High. Although the financial benefits are difficult to quantify, the safety improvements far outweigh this, contributing to a reduction in loss of life every year.

Street light repair and replacement

- Automation of street light repair/replacement is a key area of opportunity for automation as the tasks are relatively repetitive but full automation could prove quite complicated.
- Potential Impact on Industry: Medium. Street light repair could be transformed by automation. This is quite a large market, worth hundreds of millions per annum. However, the labour-intensive nature of this area means that it is unlikely to be fully automated. The simplest part of the process to automate will likely be the travel to and from each street lamp.

Rail track repair

- Much of the focus of automation has been on road-based vehicles, however there is the opportunity to automate track-based repair vehicles. Parts of this industry are already automated. Track repair is a time consuming and labour-intensive process. Opportunities include cutting of old track, removal and repair.
- Potential Impact on Industry: High. Track maintenance and repair is a multi-million pound industry which could benefit from further automation. This would remove operatives from harm's way and potentially speed up the process.

Aeroplane tugs

- The automation of airside areas presents multiple opportunities. Aeroplane tugs could be automated and would be 'summoned' to the aeroplane's location to attach to it and drag it to the terminal.
- Potential Impact on Industry: High. The airport industry is worth hundreds of millions. Airside environments are controlled environments and although heavily regulated, are easier to automate than the deployment of CAVs on roads. Tugs would prove relatively simple to automate delivering labour savings.

Baggage vehicles

- Baggage vehicles could be automated and requested at certain gates prior to the aeroplane's arrival. Automation would also involve fitting the conveyer to the aeroplane, though it is likely that some human interaction would still be required to move the bags off the plane.
- Potential Impact on Industry: High. As per above, airports are highly labour intensive and present major opportunities for automation. Major airports can have hundreds of tugs, all of which could benefit from automation, reducing the size of the workforce.

Airport Foreign Object Detection (FOD)

- Runways are manually inspected multiple times a day for foreign objects. This is automated at some airports but is largely done manually, involving a team of several people walking the full length of the runway in a line.
- Potential Impact on Industry: High. Automating this process would release huge benefits at airports, potentially enabling additional take-off slots from the runway each day. Inspections could take place in between landings/take-offs

4. Conclusion

A key conclusion of this project is that the point cloud maps that an AV generates are potentially of value to transport authorities when integrated into existing service delivery tasks. However, further work must be done to make sure it is in a format which can be consumed by industry standard tools. Regarding the specific use cases, the approach shows initial promise in completing inventory surveys and may be of value in applying to other use cases.

Amey, RACE and Yotta are collaborating on a project that will see them working with Oxfordshire County Council to improve GPS integration into the point cloud map and then practically some of the above use cases, with a focus on white lining, signage and junction visibility.

The authors would like to acknowledge the financial support provided by the UK Centre for Connected and Autonomous vehicles, without which the work would not have been possible.

5. References

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[1] https://weareyotta.com/software/horizons/

[2] https://www.oxbotica.ai/selenium/