A2/M2 Connected Corridor Connected Autonomous Vehicle Testbed

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ABSTRACT

The A2/M2 Connected Corridor pilot is a flagship project which will contribute to industry knowledge and promote the UK as a market leader in Connected Autonomous Vehicles (CAV) and Cooperative Intelligent Transport Systems (C-ITS) technology. Working in collaboration with Highways England, the Department for Transport, Transport for London (TfL) and Kent County Council, we designed, installed and implemented one of the UK's first pilot connected vehicle corridors on a live road, to demonstrate how we could improve people's lives with safer, faster journeys.

The project is part of a European initiative to create a network of interoperable, connected corridors for autonomous vehicles across the Netherlands, Belgium, UK and France, aiming to achieve seamless interoperability of services between the countries and ensure safer and more efficient mobility of people and goods.

The key focus is on factors likely to determine user acceptance, engagement, trust, and likely continued usage of CAV HMIs.

KEYWORDS

CAV, HMI, International

Introduction

We delivered the first phase of a C-ITS road corridor between London and Dover, creating a realtime testbed which will allow industry to innovate, test and evaluate emerging technologies, services and Human-Machine Interfaces. The key objectives of the project were to:

- Provide an aid to understanding and quantifying the benefits of C-ITS services
- Provide a trial site to be offered to UK industry to provide feedback on ergonomics, anthropometrics and vehicle to human interfaces
- Contribute to the development of C-ITS technical standards and specifications
- Prove the concept of an alternative to smart motorways and other infrastructure intensive services
- Aid the understanding of the applicable and beneficial business models
- Demonstrate to the UK government, businesses, road operators and the EC the viability, scalability and interoperability of the wider deployment of CAV technology

Method

In October 2018 a week-long test event was run to attract people from the automotive industry and support them in their understanding of the technology and how it could be used to influence future vehicle designs, with particular focus on how messages and information are fed back to the driver

should they need to take control of an autonomous vehicle, recognising the requirements for the interface design to be accessible to users with differing experience of human machine interfaces.

We produced a solution which consumed both simulated and real-time traffic data, using cellular communications and the latest broadcast technology, ITS-G5. The system would be used to undertake basic cross boundary tests to demonstrate how vehicles could cross from one traffic service to another as would be the case when travelling between countries, including human machine interfaces meeting usability requirements in terms of driver-based support.

With the large number of contributors and stakeholders involved, we recognised that effective collaboration was the key to the successful delivery of this project and testing was undertaken with different ethnographic and anthropometric groups to ensure optimal infrastructure to car operations.

We applied our collaborative working practices, accredited to BS11000:2010, to manage the diverse range of contributors and stakeholders. We set clear expectations of working as 'One Team' and identified strategies to minimise risk and provide programme certainty.

Our approach ensured a shared understanding of the HMI functionality requirements whilst enabling all our internationally diverse partners to contribute innovative usability ideas on an equal basis, including consistency and standardisation of dialog boxes for ease of understanding.

We also understood the need to maintain relationships with the wide range of other organisations involved in CAV research and development to monitor the rapid technological developments and manage the associated uncertainties in the market. We developed an 'eco-system' of interested parties, such as research institutions and potential service providers, beyond the core partners. Regular engagement with the eco-system has ensured effective knowledge sharing and has proved to be a valuable source of continuous improvement and innovation, adding value where requirements are evolving rapidly, in particular around the standardisation of design principles around CAV and the human machine interface

Infrastructure to Vehicle communications via Human Machine Interfaces (HMI)

Open Software Interface, to facilitate collaboration with third parties, in utilising our published data sources, APIs and end device simulators for the development of future services.

- In-vehicle kits fitted in multiple test vehicles to communicate with Road Side Units (RSU) or via a cellular network. Information presented on the in-vehicle displays use a Human Machine Interface (HMI) based on the TomTom system, providing messages and information in a format already familiar to motorists.
- Data sourced from A2/M2 highway authorities (Transport for London, Kent County Council, Highways England), including information on road-works, road conditions, temporary speed limits and the time remaining before a traffic light turns to green. This supported a Green Light Optimised Speed Advisory (*GLOSA*) system, shown to reduce both CO2 and fuel consumption by providing drivers with speed recommendations when approaching a traffic light.
- A cloud platform developed to connect the diverse range of infrastructure assets with multiple trial vehicles, and provide simulated scenarios to test a range of real-world situations.
- A full Service Desk, certified to ISO 20000, to provide support for all aspects of the service. The hardware modules were continuously monitored for performance and health to ensure service continuity and minimise risks to the driver.

The test event was a successful large-scale interoperability test, which attracted 62 participants from 34 organisations across 6 countries, including international mobile service operators and automotive

OEM manufacturers. Results from the evaluation of the test event, and future events, are feeding into InterCor and C-ROADS, the European platform for C-ITS deployment, to harmonise future European C-ITS technical standards and specifications.

The next phases of the project will see the testbed extended along parts of the A102, A2, M2 and A229, continuing to provide a better understanding of the opportunities, risks and challenges facing transport network operation in the coming years. The collaborative sharing of knowledge provides value for money and supports the Government's aspiration for the UK to become a leader in CAV technology

On the user experience front, the project was designed to gather insights and experiences to feed proposals for further UX focused testing. As such, the goals for the A2M2 was not to find solutions but discover the questions that need investigation. A primary lesson learnt on this front was the role of the location of the physical signs on current motorways have in driver's situational awareness and how to redress the issue in connected vehicles.

Solution Design

In designing our solution, we identified strategies to minimise programme risk, assure a quality solution and provide confidence that we would meet the critical test event milestones. These included:

Modular and Open architecture: The system was designed with open, standardised interfaces, delivered over Platform-as-a Service (PaaS) infrastructure, which enables expansion without vendor lock-in.

Proven COTS products: We utilised Commercial Off The Shelf products wherever possible, which were well proven in other projects, providing assurance that the solution will be right first time and benefiting from lessons learnt in the other InterCor test scenarios.

Security, redundancy and scalability: Microsoft's Azure platform operates to 99.9% availability and enables instant creation of secondary instances in the event of failure. It is scalable to handle increased load for future services and in unforeseen circumstances. Security was assured using industrial standard encryption and Public Key Infrastructure (PKI). Security software and processes, supported by proactive certificate management, ensured that only confirmed and trusted sources could interact with the system.

Safety by design: Our Road Side Units (RSUs) require the minimum configuration to enable 'plug and play' installation. The RSU hardware supports remote fault finding, configuration and firmware updates, reducing the time spent at the roadside for installation and maintenance and minimising the risks from roadworker exposure.

An Agile Approach to Project Delivery

We adopted the agile methodology to address the project requirements and to provide a quality delivery process that worked across all the partners, whilst maintaining the end user focus. Our collaborative process ensured clarity, traceability and customer involvement at the key stages of the development.

Detailed requirements were captured and documented as user stories in an agile backlog, with a separate backlog maintained for each delivery partner.

We used the Atlassian Jira toolset to manage the backlog and record progress, clarifications and design decisions, ensuring complete transparency and traceability. The output from each of the

scrum teams was received by the overarching integration team and put through a defined test process to ensure compliance with the requirements.

Each sprint team held daily 'stand up' meetings where team members reported on their activities since the last meeting, the plan of action till the next meeting and any issues blocking them from achieving their objectives. At the end of each sprint, each team held a retrospective meeting with all team members providing input on the activities that went well, those that did not go well, and changes that could be made to improve team performance on future sprints. We also encouraged 'chapters' to form, where there were shared areas of competency across the sprint teams, to meet regularly and facilitate knowledge transfer.

Each development cycle (sprint) ended with a thorough review of the backlog for each partner with the product owner in conjunction with the customer, providing the final decision on whether a user story was successfully completed. The Jira tool provided automated 'burndown' graphs to track the completion of user stories against the total backlogs. It also provided an indication of each team's 'velocity', or the amount of work the team delivered to plan, a useful input into the planning of future sprints.