Computer BUS

Later this year, a single-decker will drive itself and passengers across the Forth Road Bridge in Scotland, in what is said to be a world first

Although the vehicle operating the scheduled 14-mile service is semi-autonomous, it is not driverless: by law, a human driver sitting in a fully functional cab will oversee all of the bus's actions and intervene, if necessary. This human-machine combination is the result of a £4m government-funded CAV Forth project, involving operator Stagecoach, bus manufacturer ADL (Alexander Dennis Ltd) and Fusion Processing.

In focusing on a passenger-carrying vehicle, this project differs from most other autonomous vehicle trials proposed or currently underway in the UK and worldwide that focus on passenger cars. Claimed benefits for them all include reduced traffic and improved safety.

Stagecoach project manager Louise Simpson explains its interest in the project: "We wanted to get involved mostly because we see autonomous vehicle technology as part of the future. We recognise the value of innovation, and we keep tabs on new technologies. We are interested in exploring anything that offers the opportunity to provide passengers with a viable alternative to using a car."

And although car cruise control is a precursor of today's autonomous driving systems, this particular project's roots trace back in two directions. First is an earlier product from the provider of the autonomous brain, Fusion Processing. Its CycleEye product, which launched several years ago and is fitted to First Group's Metrobus fleet in Bristol, aims to warn drivers of the presence of cyclists along the vehicle's flank. It receives signals from an array of body-mounted sensors, and informs the driver from a cab-mounted warning screen. "It does a lot of the work that forms the basis of situational awareness, detecting objects and predicting what they are doing," contends Jim Hutchinson, Fusion Processing's CEO.

A second project, again with partners Fusion Processing, ADL and Stagecoach, involved automating a few bus movements inside Stagecoach's Sharston, Manchester depot. This related to the process of putting the buses away for the night. The companies deployed the proprietary Fusion Processing CAVstar autonomous driving system in a single bus to handle evening chores – refuelling, washing bay, parking up – without direct human control.

The project proved the worth of the autonomous technology, according to Simpson. "I have a PCV licence, and I would never attempt to put a bus through a bus wash because the margin of error that you've got either side of those wheels is so minimal. To have a vehicle that could effectively take itself through that space completely without any concern or issue of it battering the side of the wash or hitting the garage is quite incredible, actually."

And that project also revealed the extent of the market opportunity, contends Stuart Cottrell, ADL's head of advanced engineering, who states: "Inherently, moving a vehicle around in a tight space in the dark, in bad weather, accidents happen; people get hit by vehicles; other vehicles get hit. A personal, societal and financial cost in some of those activities is far beyond the employment [cost] side."

However, when deployed on a public road, more stringent controls are required. He adds: "The level of functional safety is much higher. It's a mixed environment, carrying passengers, at higher speeds [up to 50mph]. That is a step up from a closed environment with no passengers. That's driving us to look at system redundancy and fail-safe procedures."

The sheer complexity of most urban bus routes was part of the reason why the Forth Road Bridge route (pictured right) was chosen, points out Simpson at Stagecoach; it has a large share of motorway driving and only a single intermediate stop, at the south end of the bridge. This limits the bus's exposure to pedestrians, whose behaviour is harder to predict. "It is far too early to consider extending AV driving services into the heart of Edinburgh," she adds. Another project partner, Transport Scotland, is erecting a series of cameras to monitor the entire route, and may help further by adapting road infrastructure.

The project also reduces the bus's processing load by relying on the driver. At the beginning of the trial, the vehicle will only handle up to 80% of the driving, leaving the driver to negotiate roundabouts, handle parking up and other tricky tasks. Those manoeuvres completed, he or she would press a button to hand over control to the bus. Touching a pedal or turning the steering wheel immediately returns control back to the driver, a protocol familiar from cruise control. During a three-month testing phase before passenger services start, the team will be able to extend the bus's capabilities in more complex traffic situations, such as joining traffic at junctions and roundabouts.

What's certain is that the autonomous system will guide the bus through the pre-programmed route while keeping a safe distance from the vehicle in front, as well as watching out and compensating for obstacles.

Doing that requires installation of CAVstar, which includes cameras, radar, LiDAR, and ultrasonic sensors to provide the best possible detection in all operational conditions. ADL is responsible for retrofitting these on series-produced 12m Enviro200 buses.

Providing input is only half of the job; the other element is enabling the system to be able to act, by turning its instructions into action, to control throttle, brakes and steering. "To get a vehicle to be autonomous-ready, the

key actuators need to be able to receive and act upon inputs from the vehicle network," explains Cottrell. ADL has already done the first, taking torque and speed input from the Voith transmission for the Cummins engine – that was straightforward, he says. Although converting the Knorr-Bremse air brake system was a little more complex, he points out that the company had done a proof of concept of autonomous emergency braking, so far unused (see box). But converting the steering has proven much more challenging.

"Right now, [when] the driver turns the wheel, there's hydraulic assistance given to that so the wheels of the vehicle turn. We're having to use systems that can take that input over the vehicle network looking at desired steering angle, which comes from the automated driving system, and then they can physically do the work to turn that steering box and turn the vehicle wheels. That's something that we haven't done before. It is something pretty new, and not commercially available in the heavy vehicle sector."

As of mid-November, the company was still working with a straight-through mechanical linkage, with the idea of adding a torque input over the top of that to turn the mechanism – the steering box and the steering wheels and the in-cab steering wheel as well. Still, Cottrell remained uncertain if this would pass muster from a functional safety point of view: "It is getting to the stage that people are unlikely to give us dual system redundancy in one unit." That means involving another control system, such as braking, to provide a back-up in case the steering fails.

A number of special checks will aim to ensure that the modified buses are safe to operate. First, within ADL, an independent internal department will risk-assess that work; the project team at ADL will also be required to meet VCA's framework for manufacturing trial autonomous vehicles. Third, project partner the Bristol Robotics Lab will audit the CAVstar capability.

Another tricky issue will be preparing the drivers for their new role on a semi-autonomous bus, admits Simpson. "It is difficult to determine how to train a driver not to drive. Building trust is a key issue." She reports that her Sharston, Manchester colleagues reported that driving an autonomous bus is akin to teaching a new driver. She says: "You are hyper-aware of the decisions that they make. You have to make sure the trainee is setting up the bus at the right point and making the right manoeuvres." While some might say that drivers of autonomous buses might lose concentration and zone out, in fact it's quite the opposite. For that reason, a key priority for Stagecoach is how to help them maintain focus when operating an AV bus without burning out.

At the same time, she reports that early findings of social research, carried out by project partner Napier University, have provided some occupational reassurance to bus drivers. "The research has shown a very strong theme that the driver still has to be a key part of the service and the technology, regardless of how we go forward with it." TE

ADL'S AUTONOMOUS ELECTRIC BRAKING PROJECT

In 2015, the bus manufacturer "started looking at safety and the cost of operations of collision claims, as well as having the vehicle offroad for damage repair," recalls Stuart Cottrell. ADL research found, unsurprisingly, that most collisions involved the front face of the vehicle; it also revealed collision speed profiles. Together with an unnamed detection system supplier, a proof-of-concept system was developed. It retains the air brake, but adds new controls to receive and act on the deceleration demand based on input from the sensor system. It either prevents collisions by bringing the bus to a stationary position, or mitigates the effects of a collision by reducing speed. A big barrier to roll-out is building customer confidence about false positives – that it won't see a shadow of another vehicle and brake. Prove-out would be an expensive business of analysing many thousands of miles of operational experience. However, a new development may change things. TfL's bus safety standard (*www.is.gd/tubafi*) requires AEB systems for new vehicles from 2024.