> CAVs, in theory, can revolutionise our approach to traffic management. However, the issue is: with unknown characteristics and behaviours, how do we understand their impact?

The FLOURISH project will help to provide a better understanding of consumer demands and expectations, particularly the implications of an ageing society. Photo courtesy of: *Transport Systems Catapult*

Modelling Connected and Autonomous Vehicles

The FLOURISH project, funded by InnovateUK this year, will develop services and capabilities that link user needs and system requirements, focusing on the core themes of connectivity, autonomy and customer interaction. By **Mark Brackstone**, **TSS-Transport Simulation Systems**, and **John McCarthy, Atkins**

The UK government announced FLOURISH in February this year as one of eight projects that will help to advance the successful implementation of connected and autonomous vehicles (CAVs). The three-year, £5.5-million project will address three key objectives:

- Achieve a better understanding of consumer demands and expectations, particularly the implications of an ageing society;
- Address vulnerabilities in CAV technology, particularly cyber security and wireless communications;
- Enable vehicle manufacturers and transport authorities to create a safe and secure CAV network.

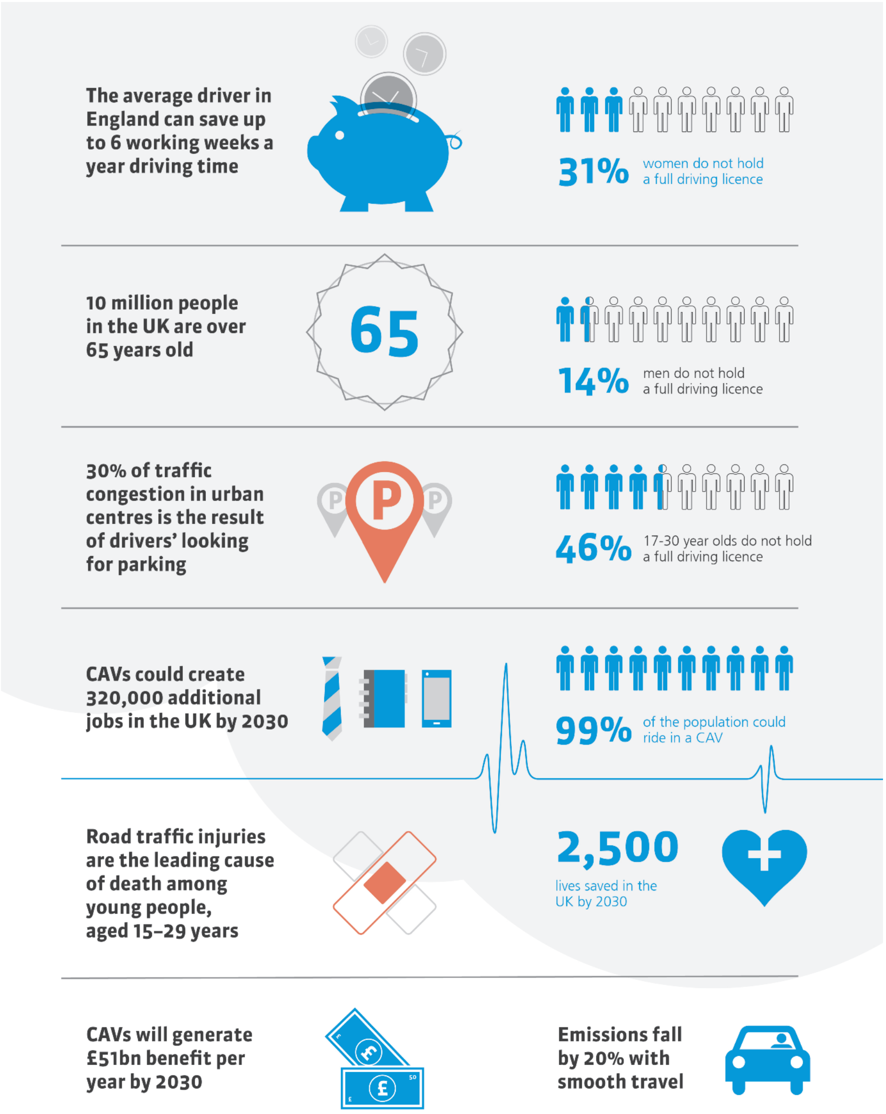
As part of this last objective, TSS-Transport Simulation Systems and Atkins are working together to establish an integrated modelling platform for CAVs. This platform will help to assess the potential operational effectiveness of CAV fleets within a virtual test area in the City of Bristol.

Modelling driverless vehicles

The modelling of CAVs has been possible in most types of traffic simulation software for many years. It's quite easy to specify a set vehicle 'type' or 'class' for CAVs and associate certain behaviours and parameters, with them, such as shorter desired headways or faster reaction times, to mimic the removal of the human driver from the control loop. Similarly, one can apply modifications to demand profiles for particular classes, for example by manual changes to the origin/destination matrix. However this assumes that vehicles of the future would behave according to existing paradigms, which, experience has shown us, are decidedly sub optimal in terms of routing decisions and second-to-second vehicle control. Transportation as we know it today has emerged through decades of interaction of societal expectations with competing factors such as supply and demand, or travel time and safety. CAVs, in theory, give us a chance to start again with traffic management. However the issue is: if we remove human agents from the system, what do we replace them with?

A new paradigm for drivers

With less human involvement, the transport system is, in a sense, more deterministic; however, coming up with optimal strategies is far from straightforward and presents a whole new set of modelling problems, ranging from micro to macro. Micro problems would be at the local level of the dynamic controllers that govern the movements of the vehicle: What do vehicles do if they encounter an obstacle? What size gaps should they require when changing lanes? How should they cooperate with other vehicles? Macro problems relate to routing plans implemented from traffic management centres. How will information be exchanged between the Traffic Management Centre (TMC) and the vehicle (V2I, vehicle to



Connected and autonomous vehicles infographic from white paper on *Connected & Autonomous Vehicles – introducing the future of mobility*, by Atkins Global http://www.atkinsglobal.com/en-GB/uk-and-europe/about-us/reports/connected-and-autonomous-vehicles

infrastructure) and potentially from vehicle to vehicle (V2V)? Such systems (collectively, V2X) need to be considered in order to ensure a degree of robustness to allow for latency, data integrity and network blackspots in control plan implementation, to ensure operational reliability, and not least, safety.

A new simulation toolbox

The FLOURISH team will be using the Aimsun traffic modelling software to research how to define these rulesets and plans using dedicated new tools for the building blocks for CAV management. As FLOURISH's approach looks at both micro and macro environments, it will allow the development of a unique top-down and bottom-up approach to a realistic and verified modelling environment. This will allow for replication and scaling for this emerging global market. FLOURISH will in tandem create an evolving and dynamic rules engine at the heart of both in-car and in-network environments. The development of this engine, coupled to project partner Aiseedo's development of an artificial intelligence capability, is a central cog in the creation of an automated and known response to the various and constantly changing parameters and environments that a CAV will encounter.

These tools, designed for use with Aimsun, will include for example a trajectory conversion tool, designed to simulate the production, transmission and storing of CAV information, allowing for the variation of roadside equipment location and types, cellular region information, and strategy plans to produce a series of snapshots that the vehicle would produce and receive in practice. Input to these tools is to be provided by project partners at the University of Bristol who are to examine detailed Dedicated Short Range Communications (DSRC) performance and how it relates to the Bristol test area.

Testing CAV strategies

Armed with these tools it will be possible to use Aimsun to test CAV network strategies. Key features may include:

Queue warning, with vehicles automatically broadcasting their status (e.g., harsh braking, speed, lane location) to surrounding vehicles and infrastructure, thereby allowing queues to be detected/predicted as well as pre-warning;

Dynamic speed harmonisation to dynamically adjust and coordinate maximum speeds in response to congestion, incidents etc., in order to maximise throughput;

Cooperative Adaptive Cruise Control (CACC), which builds on standard Adaptive Cruise Control (ACC) by utilising V2X communication to synchronise the movements of many vehicles within a platoon, thereby establishing a smoother flow than would otherwise be possible using purely autonomous vehicles.

Project partners, Dynniq, will be studying the integration and actuation of these strategies within the existing TMC environment.

There is a tremendous commercial opportunity associated with this work. For example, FLOURISH looks to provide a unique environment, both physical and virtual, where qualitative and quantitative assessment of performance is linked to the development of accurate models that will not rely on averages or estimation but are instead linked to real life performances and capabilities. FLOURISH's modular approach to the development of the models, and to the integration of a macro and micro CAV capability within Aimsun, underscores the need for a system level understanding of CAVs and in turn, present is a modelling environment that is both robust and refined enough to represent the realities of a real world deployment. With the core tool set likely to be available next summer, the project should be reporting on its first findings in 2017.

■ **Mark Brackstone, TSS-Transport Simulation Systems**, and **John McCarthy, Atkins**