Institution: University of Southampton

Unit of Assessment: 15 General Engineering

Title of case study: 15-33 Intelligent Traffic and Vehicle Systems

1. Summary of the impact

This research by the University's Transportation Research Group (TRG) has contributed to the development of sustainable road transport networks both in the UK and other leading cities worldwide. In summary:

1. TRG has developed/evaluated the algorithms for advanced bus priority at traffic signals for Transport for London (TfL) – an application benefitting bus passengers and operators across London, valued by TfL at ~£29 million/year.
2. TRG provided the UK's National Traffic Control Centre (NTCC) with improved methods to forecast traffic flows and journeys on the UK's motorway network – producing benefits estimated at £50 million/year.
3. TRG's experimental research for Jaguar has led to better dashboard displays for drivers. Jaguar has valued this impact at ~£1 million to their business.

2. Underpinning Research

The UK government has pledged to establish a transport system that, as the Department of Transport puts it, acts as an "engine for economic growth, but one that is also greener and safer and improves quality of life in our communities". This idea of transport as a socio-technical system integral to the sustainable development of urban areas worldwide underpins more than four decades of research into advanced traffic management and Intelligent Transport Systems (ITS) by the University of Southampton's Transportation Research Group (TRG).

1. **Bus Priority**: Since 1993, TRG academics have developed research into prioritising bus movements to support schemes by city authorities around the world to develop more sustainable transport systems. They carried out 14 studies, with total funding of £4 million, for the Engineering and Physical Sciences Research Council (EPSRC), the European Commission (EC) and Transport for London (TfL). TRG developed and applied microscopic simulation models to design and evaluate bus priority algorithms for traffic signals and conducted field trials at more than 200 traffic signals. In 2006, Professor Nick Hounsell, Head of TRG, began leading a five-year project to design, specify and evaluate TfL's bus priority systems at signals in London, using London's new iBus system. Results were published in academic journals from 2008 to 2012 [e.g. 3.1, 3.2]. These algorithms have been built in to the latest versions of the SCOOT Urban Traffic Control software supplied by TRL Ltd – a UK export success story with systems operational in over 200 cities worldwide.
2. **Road Traffic Operations**: TRG research [3.3, 3.4] has also supported the UK Highways Agency's (HA) management of 7,000km of motorways and major roads in the UK. Twelve major studies into road traffic flow operations have been undertaken by TRG since 1993, with funding totalling £4 million. Led by Mike McDonald (2000-date), Emeritus Professor of Transportation Engineering, and Hounsell, researchers used real-time traffic data, simulation modelling and TRG's Instrumented Vehicle (IV) to develop new algorithms to forecast traffic flows and journey times (2006-08). The IV is a vehicle fitted with sensors that travels in traffic and analyses driver behaviour, and how their behaviour changes over time. TRG research also focused on improving IV performance to produce more accurate traffic flow forecasts. During this period (2005-07), SERCO, which was appointed by the HA to set up and run the UK's first National Traffic Control Centre (NTCC), sub-contracted TRG to analyse 18 months of national traffic data obtained from traffic detection systems. The academics used the results to propose optimal methods to forecast traffic flow on Britain's motorway and trunk road network. ESPRC

grants also funded research into new 'machine learning' methods for optimising the use of traffic signals. Experts were asked to study real traffic situations and operate traffic signals according to what they saw. A computer monitors the human actions, learns from them and can reproduce them at a later date.

3. **In-vehicle information systems (IVIS)** The development of IVIS [3.5, 3.6] has comprised a third component of TRG research and involved Neville Stanton, Professor of Human Factors in Transport (2009 – date). Increasingly sophisticated IVIS in modern vehicles have the potential to reduce accidents, increase highway capacity and improve driver satisfaction. However, drivers need to be able to interact with such technologies efficiently, effectively and safely, and distraction time must be kept to a minimum. TRG academics used its IV and the Southampton University Driving Simulator (SUDS) to develop recommendations for Jaguar (the research sponsor) for their IVIS as well as developing more general guidelines for the automotive industry.

3. References to the research (best three are starred)

[3.1] *Hounsell N.B., Shrestha B.P., Head, J.R., Palmer, S. and Bowen, T. (2008). The Way Ahead for London's Bus Priority at Traffic Signals. Institution of Engineering & Technology Intelligent Transport Systems, Vol. 2(3), pp193-200

[3.2] Hounsell, N.B., Shrestha, B. and Wong, A (2012). Data management and applications in a world-leading bus fleet, Transportation Research C, Vol. 22 , 76-87

[3.3] *Brackstone M., Waterson B. & McDonald M. (2009) "Determinants of Following Headway in Congested Traffic", Transportation Research Part F: Traffic Psychology and Behaviour 12(2), 131-142

[3.4] *Box S, Waterson B (2012) 'An automated signalized junction controller that learns strategies from a human expert', Engineering Applications of Artificial Intelligence 25(1), 107-118, doi:10.1016/j.engappai.2011.09.008

[3.5] Piao J., and McDonald M., (2008) Advanced driver assistance systems from autonomous to cooperative approaches. Transport Reviews, 28(5), 659-684

[3.6] Harvey C., Stanton N.A., Pickering C.A., McDonald M., Zheng P., (2011) "A usability evaluation toolkit for In-Vehicle Information Systems (IVISs)" Applied Ergonomics 42(4) 563-574

4. Details of the impact

- **Bus Priority**: TRG studies into bus priority, funded by the EC and TfL, have led to the design of new bus priority systems at traffic signals in London. Implemented in 2009 through London's iBus system – a satellite-based Automatic Vehicle Location system installed on all buses across the network – TRG's research has enabled priority to be given to 8000 buses at 2000 traffic signals in London. TfL estimates that this generates economic benefits of £29 million a year between 2009 and 2014 (2007 prices) from reduced bus delays and journey times, benefitting both bus passengers and operators [5.1, 5.7]. Other positive impacts included a reduction in bus fuel consumption and carbon emissions, as well as encouraging a modal change from private low occupancy vehicles to more efficient high occupancy public transport. The sophistication of the algorithms also enable these benefits to be achieved with little or no impact on non-priority traffic. Impact has reached other priority vehicles as well as buses. For example, vehicles in the 'Olympic Family' benefitted from this priority provision on the London Olympic routes in 2012. Following the successful evaluation of the priority algorithms in London by TRG, Siemens UK have incorporated the bus priority software into the world-leading SCOOT urban traffic control system, developed and marketed in the UK. Impact of TRG research is therefore felt in up to 250 cities around the world which operate SCOOT.

- **Road traffic Operations**: TRG's research into road traffic operations allowed SERCO to introduce a range of improved traffic estimating methods in 2008, including flow, delay, journey time and incident detection [5.2]. These new estimates were used by the NTCC to provide improved real-time traffic information to drivers and improved traffic management on the UK's strategic road network. While it is difficult to assess the substantial positive impact of more accurate journey time information, simulation modelling by TRG has indicated that the early detection and identification of incidents is likely to have saved around £50m per year during the 2008-2013 impact period [5.8]. In 2011 SERCO lost the contract for running the NTCC to a competing consortium (Thales Group and Mouchel) and the NTCC evolved into the National Traffic Information Service (NTIS). TRG research continued to be supported by Thales and between 2011 and 2013, TRG researchers designed new algorithms to reduce traffic incidents and more accurately predict journey times within the NTIS for the benefit of drivers. Similar research has been undertaken by TRG on the urban network, including research with Siemens to create a new road traffic state estimation tool using diverse data sources as a platform for improved traffic control [5.8]. TRG's research into traffic signal optimisation using human expert control and machine learning has used simulation to indicate a potential 10-20% delay saving over current operational systems; on-street trials and impact measurements are expected from 2014.
- **In Vehicle Information Systems (IVIS):** In 2008, Jaguar supported TRG's research into IVIS. TRG academics led by Stanton used the IV to compare traditional and intuitive voice-actuation systems with manual and touch-screen operations. This led to a long-term collaboration in which Southampton adapted a Jaguar car into a driving simulator. TRG drew on the simulator testing results to advise Jaguar engineers on how to consider human factors in the design of IVIS. Jaguar has been able to implement design philosophies that improve the usability of their systems for drivers. It estimated the value of TRG's research on this one specific study at £1 million to their business [5.3, 5.9].
- **Outreach and public Engagement:** The TRG team has also engaged the public in how engineering solutions are employed to control traffic lights, and ultimately make their driving experience smoother and safer. Using a giant Scalextric to illustrate their research, the TRG team ran a stand at the Royal Society's Summer Science Exhibition in June 2011 [5.4, 5.10], the first time any university-based transport group had exhibited. The exhibit – 21st Century Traffic Control: The Invisible Referee – was based on the research into novel machine learning methods for traffic signal control. The exhibition attracted more than 14,000 visitors, including senior policymakers and MPs. The TRG stand was singled out in a review of the event by *The Guardian* [5.5] and it led to the *BBC* commissioning a piece for the *One Show*, which aired in August 2012 [5.6, 5.10]. The show, which attracts 5 million viewers, featured one of its journalists controlling traffic more efficiently than a computer, which relates to the machine learning research. The exhibit was designed in collaboration with the Transport Research Laboratory (TRL), the Motor Industry Research Association (MIRA), innovITS and Siemens, who were all industrial partners in the showcased research [5.10]. The exhibit has also been part of the University of Southampton's Science and Engineering Roadshow, which toured several national public engagement events in 2012, including the Cheltenham Science Festival and Bestival, the four-day music festival on the Isle of Wight. According to Bestival organisers, around 10 per cent of festival goers – 6,000 people – entered the Science Tent, for which TRG's stand was one of the main displays. The website and YouTube channel set up to accompany the exhibit have received more than 6000 hits since July 2011.

5. Sources to corroborate the Impact

Publications

[5.1] Clarke R., Bowen T. and Head J. (2007). Mass Deployment of Bus Priority Using Real-Time Passenger Information Systems in London. Proceedings of European Transport conference (published by Association for European Transport) (9 pages) http://www.tfl.gov.uk.edgekey.net/assets/downloads/TfL-mass-deployment-ibus.pdf

[5.2] Zheng P., McDonald M. and Jeffery, D (2008). Event detection based on loop and journey time data. IET Intelligent Transport Systems, Vol 2, No 2, pp. 113-119.

[5.3] Harvey C. and Stanton N.A. (2012). Modelling the hare and the tortoise: predicting the range of in-vehicle task times using critical path analysis. Ergonomics, V 56, No 1, pp. 16-33.

Websites

[5.4] http://www.invisible-referee.soton.ac.uk/

[5.5] http://www.guardian.co.uk/science/blog/2011/jul/06/royal-society-summer-live-exhibition

[5.6] http://www.southampton.ac.uk/mediacentre/news/2012/aug/12_148.shtml

Organisations

[5.7] For **bus priority**: Chris D'Souza, Principal Engineer, Research and Data Analysis Team, Surface Transport, Transport for London (TfL), London.

[5.8] **Traffic Operations 1.** Motorway: Paul Burton, Head of Traffic Engineering, SERCO, National Traffic Control Centre, Quinton, Birmingham **2.** Urban**:** Mark Bodger, Systems Marketing Manager, Siemens Mobility, Traffic Solutions, Sopers Lane, Poole.

[5.9] For **IVIS**: Carl Pickering, Head of Electrical/Electronic Research, Jaguar Land Rover, Coventry, United Kingdom.

[5.10] For **Public Engagement**: **1.** Royal Society: Rachel Francis, Acting Assistant Manager; **2.** BBC: Madeleine MacDonald , Producer: **3.**TRL: Catherine Ferris, Manager; **4**. MIRA: Mandeep Panesar, ITS Embedded Engineer **5.** Siemens: Mark Bodger, Systems Marketing Manager.