# ANNUAL REPORT 2015
# TRANSPORTATION RESEARCH GROUP

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## 1. OVERVIEW

The Transportation Research Group (TRG) was established at the University of Southampton in 1967 and has operated continuously since then. It sits within the Civil, Maritime and Environmental Engineering and Science Academic Unit (CMEES) which is part of the Faculty of Engineering and the Environment (FEE).

This report covers the research activities within TRG during the period 2015.

TRG academic staff members during 2015 were:

- Nick Hounsell, Professor of Highways and Traffic, and Head of TRG to July 2015
- John Preston, Professor of Rail Transport and Head of TRG from August 2015
- Neville Stanton, Professor of Human Factors in Transport
- Mike McDonald, Emeritus Professor of Transportation Engineering
- Dr Tom Cherrett, Associate Professor of freight and logistics
- Dr Ben Waterson, Lecturer specialising in modelling and simulation
- Dr Simon Blainey, Lecturer, specialising in rail transport and modelling.

During this period Dr Simon Box was appointed Lecturer, specialising in on transport simulation and data analytics, and Dr Katie Plant was appointed as New Frontiers Fellow in Human Factors in Engineering.

**Research Staff** in TRG during 2015 included Dr John Armstrong, Adrian Hickford, Fraser McLeod, Dr Jinan Piao, Katie Plant, Dr Aaron Roberts, Dr Alan Wong, Dr Kirsten Revell, Dr Alejandro Ortega, Alex Eriksson, Daniel Heikoop and Dr James Pritchard. Leavers were Dr Birendra Shrestha, Dr Claudia Iacob and Judit Varga. Their research activities are summarised in later paragraphs. **Technical Staff** supporting TRG included Dr Gavin Bailey, Karen Ghali and Daniel Fay. Melanie Hallford continued in her role as **Senior Administrator** for the Group with Joy Richardson as administrator for Human Factors projects.

We are fortunate to have a number of Visiting Professors and Research Fellows who contribute significantly to the Group. These include Professor Jianping Wu, Tsinghua University; Professor Pengjun Zheng, Dean of the Faculty of Maritime and Transportation Engineering at Ningbo University in China; Professor David Jeffery; Dr John Walker; Dr Terence Bendixson, Dr John Schoon

We also had some 20 students attached to the Group undertaking PhD or EngD (Engineering Doctorate) research in transport in 2015. PhD degrees were awarded to Yok Hoe Yap, Kirsten Revell, Gavin Bailey, James Hamilton, Katie Plant, Xucheng Li, James Snowdon, James Pritchard, and an MRes awarded to Yusuke Miyazaki in this reporting period.

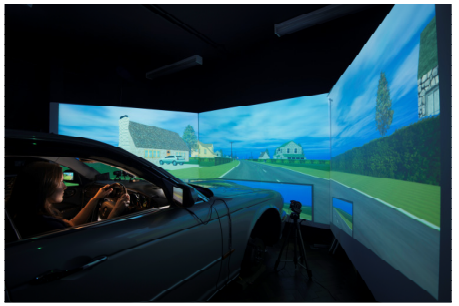
Postgraduate teaching continues to be an integral part of TRG activities, particularly the MSc in Transportation Planning and Engineering. Some 30 new students enrolled in September 2015, both full-time and part-time. We are pleased to continue as a partner within the Universities Transport Partnership (www.utp.org).

Overall, we have maintained a healthy portfolio of research in 2015, By the end of the year, our research grants and contracts had a total value of over £7 million, with over £4 million of this from EPSRC.

TRG facilities which have been installed or further enhanced in 2015 include:

- SUDS (Southampton University Driving Simulator), located in Building 176 at Boldrewood.





- The TRG Instrumented Vehicle (IV) for on-road trials and new garage facility in Building 185 of Boldrewood.


- Our well-equipped transport data analysis facility, located in Building 176, Boldrewood.
- ComTET – A command teamwork experimental test bed for submarine control rooms, located in Building 21, Highfield.
- Our Outreach activities including demonstrations based on Scalextric and Hornby Model Train sets.

**Outreach**

In 2015, TRG again took the lead to provide many public engagement activities both for the Group and the University, under the direction of Dr Ben Waterson (for Transportation Research), and Dr Alan Wong (University 'N Cubed' Public Engagement Coordinator). This included:

- providing interactive activities to engage the public in our transportation research at the Cheltenham Science Festival and Bestival, the local major music festival;
- organising an independent **TED** (Technology, Entertainment and Design) event for the University of Southampton at the Nuffield Theatre, that showcased local science ideas worth spreading, including the design of intelligent transport systems;
- running some of the Researchers' Cafés for the University, including those partly sponsored by The Lloyd's Register on Boldrewood Campus, to encourage cross-collaboration and highlighting the research being conducted by early-career researchers and postgraduate students;
- acting as the Faculty Champion for the Three-Minute Thesis (3MT) Competition, to improve the science and research communications skills of postgraduate students.

In September 2015 John Walker was appointed Editor-in-Chief of a new series of books on "Transportation" by the Institution of Engineering and Technology (IET).

## 2. EXTERNAL ACTIVITIES

The following sections summarise the range of external activities undertaken by TRG Academic Staff members in 2015:

**Nick Hounsell:**
- Member of the Traffic management and Operations panel of the CIHT's Network and Infrastructure Management Board
- Member of the EPSRC Peer Review College
- Member of ITS EduNet, the European network for education and training in Intelligent Transport systems
- External Examiner for the Transport Masters Course at Napier University
- Academic reviewer of candidates applying for the Transport Planning profession (TPP) qualification
- Expert advisor to Monash University, Melbourne, Australia on a Public Transport priority research project, sponsored by the Australian Research Council (ARC)

**John Preston:**
- Member of the Commonwealth Scholarship Commission's Panel of Advisers.
- A member of the Netherlands Institute for Transport Policy Analysis.
- Member of the EPSRC Peer Review College
- External examiner for Masters level course at Cardiff, Leeds and Newcastle Universities.
- Co-Chair (with Professor Ingo Hansen of the Technical University of Delft) of the World Conference on Transport Research Society's (WCTR) Rail Special Interest Group.
- Committee Member of the International Association of Rail Operations Research (IAROR) and the International Conference on Competition and Ownership in Land Passenger Transport.
- Lead on the Academic Response to the Rail Technical Strategy with respect to customer experience.
- Invited to give presentations to the Transport Economists Group (London, 25 February) and Chartered Institute of Logistics and Transport (Southampton, 20 May)

**Neville Stanton**:
- Editor of the peer-review journal Ergonomics
- Member, Editorial Board, Theoretical Issues in Ergonomics Science
- Book series co-editor for Ashgate on 'Human Factors in Defence'
- External examiner for bachelors and masters degrees in Occupational Health and Safety at the National University of Ireland, Galway.
- Chair of the The Honourable Company of Air Pilots and the Air Pilots Trust Annual Aviation Safety prize
- Chair of the third International Conference on Human Factors in Road and Rail Transportation, July 26-30, 2015, Las Vegas, USA.
- Chartered Engineer with the Institute of Engineering and Technology
- Chartered Psychologist with the British Psychological Society
- Chartered Ergonomist with the Institute of Ergonomics and Human Factors
- External expert advisor for Australian Research Council funded rail level crossing project, University of Sunshine Coast, Queensland, Australia.
- Plenary keynote address at Transportforum, Linkoping, Sweden (8-9 January, 2015).
- Invited Keynote speaker at the 18th International Symposium on Aviation Psychology, Dayton, Ohio, USA (May 4 - 7, 2015).
- Invited Keynote speaker at the 17th International Summer School on Aviation Psychology, Graz, Austria (July 6-10, 2015)
- Plenary Keynote speaker at AutomotiveUI 2015 at the University of Nottingham (September 1 –3, 2015).

**Mike McDonald:**
- Trustee of the Rees Jeffreys Road Fund.
- Transport Research Foundation Fellow.
- Pao Yu-kong Professor at Ningbo University, China.



- Advisor to the EC WIKI project dealing with the implementation advice for transport innovations.
- member of several professional and government committees and advisory bodies including the Research Councils and the Technology Foresight Programme.
- Significantly involved with the EC Transport Telematics programmes
- International recognition as an expert in Intelligent Transport Systems.
- Member of the Advisory Board the EC ESPRIT project, which is concerned with the implementation of autonomous vehicles.
- Council Member of the UK Transport Technology Forum, and is supporting MISTRAL in the development and assessment of its Swedish research programme in transport.

**Tom Cherrett**:
- Member of the i) U.S. Transportation Research Board's, Standing Committee on Urban Freight Transportation (AT025) ii) Editorial Board (Proceedings of the ICE: Transport Journal) iii) Logistics Research Network (LRN) committee iv) IET's (The Institution of Engineering and Technology ) Transport Policy Panel.
- External Examiner; MSc Transportation Planning and Engineering course at Newcastle University (2015-2019).

**Ben Waterson**:
- Member of the Editorial Board for the Institution of Civil Engineers : Transport Journal

**Simon Blainey:**
- Member of the Rail Research UK Association Executive Committee
- Membership Secretary for the Royal Geographical Society's Transport Geography Research Group

**Katie Plant:**
- Associate member of the Chartered Institute of Ergonomics and Human Factors (CIEHF)
- Scientific Committee of CIEHF conference on Human Factors and Aviation Safety (8-9th November, East Midlands Airport)
- Presented with Honourable Company of Air Pilots prize for aviation safety research

## 3. RESEARCH

TRG research fits within a view of transport as a socio-technical system capable of delivering sustainable outcomes but also with the potential for unsustainable outcomes if the interactions between transport technology and society are not adequately addressed. We are particularly interested in how society shapes, and is shaped by, technological developments in transport. This requires an interdisciplinary approach involving the engineering and physical sciences, along with the social sciences and humanities. In particular, we bring together traffic engineering, transport economics and human factors. TRG's work is multi-modal and covers both passenger and freight transport, whilst also examining the extent to which information technology may act as a complement or a substitute for transport.

A focus of our research remains on Intelligent Transport Systems, with a growing portfolio of studies on Human Factors in Transport. We also undertake research on a number of other interrelated themes, including bus priority, energy and environment, freight and logistics, future technologies, rail and transport economics and policy.

The remainder of this report summarises TRG research activities ongoing in 2015 within different topic areas. Research titles listed in **blue** represent contract (funded) research, whilst those in **green** are studies by Postgraduate Research students (PhD, EngD or MRes)

### 3.1 Traffic Operations, Management and Control

**TIDE – Transport Innovation Deployment in Europe** (European Commission Information Society, from 2012 to 2015). Dr B. Shrestha, Emeritus Prof M. McDonald. *Contract Holder:* Prof N.B. Hounsell.

The mission of the TIDE project was to enhance the broad transfer and take-up of 15 innovative urban transport and mobility measures throughout Europe and to make a visible contribution to establish them as mainstream measures. TIDE focussed on 15 innovative measures in five thematic clusters: financing models and pricing measures, non-motorised transport, network and traffic management to support traveller information, electric vehicles and public transport organisation. Each cluster was led by a city which has particular experience on the specific thematic area(s) and ambitious aims for future developments. The cities were assisted by Thematic Support Partners, who were Transport Consultancies and Universities with proven expertise in the respective cluster areas. TRG was a thematic support partner for 'network and traffic management to support traveller information' cluster and supported Reading Borough Council in this application. www.tide-innovation.eu/en/.

**Monitoring and Evaluation of Managed Motorway Schemes** (EPSRC and Mott MacDonald Ltd. EngD Studentship, from 2008 to 2015). Mami Jennifer Ogawa. *Supervisors:* Prof N.B. Hounsell (University of Southampton), R. Meekums (Mott MacDonald Ltd.)

Managed Motorway schemes aim to address congestion and improve Journey Time Reliability (JTR) by utilising a set of advanced Intelligent Transport Systems applications to make as much use of the available capacity as possible. This research used substantial new databases from managed motorways to explore capacity, driver behaviour, lane utilisation and other features of managed motorways, including variants such as 'Through Junction running' and 'All-lane running'.

**Improving Traffic Movements in an Urban Environment** (EngD studentship from October 2010, Awarded 2015). Andrew Hamilton. *Supervisors:* Dr B.J. Waterson, Dr T.J. Cherrett, Dr S. Box (University of Southampton), Mr I Snell (Siemens).

This research project investigated the potential improvements in traffic signal control systems that can be enabled through richer data sources. It focussed specifically on the benefits of knowing, in advance, a vehicle's intended route through an isolated junction. The research involved both simulation work to quantify the benefits of including turning intention into traffic control algorithms (including sensitivity tests with imperfect knowledge) and investigation into the level with which turning intention actually can be predicted from outside the vehicle.

**Modelling Roundabout Capacities** (PhD studentship sponsored by the Government of Brunei Darussalam, from January 2012, Awarded 2015). Yok Hoe Yap. *Supervisors:* Dr. B.J. Waterson (University of Southampton), Dr. H.M. Gibson (Transport Research Laboratory)

The capacities of roundabouts are often determined using empirical relationships which predict entry capacity based primarily on geometry and circulating flows. This research aims to advance the state-of-the-art in roundabout capacity analysis, specifically by improving our understanding of additional factors which may have significant impacts on roundabout capacities. Existing roundabout capacity modelling methods have been critically reviewed, and new empirical models developed using regression and benchmarked against neural networks. Microscopic simulation analyses have enabled the impacts of entry-exit separation distance and exiting flows to be better quantified and incorporated into new empirical models. This research thus forms a key step towards improving roundabout capacity analysis and design.

**Optimising Urban Parking Operations** (PhD studentship, from October 2011) Chris Charles. Supervisors: Dr B.J. Waterson and Dr S. Box

The imperfect interactions between parking supply (spaces and costs), parking demand (durations) and parking behaviour (searching) create inefficiencies in the system that lead to traffic congestion, economic costs, increased pollutant emissions and increased frustration amongst drivers. Other transport sectors (most noticeably air travel) however have established strategies for optimally aligning supply and demand through web based 'pre-booking' systems.

This research is therefore considering the practical, environmental and economic consequences of operating an equivalent pre-booking style system for private car-parking in urban areas, addressing issues such as deterministic/stochastic durations of stay, search strategies of non-booked drivers, revenue optimisation, capacity utilisation and modal shift.

A pre-booking parking system arguably contradicts current sustainable transport policy as it potentially enhances the attractiveness of the private car to access the town centre. However, with a pre-booking system in place, it becomes evident to travellers when they will be unable to park their car close to their intended destination, encouraging mode shifts to public transport or trip-retiming effects. Prior knowledge of parking availability can therefore have a significant benefit on patterns of movement within urban areas and hence reduce the consequential economic and environmental costs.

**Modelling Driver Experience and its Role in Adopting Diversion Behaviour** (EPSRC DTC PhD Studentship, from October 2009, Awarded 2015) James Snowdon. *Supervisors:* Dr B. Waterson, Dr H. Fangohr (Computational Engineering Research Group).

While traditional, aggregate techniques for transportation demand forecasting are capable of providing a single impression of road network usage, the consideration of individual traveller's decisions allows for varying levels of experience and the presence of more plausible decision rules to be explored along with their impact on traffic flows. This research has developed computer games to determine and model driver routing reactions to incidents and unexpected congestion using a combination of information gathered en-route, such as from variable message signs or the observed presence of congestion, and past experiences of the road network from

previous trips. If the presence of a congestion causing incident is likely but uncertain, a driver must decide whether to hope for favourable conditions on a potentially faster route (but risk disruption to their journey) or divert to take a more reliable (but higher travel time) alternative. In particular this research addresses the question of how sources of uncertainty impact on trip routing decisions and contribute to expected traffic flows on an "average" day.

**Benefits with Changing Penetration of Autonomous Vehicles** (part-time PhD student from February 2015). A. Graham *Supervisors:* Dr T.J. Cherrett, Prof N.B. Hounsell

Self-driving (autonomous) and connected vehicles are being developed at a pace in terms of automotive and sensor technology. But the deployment of them within a legacy fleet of conventionally driven vehicles is less clear. A specific problem is the trajectory of benefits – such as improved capacity – from zero penetration to full penetration. This project will research how benefits change over time with penetration of vehicles to produce guidance for traffic management systems.

## 3.2 Bus Operations and Priority

**A Comparative Assessment of Innovative Public Transport Technologies** (PhD studentship, from October 2011, Awarded 2015). Xucheng Li. *Supervisors*: Prof J.M. Preston, Dr B. Shresthra.

The increasing urbanization around the world increases passenger requirements for public transport. Due to the increasing demand for public transport, many innovative modes have been developed to suit various passenger requirements in different cities. This research aims to study the key characteristics of different public transport technologies including conventional buses and innovative forms such as Personal Rapid Transit and Straddle Bus and hence develop a comparative model to assess those public transport forms in terms of user benefits and non-user benefits. Two different but closely related models will be developed to form the assessment. The first is a stand-alone spreadsheet model on Microsoft Excel to investigate the theoretical social cost of public transport technologies operating on a single route. The second model is a microsimulation model based on a realistic city network to assess the performance and actual social cost when the public transport modes interact with other vehicles in the traffic flow. Results from these two models can then be used to show the most feasible public transport technologies for the selected network.

**Exploring New Bus Priority Strategies at Isolated Vehicle Actuated (VA) Junctions** (EPSRC, PhD Studentship, from October 2010). Bashir Ahmed. *Supervisors:* Dr N.B. Hounsell, Dr B. Shrestha

Priority to buses at traffic signals is very effective in improving bus speeds and reliability, thus improving passenger service quality and operational efficiency. Research in to priority strategies in Urban Traffic Control systems has been extensive in recent years, so this study has focussed on isolated traffic signals under Vehicle Actuated (VA) control, where little new research has occurred since the SELKENT study in London in 1987. The research has involved devising new control strategies for VA junctions taking advantage of new detection possibilities, and evaluating these strategies both mathematically and using the microscopic simulation model VISSIM.

**The Improvement of Bus Networks Based on GIS Technology** (PhD Studentship, from October 2013).Yuji Shi. *Supervisors:* Prof N.B. Hounsell, Dr S.P. Blainey)

A fundamental way to solve today's urban traffic problems is to prioritize the development of public transport. However, today's bus networks are still not perfect. In the UK outside London, privatization and bus deregulation have contributed to some problems concerning bus network structure, fares, demand, and service quality. The aim of this research project is therefore to use Southampton as a case study to diagnose its current bus system, to find out its weak areas and problem lines, and to explore the corresponding improvement methods which could be applied. Due to the wide application of Geographic Information Systems (GIS) in transit for the last two decades, specialised transportation GIS software (e.g. TRACC) will be used in this research to help with mapping, planning and visualizing the research results.

**Evaluation of Bus Performance Using Advanced AVL Data:** (PhD Studentship from Sept 2012), Mahesh K Dhakal. Supervisors: Prof N. Hounsell and Dr B. Shrestha)

Automatic Vehicle Location (AVL) data is used in bus transit for a number of reasons including performance evaluation. In London, this is available on 8,000 buses using their iBus system. A range of studies have been conducted in the past to evaluate bus performance, such as 'Headway Regularity' and 'On-Time Performance'. This research is focussing on Bus Journey Time *Variability* (JTV), an important performance measure in the Mayor of London's aspiration to provide consistent journey times for all road users. Research is also analysing passenger 'Excess Waiting Times (EWT)' – a key performance criterion currently used by Transport for London (TfL). In particular, the large databases across a number of bus routes are allowing correlation analyses to be undertaken between JTV and EWT, to assess the extent to which these performance criteria are compatible.

## 3.3 Energy & Environment

**LSTF Case Study on Carbon Impacts and Congestion Relief** (DfT, from August 2013 to January 2016). A.J. Hickford, Dr A. Wong, K. Ghali, Prof I. Williams. *Contract Holder*: Prof J.M. Preston

This case study analyses the extent to which Local Sustainable Transport Fund (LSTF) schemes have an effect on carbon impacts and congestion relief across three U.K. regions, by using a longitudinal cohort survey, and building on experience gained from the iConnect project. TRG has been taking the lead in monitoring and evaluating the extent to which these schemes have reduced carbon emissions and/or generated modal shifts towards sustainable travel, including walking, cycling and public transport, working in partnership with Solent Transport, Transport for Greater Manchester, Leicestershire County Council and Loughborough University. Follow up travel and behaviour data was collected in 2014/15, and compared to previous baseline data as carried out in the five treatment areas (Rochdale, Hyde, Coalville, Eastleigh, Gosport) and also compared to similar surveys in three control areas (Wigan, Hinckley, Locks Heath). The draft results have been reported to the DfT, which includes complimentary (secondary) traffic data and enriching qualitative focus group data from the respondents.

**Centre for Sustainable Travel Choices** (Solent Transport and SCC, from September 2012 to August 2015, part extended to March 2016). Dr A. Wong, A.J. Hickford, K. Ghali *Contract Holder*: Prof J.M. Preston

The Centre is a partnership between Southampton City Council, the University of Southampton and Sustrans, that aims to promote local sustainable and active travel, whilst suppressing private car use. It oversees the work related to two Local Sustainable Transport Fund (LSTF) bids and a Better Bus Area Fund (BBAF) bid, with the University leading on the monitoring and evaluation of the physical interventions and travel behaviour change schemes. Online, card and paper survey tools were used to collect follow-up data in 2014/15, which was compared against the baseline information gathered in 2012/13, and reported to the SCC Project Board. The before-and-after review included secondary data on traffic flows, measures of congestion and public transport usage, as well as other (external) survey data, which collectively provided comparisons of respondents' travel behaviour and attitudes in and around the City, and how they have been affected by the schemes.

**Evaluation of flywheel and thermal management emission abatement technologies on Southampton Buses** (Southampton City Council, from July 2015 to March 2106). Dr A. Wong, Dr. D. Laila *Contract Holder*: Dr S. Box

This research is funded by the Department for Transport's Clean Bus Technology Fund and is being undertaken in conjunction with GKN, First Group and the Go-Ahead Group. The performance of Kinetic Energy Recovery Systems and Selective Catalytic Reduction is being assessed using First Southampton's route 7 as an experimental test bed. The set-up involves high fidelity tailpipe measurements using a Horiba OBS 2200 Portable Emission Monitoring System and J1939 CAN data from bus engines using a telematics unit designed at the University of Southampton. Before and after on-road trials are being conducted using fleet vehicles fitted with the two new technologies, and the results are expected to be reported later in 2016.

**Intelligent Agents for Home Energy Management** (full-time PhD studentship from October 2010, Awarded 2015) Kirsten Revell. *Supervisors:* Prof N. Stanton, Prof A. Bahaj

This collaborative interdisciplinary project sought to develop intelligent agents within the smart grid in order to reduce energy use within domestic settings. Bringing together an interdisciplinary team comprising School of Electronics and Computer Science, Sustainable Energy Research Group and Transportation Research Group this three year EPSRC project sought to apply novel artificial intelligence approaches to develop intelligent agents that enable domestic consumers to visualise, understand and manage their energy use. The human factors work package of this project, addressed the fact that it is humans, and not buildings, that consume energy. Understanding how to influence householder's energy consuming behaviour, could inform far reaching strategies to combat climate change. This work package explored how a Mental Model (MM) approach to design, could encourage achievement of home heating goals. Methods to capture, analyse and apply mental models of home heating systems were developed. A lab-based experiment comparing a naturalistic home heating interface with a mental model promoting interface was used to demonstrate how changes in interface design can increase goal achievement by promoting mental models that enable more appropriate behaviour strategies with heating controls.

**Towards a Verifiably Robust Cycle Microsimulation Model** (EPSRC DTC PhD Studentship, from October 2012). Chris Osowski. *Supervisor*: Dr B. Waterson, Dr S. Box

Quantitative tools are widely used to evaluate the effectiveness and value for money of schemes both before and after implementation. Tools for motorised traffic and pedestrians are widely available but this is not the case for cyclists. Additionally, the core behaviours of cyclists which would inform such a model are also poorly studied. This project aims to develop and validate a model for bicycles with the aim of enabling the modelling of interactions between bicycles and ultimately with other modes. Such a model would have application to shared-space and common highway scenarios and would form the basis of economic scheme evaluation tools.

**Developing tools to determine the environmental impact of transport interventions** (EPSRC and Southampton City Council, EngD studentship, from October 2012). Matthew Grote. *Supervisors*: Prof I.D. Williams (Centre for Environmental Science), Professor J.M. Preston and S. Kemp (Centre for Environmental Science).

Road traffic is an important source of greenhouse gas (GHG) emissions and other air pollutants detrimental to air quality. These emissions are exacerbated in urban areas by the stop-and-go nature of congested traffic conditions. Therefore, when relevant authorities make decisions regarding changes to a transport system (transport interventions), quantifying the impact on emissions from road traffic is essential. The only practical method to quantify emissions at road network level (e.g. a city's road network) relies on Road Traffic Models (RTMs) to simulate vehicle movements, and Emissions Models (EMs) to calculate resulting emissions. Currently the EM options available to relevant authorities are simple models based on vehicle average speed that do not fully account for the impacts of congestion; or more complex models that do account for congestion, but are excessively resource intensive. This research is developing a new EM that can predict emissions from road traffic at network level, including the important influence of congestion, whilst avoiding the complexity that would render it impractical as a decision support tool for relevant authorities. A survey of Local Authorities has been undertaken in order to scope the new EM and data on vehicle traffic operations has been collated. Southampton City Council (SCC) is the industrial sponsor for this project, and the background to their involvement is SCC's ambition for Southampton to be a world-leading low-carbon city, and a desire to know how transport can contribute to realising this ambition.

## 3.4 Freight & Logistics

**Delivery and Service Plan Project** (Southampton City Council, from 2014 to 2016). Gavin Bailey, *Contract Holder:* Dr T. Cherrett

Assessments undertaken by Public Health England have indicated that up to 6% of all mortalities in urban centres may be attributed to poor air quality, recognising freight vehicles to be a major contributor to this. Ten Air Quality Management Areas (AQMAs) have been identified across Southampton where the air quality has fallen short of the minimum standard expected under EU Legislation. To address these issues, Southampton City Council has commissioned work from TRG to provide Delivery and Servicing Plans to public bodies and private businesses across these areas to help them re-appraise their delivery and servicing strategies to reduce freight impacts.

Delivery and Servicing Plans (DSPs) were developed by TfL as part of their Fleet Operators Recognition Scheme (FORS) to encourage businesses to consider the road network and air quality impacts of their vehicle logistics operations on the local environment. A DSP requires an independent audit of core goods and service activities using surveys, interviews and desk analysis of procurement and delivery records for a standard operating period. It then quantifies the daily freight and servicing activity (arrival times of vehicles by activity type, the duration of visits (loading/ unloading/ servicing), the recipient department and size and urgency of items). It also identifies the background to the procurement processes which lead to the generation of orders and freight activity.

To date, this project has engaged with public organisations (NHS IoW and University Hospital Southampton, Southampton Solent University, University of Southampton) and private sector organisations such as DP World, ABP, Steve Porter Transport Group, Old Mutual Wealth, West Quay Shopping Centre.

**CITYLAB** (EU Horizon 2020, from 2015 to 2018). F.N. McLeod. *Contract Holder:* Dr T.J. Cherrett.

The CITYLAB project is based on the concept of using cities as laboratories for experimentation in the area of goods transport. Southampton is one of seven cities testing various freight initiatives, along with Brussels, London, Paris, Oslo, Rome and Rotterdam. At the University of Southampton, our aim is to reduce the amount of freight transport that large municipal organisations generate through their purchasing of goods and services, by identifying opportunities for consolidation (e.g. of orders, suppliers, supply chains). One option is to use the Southampton Sustainable Distribution Centre at Nursling, operated by Meachers Global Logistics, as a consolidation point for incoming goods. We are also liaising with other local municipal

organisations (e.g. Southampton General Hospital, Southampton City Council and Southampton Solent University) to investigate opportunities for joint procurement and consolidation to reduce environmental impacts.

**Developing Sustainable Supply Chains for Healthcare** (ESPRC and Transport for London). EngD Studentship, from October 2010, Awarded 2015). Gavin Stephen Bailey. *Supervisors:* Dr T.J. Cherrett, Dr B.J. Waterson (University of Southampton), Mr J. Chani (Transport for London).

This research involves the assessment of current NHS logistics practices for Great Ormond Street Hospital for Children (GOSH). The work involves evaluating a number of different strategies to improve the internal and external operation of hospital supply chain activities at GOSH, with the end goal of implementing successful models and mechanisms throughout all major NHS London trusts. The aim of the research is to provide more cost effective, resource efficient and environmentally friendly medical supply to hospitals whilst maintaining the necessary levels of service typically required within healthcare. Audits at GOSH have been conducted in the form of Delivery and Servicing Planning and Travel Planning to assess the current operations of the hospital. One of the main focusses of the research is reducing the number of vehicles making deliveries during day-time hours. Two solutions were tested i) unattended Locker box delivery solutions, intended to enable more out-of-hours deliveries to be made during less congested periods of the day; and, ii) consolidating hospital deliveries at a mobile London out-base. Finally, a third solution for courier traffic related to the pathology department, which represents a significant financial outlay at the Trust, was conducted demonstrating the road network and environmental impacts of vehicular consolidation.

**Selection of Low Carbon Technologies for Heavy Goods Vehicles** (EngD studentship, from October 2010). Anthony Velazquez. *Supervisors:* Dr T.J. Cherrett, Dr B.J. Waterson, Mr P. Holdsworth (Martin Brower)

This research is investigating the ways in which adopting various alternative vehicle, powertrain, fuel and refrigeration technologies could positively contribute to decarbonizing food logistics fleets. The work undertakes economic, environmental, operational and technological appraisals to determine the optimal combination of low carbon technologies for more efficient fleet operation using the logistics fleet of a major UK fast food chain as a case study. More sustainable freight with vastly reduced carbon emissions could minimise costs, while at the same time improving energy security and waste management, mitigating volatility of fuel prices and other negative externalities of road haulage such as the impact of transport on global warming and air quality emissions.

**Time-Dependent Vehicle Routing Problems for Flexible Logistics** (PhD studentship sponsored by the Government of Colombia, from October 2013). Nicolas Rincon Garcia. *Supervisors:* Dr B.J. Waterson, Dr T.J. Cherrett.

The vehicle routing problem (where, in the basic formulation, a set of $N_v$ vehicles must be assigned to visit $N_L$ locations with the minimum total route length) is one of the most widely studied theoretical problems in logistics. The basic formulation however is almost never applicable in reality and therefore over the years many variations have been proposed, including for example capacity constrained problems for heterogeneous vehicle fleets, time constrained 'delivery window' problems which restrict the freedom of the schedules, and congested network problems which attempt to reflect time variant travel times between locations.

Unfortunately, despite this attempt to make theory better reflect reality, theoretical models are often poorly suited to especially smaller or atypical logistics operations as they do not reflect the real constraints imposed by unpredictable real life scenarios. This research therefore seeks to develop



improved implementations and better use of existing algorithms.

## 3.5 Future Technologies

**CITYMOBIL2** (European Commission, from 2012 to 2016). Dr J. Piao, Contract Holder: Prof M. McDonald, Prof N.B. Hounsell

CityMobil2 is a European project under the Seventh Frame- work Programme for Research and Technological Development. It started in September 2012 and will run for four years. The main objective of CityMobil2 is to implement large-scale pilot platforms for technical and socioeconomic test and validation of automated transport systems (ATS) in urban environments by demonstration and evaluation in cities with different socio-economic conditions. By using the pilot demonstration test bed established, CityMobil2 will undertake research focusing on technical, financial, cultural, behavioural aspects, and assess ATS's potential effects on land use policies and how new systems could fit into existing infrastructure in different cities. The project has 47 partners including local cites for demonstration, manufacturers of automated road transport systems, and academic/research institutions. TRG is mainly responsible for the evaluation of demonstration results – see: http://www.citymobil2.eu/

**Electric Vehicle Drivers and their Use of Digital Media.** (PhD, from December 2013). Farah Alkhalisi. Supervisors: Dr B.J. Waterson, Dr T.J. Cherrett.

Promoting the use of renewable-source fuels has greater potential to reduce transport-related carbon emissions in the short to medium term than changed traveller behaviour, especially given doubts that Western Europe has reached 'peak car'. Though electric vehicles (EVs) currently account for around 1% of new cars sold in the UK, they are intended to play a key role in meeting the objectives of the 2008 Climate Change Act. Strategies to counter barriers – both technical and cultural - to EV purchase or adoption are therefore clearly necessary.



Transport users, cyclists and walkers are increasingly using digital technologies such as social media platforms, smartphone apps and crowd-sourced databases to overcome infrastructural shortfalls; for car-sharing; and for intermodal transport. Little is known, however, about the extent to which EV drivers could be similarly using digital resources related to, for example, location of public charging points; scheduling and remote monitoring of their cars' charging; or technical data and information-sharing. This research therefore attempts to understand the relationships between electric vehicle drivers and digital media.

**Mitigating range anxiety and reducing energy consumption in drivers of electric vehicles** (iPhD student from October 2015). R. Deacon *Supervisors*: Prof N. Stanton, Dr S. Box. Industrial sponsor: Jaguar Land Rover.

Range anxiety, or a driver's lack of confidence in an electric vehicle's ability to complete a specified journey, is considered to be the primary barrier to the purchase of battery electric vehicles (BEVs). However, most new BEVs have a range of 100 miles, whilst the average UK driver travels just 25 miles per day (National Travel Survey 2013). In order to reassure the motoring public, the driver requires accurate and user friendly feedback so as to be able to maximise the economy of the BEV, maximise range and boost user confidence. A series of studies are planned in the Southampton University Driving Simulator (SUDS) that will investigate a variety of different information presentation methods and their effects on driving performance. The project aims to test the effects of new driver interfaces that will be developed with the aims of reducing range anxiety and minimising energy consumption. It is expected that this project will help recognise the potential of BEVs in the development of Sustainable Infrastructure Systems.

**Optimising Wireless Electric Vehicle Charging Locations** (iPhD student from October 2015). L. Hutchinson *Supervisors*:

Dr B.J. Waterson, Dr S. Box. Industrial sponsor: Transport Research Laboratory.

Dynamic Wireless Power Transfer systems, where electric vehicles receive a power charge as they travel along the road have the potential to significantly extend the range and usability of such vehicles.

While much research has taken place examining the optimal location distribution of traditional (plug-in) charging points however, the optimal distribution of wireless charging infrastructure, both in isolation and in combination with plug-in systems has received little analysis.

This research therefore seeks to create a modelling framework that - given the inputs of a network, driver requirements and the infrastructure capabilities - can attempt to optimize the distribution of both wireless charging systems and plug-in charging stations within the network.

It is anticipated that the creation of such a modelling framework will require developing and combining ideas and approaches from:

- Mathematics/Operational Research : Scheduling and resource optimisation (including heuristic approaches)
- Complexity Science : Agent based models to represent traveller behaviour such as route choice
- High performance computing : Using the University's IRIDIS cluster

to understand how the locations of wireless charging systems can affect the overall dynamics of the road transport network.

This project is in partnership with the Transport Research Laboratory (TRL) (www.trl.co.uk) and it is anticipated that extended placements at TRL will form part of the research activities.

**Transport Systems Catapult: University Partnership Programme (**TSC from 2015 to 2017) Dr S Box; Contract holder Prof N.B. Hounsell

The Transport Systems Catapult (TSC) has set up a Universities Partnership Programme (UPP), involving eight core Universities actively working in Intelligent Mobility (IM) and who can cover the different regions in the UK. The University of Southampton is covering southern England and is undertaking three main activities: (i) *Knowledge Exchange: Seminars and Workshops:* Activities include workshops on knowledge exchange and transfer on IM involving staff from the University, the TSC and relevant industry players in the South of England (ii) *Knowledge Exchange through secondments:* This involves secondments of research staff and students to the TSC and potentially secondments of TSC staff to Southampton and (iii) *User needs for education and training in IM.* These activities are focusing on two of the TSC Business Unit themes – (i) Autonomous Transport Systems, with Southampton taking a leading role in maritime transport and (ii) Modelling, notably establishing an open test bed platform.

**Rocket trajectory prediction problems** (PhD Studentship, from July 2014) Willem Eerland. Supervisors: Dr S. Box, Dr A. Sobester (Computational Modelling Group)

When it comes to accurately simulating a rocket's trajectory the simplest rockets can pose the greatest challenge. This is because unguided rockets are at the mercy of the atmospheric conditions and small errors in their thrust and aerodynamics, making their trajectory highly uncertain. This sponsored project will involve combining six-degree-of-freedom aeronautical simulations with stochastic modelling, applied probability and pattern recognition to make predictions about trajectories. Models will be validated by flying test rockets as unguided rockets are a cheap and effective way of deploying sensors into the atmosphere. Balloon launched rockets can potentially reach very high altitudes at low cost. Also, some terrorists have access to simple unguided rocket based weapons. Military and civil law enforcement agencies require software tools



to predict likely launch points for these weapons in order to protect important infrastructure, for example airports, military bases and Olympic stadia.

## 3.6 Rail

**A New Station Demand Forecasting Model for Wales** (Welsh Government, January 2015 to March 2016). *Contract holder:* Dr S.P. Blainey.

Building on previous rail demand forecasting research undertaken at TRG, this project involves the recalibration of 'trip end' rail demand models previously developed for England and Wales, making use of Geographically-Weighted Regression. As part of this process the models were also extended to take into account the destinations served by trains from local stations in the forecasting process. Following calibration the new models will then be used to produce passenger forecasts for a range of proposed new railway stations across Wales.

**Integrating data sources to enhance the experience for passengers with special needs through privacy aware mobile applications** (RRUKA, September 2015 to November 2016). *Contract holder:* Dr S.P. Blainey, joint with University of Surrey and Loughborough University

The project will explore issues related to the provision of personalised journey information for rail passengers through mobile applications for both customers and station platform staff. Specifically, it will: 1) examine from a human perspective what specific problems are experienced by passengers with special needs and/or disabilities when they are making rail journeys, particularly where disruptions occur; 2) assess how different data feeds from ATOC, TfL, and Network Rail could be used to provide integrated personalised journey information for particular passengers; 3) identify ways in which the location of a particular passenger on board a train can be determined, in order to optimise the provision of personalised information and passenger assistance services; 4) explore how passenger location information can be combined with other data feeds to improve the ability of rail staff to provide support for those who need it most; and 5) explore the trade-offs between data privacy and an improved, personalised rail journey experience. In order to achieve these objectives technical prototypes will be produced to demonstrate the concepts investigated during the project.

**Impact Acceleration Account Knowledge Transfer Secondment (KTS) Rail Energy Systems** (EPSRC and Arup, July 2014 – October 2015) J. Pritchard. *Contract Holder:* Prof J.M. Preston

This KTS built on earlier work undertaken as an EngD on the energy consumption of rail operations and infrastructure. It involved developing Arup existing software tools, including CO2ST – a tool for estimating embedded carbon in infrastructure construction. The KTS involved moving it to a new database platform which is accessible on the Arup Network, and developing the rail section to be compliant with Network Rail's standards. This enables users across the business to share knowledge and ensure that it captures the latest practices within the rail industry.

The KTS also involved further development of the RouteMaster tool, used to model the operational energy consumption of a train. Enhancements include additional trains in the rolling stock library, the ability to model coasting, and the option of modelling tunnels along a route. The ability to model the impact of tunnels on operational energy consumption has enabled some initial steps to be taken towards understanding the trade-offs between embedded and operational energy in rail infrastructure design.

**The Use of Passenger Loading Data to Influence Behaviour and Provide an Improved Experience for Passengers and Operators alike** (RRUKA, October 2015 – November 2016) Dr J. Pritchard. *Contract Holder:* Prof J.M. Preston

This project, undertaken in partnership with Govia Thameslink Railway (GTR), is using Stated Preference survey methods to understand how rail passengers might respond to information provided about crowding levels. Crowded trains can adversely affect the experience of rail passengers. They can also cause practical issues for train operators, especially if slow boarding and alighting at stations makes it hard to maintain tight dwell times. It is thought that some of these issues can be mitigated by providing better information to passengers and encouraging them to make different travel choices as a result. At one level, the choice of carriage on a particular train is important – by spreading passenger loading more evenly throughout a train, it may be possible to reduce the number of instances of overcrowding. At another level, the choice of train itself is important. If passengers can be encouraged to travel on alternative, more lightly loaded, services this will also help to mitigate some of the problems. An increasing number of data sources for monitoring train loading are becoming available, including on-train systems which can estimate the number of passengers in a given carriage. Methods of communicating with passengers are also becoming more sophisticated, with an increased use of real-time information systems and a high proportion of smartphone.

The main aims of this project are to prove that it is feasible to mitigate crowding by improving information provision and influencing passenger choice, and to understand how such information should best be presented.

**Improving Quality of Rail Service in Kuala Lumpur, Malaysia** (PhD Studentship, from October 2008). Siti Nurbaya Ab Karim. *Supervisors:* Prof J.M. Preston, Dr S. Blainey

Passenger Boarding and Alighting surveys have been undertaken to gauge optimal headway, optimal fleet size, optimal vehicle capacity and optimal pricing based on an economic optimization approach. The number of *KTM Komuter* train sets required has been examined using the ROMAN-D software based on both the actual and design operating service frequencies. As a result, a better *KTM Komuter* Working and Public Timetable has been identified. The key results of the O-D surveys depicted that there were high possibilities for the integration of Non-Motorized Transport (NMT) and Public Transport (PT) with mode splits of 21% walk and 40% PT for access and 39% walk and bicycle and 32% PT for egress. Descriptive analysis resulted in the corresponding access-egress walk distances for the commuters who walked to and from the rail stations (892 m and 623 m). The corresponding mean access and egress travel distances including PT were 15.0 km and 13.1 km, respectively. The resulting values of the Generalised Journey Time were high suggesting the importance of these determinants in deterring passengers from choosing *KTM Komuter* as a main mode of transport. For the results of the Attitudinal surveys, both the overall service quality and level of service were mostly rated as being fair by the *KTM Komuter* passengers. Improving parking facilities, increasing train efficiency, people services and space comfort were the main components in the KOMIQUAL models that best defined high quality *KTM Komuter* service among *KTM Komuter* users.

It was found that the number of *KTM Komuter* passengers per hour for seven time periods differed widely. The optimal fleet size, optimal vehicle capacity and optimal pricing resulted in two categories of peak period for Inbound services, namely 0630 – 1230 and 1630 – 2130 and these should be designed with the fleet sizes of 28 and 21 sets respectively. Three categories of peak period for Outbound services were noted, namely 0630 – 0930, 1000 - 1300 and 1600 – 2100 and these should be designed with the fleet sizes of 28, 26 and 33 sets respectively. A capacity of up to 249 seats per set, including standees, should be provided for Outbound services 1600 – 2100. By contrast, a capacity of up to 161 seats per set, including standees, should be provided for Inbound services 0630 – 1230. The optimal price is estimated to be RM1.83. This is slightly lower than the average fares per boarding from 2008 to 2013 ranging from RM1.90 in 2011 to RM2.40 in 2013. It is suggested that new *KTM Komuter* fares for the Klang Valley sector should be structured based on the current operating cost per day per passenger-km of RM0.21.

These models produced optimised service patterns (train frequency and capacity) and fares. A practical operating service headway should be 10 minutes during 0500–1630 hours and 15 minutes during 1630–2235 hours for both ways. This will provide an economically efficient operation and an adequate quality of service.

**Determining the Environmental Performance of Rail Transport Relative to Other Mode** (EPSRC and Arup, October 2009, Awarded 2015). James Pritchard. *Supervisors:* Prof J.M. Preston (University of Southampton), Dr J. Armstrong (Arup, University of Southampton).

The objective of this project was to investigate rail's environmental performance and make comparisons with other modes. "Environmental performance" is a broad topic and the decision was taken to focus on energy usage and greenhouse gas (GHG) emissions, the reduction of which could be classed as the key sustainability objective. After reviewing the contribution of the transport sector to overall GHG emissions levels, the decision was also taken to focus mainly on passenger transport within the UK. The standard metrics for comparison between modes are energy and carbon emissions per passenger-km. There are three separate areas of interest – operational energy usage and emissions, embedded energy usage and emissions and passenger loadings. Many comparison tools rely heavily on average data, and a review has been conducted of the available data for rail's operational energy consumption and emissions. It was found that there is a relative lack of specific data, and the bulk of the research has concentrated on investigating this further, through the development of a simulation tool and the analysis of energy metering data provided by train operators. A basic model was developed for Arup, which can output the energy usage of a train over a given route. A sizeable data set of energy consumption recorded by the train operators was analysed with a view to validating some of the simulation results and further understanding how energy consumption (and the related GHG emissions). When analysing the empirical data, significant variation in energy consumption was found between different routes, and also between different drivers. The variation in energy consumption between different routes gave rise to some interesting questions about the potential for trade-offs in rail infrastructure design; infrastructure designed to minimise operational carbon emissions may adversely impact embedded carbon emissions (for example, if large quantities of civil structures are needed to provide an optimum alignment). The variation in energy consumption between different drivers highlighted the importance of work to encourage more eco-friendly driving styles (for example, by providing Driver Advisory Systems), but also made it very difficult to accurately replicate real-world energy consumption in the simulation tool.

Some work has also been undertaken to consider embedded energy and carbon in rail infrastructure. The EngD project formed the basis for a further Knowledge Transfer Partnership with Arup, in which a software tool to better estimate embedded carbon in infrastructure was developed.

**TRACK21: Railway Track for the 21st Century – Work Package 6** (EPSRC Programme Grant from June 2010 to November 2015). Dr S. Blainey, Dr A. Ortega. *Contract Holder:* Prof J.M. Preston

It is widely acknowledged that a transformation in railway track performance is essential if the UK Government's aspirations of reduced cost and increased capacity on the rail network are to be realised. This Programme Grant aimed to bring about a step-change improvement in the engineering, economic and environmental performance of railway track making it fit for a 21st century railway, by developing new techniques for its design,

construction and maintenance. Research in the project has been enhanced by support from external stakeholders, notably Network Rail, who have provided access to software including Track-Ex and the Vehicle-Track Interface Strategic Model (VTISM). Industry stakeholders have also made a range of datasets available for use in the project, such as GEOGIS and ACTRAFF. TRG's work has focused on using these tools to model the whole life cost and carbon impacts of a range of alternative sleeper and ballast systems tested in other areas of the Track21 project. Reviews of previous work on whole life cost and carbon modelling for a range of factors relating to railway track systems have also been produced. In particular, a detailed assessment of Under sleeper Pads (USPs) has indicated that there may be wider benefits related to reduced vibration and improvements in ride quality www.track21.org.uk.

**Modelling Railway Station Choice Using Geographical Information Systems (GIS)** (PhD studentship, from October 2014). Marcus Young. *Supervisors:* Dr S. Blainey, Professor J.M. Preston.

This project will explore the factors that influence railway station choice decisions made by passengers, and apply this improved understanding to update methodologies used in the planning of new and existing railway services and networks. Station choice is often treated in a fairly simplistic manner in industry demand forecasting methodology, with access and egress distance usually the only influencing factors considered and passengers assumed to choose the nearest station to the ultimate origin or destination of their trip. However, recent research suggests that the choice of station is a far more complex process than this, with many other interrelated factors potentially involved.

**T2F: Track to the Future – Economic and environmental modelling** (EPSRC Programme Grant from June 2015 to May 2020). Dr A. Ortega. Contract Holders: Prof J.M. Preston, Dr S. Blainey.

This programme grant is an extension of the previous research programme Track21 project, and will shed new light on some of the interesting outputs from Track21. It will also address some of the new questions raised to achieve a better railway infrastructure performance.

The frequency and speed of trains are being increased year after year, and as a consequence track is being more intensively used. The time gaps for maintenance are decreased year after year and the concerns to reduce cost and environmental impacts add a huge pressure to the railway system. Old infrastructure is particularly vulnerable to climate change, so this is imposing new pressures on the track, sometimes with important effects on exposed and unprotected coastal railways.

There are three key research challenges that T2F will address. First, to develop low-maintenance and long life track systems with optimised material use. Second, to design crossings and transitions so as to optimise vehicle behaviour and consequently maximising the service life of trains. Third, develop an integrated approach to design a low-noise and low-vibration track. TRG will calculate the economic and environmental impacts of such interventions. T2F will benefit from TRACK21 networking, including Strategic University Partnerships between Network Rail and the universities of Southampton, Birmingham and Nottingham, and between RSSB and Huddersfield, involvement of the university partners in FutureRailway and Shift2Rail, and finally other publicly-funded railway infrastructure research.

**Developing Integrated Tools To Optimise Rail Systems (DITTO)** (RSSB, September 2014 to September 2015). Dr. J. Armstrong, Dr S. Box, Prof C. Potts (Maths) and Prof T. Bektas and Dr A. Kovacs (Management). *Contract holder:* Prof J.M. Preston.

Building on the OCCASION project, DITTO is continuing the process of developing optimisation formulations, algorithms and processes that make better use of existing capacity without compromising service reliability. It is part of an industry wide initiative called FuTRO (Future Traffic Regulation) and is related to the development of in-cab signalling and the adoption of the European Rail Traffic Management System (ERTMS). It has the following four key components: (i) Development of optimisation tools that maintain safe operating conditions and do not exceed theoretical capacity limits. (ii) Quantification of the trade-offs between the provision of additional train services and the maintenance of service quality so as to develop working timetables that optimise capacity utilisation without compromising service reliability. (iii) Combination of dynamic data on the status of individual trains to produce an optimal system-wide outcome in real time. (iv) Use of Artificial Intelligence to examine tractable solutions to real-time traffic control.

It involves a consortium of three Universities (Southampton, Swansea and Leeds) and there is industrial support from Arup, Siemens Rail Automation and Tracsis. The work at Southampton is focussed primarily on computer modelling. Analytical methods are being developed to calculate capacity utilisation indices and relate these to the propagation of delays, with encouraging initial results. These will in turn be used to optimise train timetables using a stochastic version of the job shop scheduling algorithm, which is being developed in parallel. A dynamic simulation model, Tracula, developed by the University of Leeds and based on their car following model, Dracula, will be used to adjust train running speeds in real time. This micro-simulation will be linked to a macro-assessment of the network, based on solutions to the Multi-Commodity Network Design Problem.

These tools will be combined in public domain software called OnTrack developed by Swansea University which will also incorporate safety analyses. The results in terms of the dynamic rescheduling of trains will be compared with what train signallers/dispatchers do in real situations. For road traffic, such expert controllers often outperform existing algorithms. In such cases, machine learning tools can be used to produce new algorithms which can outperform human controllers over an extended period. This will be tested in the rail context.

**A Modelling Approach to Reduce Maintenance of Railway Track with Declining Working Population** (MRes studentship, funded by West Japan Railway Company – JR West, from September 2013, Awarded 2015). Yusuke Miyazaki. *Supervisors:* Prof W. Powrie (Infrastructure Group), Prof J.M. Preston, Dr S. Blainey.

Japan has a rapidly ageing population which has severe implications for labour intensive activities such as railway track maintenance. A model has therefore been developed for JR West that examines the automation of maintenance and attempts to optimise schedules and minimise costs. Particular focus is placed on the replacement of rails and on the treatment of ballasted formations.

**Improving pre-trip information in Britain's passenger rail system** (PhD from October 2013) Yiwei Guo. Supervisors: Prof J.M. Preston and Dr S. Box)

Although passenger information is viewed as an important influencing factor on customer experience and rail demand, the quality of pre-trip information is often disregarded due to the limitations of current technologies. On the one hand, the accuracy of timetable-based pre-trip information is prone to train delays and cancellations. On the other hand, the various forms of real-time information about service disruptions contribute little to pre-trip information at the journey level due to the transience of this real-time information.

This research is therefore aimed at improving pre-trip information in Britain's passenger rail system. Specifically, there are three objectives:

- To bring together data from multiple sources, particularly on the performance of rail in terms of punctuality (delays) and reliability (cancellations);

• To identify and assess those routes that may be particularly vulnerable to delays and cancellations;
• To develop novel routing algorithms that take into account the uncertainty in rail travel that arises from delays and cancellations, and devise ways to present the additional information (about this uncertainty) to rail passengers via online journey planners.
In particular, data have been gathered on critical connections such as travelling from Bournemouth to Brighton via Southampton Central.

## 3.7 Transport and Infrastructure Policy

**Child Pedestrian Road Safety; Practical Training and Interactive Learning Environments to Improve Road Safety** (EngD studentship, October 2009 to July 2015). James Hammond. *Supervisors:* Dr T.J. Cherrett, Dr B.J. Waterson (University of Southampton), L. Ellarby (Hampshire County Council)

This research project assessed the effectiveness of computer based interactive learning environments in aiding road safety amongst the young. It focussed on teaching year one and two school children (ages 5-7) key pedestrian skills such as; crossing the road, finding safe places to cross and crossing between parked cars.

The intention was to assess the extent to which interactive videos have an impact on roadside behaviour. An interactive video demonstrating safe crossing techniques between parked cars has been developed and tested on schools in Hampshire. Results suggest that improvements in certain crossing behaviours are demonstrated as a result of training with the interactive video, however the resource is not intended to be a replacement for practical training which must still be prioritised.

**A Comparative Assessment of Modal Shift Policies in the Passenger Sector in Korea.** (PhD Studentship from September 2011, funded by the Korean Government), Dae-Soon Park. *Supervisors:* Prof J.M. Preston, Dr S. Blainey.

The Marco Polo Programme in the EU was launched in 2003 to stimulate modal shift from trucks to trains or ships. There may be potential for similar Modal Shift Policies (MSPs) in the passenger sector. This research focusses on the question: 'What is an effective MSP from the car to public transport in the passenger sector in South Korea?', 'What is the best combination of MSPs?', and 'What factors influence the transport mode choice of commuters?" The main MSPs considered are: a commuting cost subsidy for public transport users, additional parking fees for car users, and congestion charges for car users.

In order to investigate the relative effectiveness of these policies, stated preference data were obtained from 767 respondents, who work in the Gangnam area of Seoul, through an online survey that took place in early 2013. A full factorial design was used for the purpose of the survey to estimate the main effects and interactions without correlation. Various binary standard logit models with alternative-specific and generic covariates were developed to identify the effectiveness of MSPs and understand what factors affect people's mode choice decisions. In order to overcome limitations of standard logit by allowing for random taste variation, mixed logit models are also developed. In addition, through various models both without and with interaction terms, the modal shift effects of the combined MSPs, as well as a single MSP, are compared. According to the change of allocation ratio of two combined MSPs (e.g. subsidy 0% : parking 100% → subsidy 10% : parking 90%), the market share of travel mode was also evaluated to understand interaction terms. This research offers numerical evidence of negative modal shift synergy effect for combinations of the three MSPs.

With a view to forecasting the modal shift effects of socio-economic groups and a more deep understanding of the characteristics of each group, the segmentation methods were used. An equity impact analysis of MSPs has been conducted to obtain the Compensating Variation Per Person (CVPP). In addition, the ratio of the CVPP to the average income of each income group is calculated to judge whether each MSP is a progressive or regressive policy. The expenditure and revenue of MSPs are calculated. In addition, how revenue from MSPs should be spent in order to achieve a better transport system is considered.

**lIntegrated Vulnerability Assessment of Transport Networks in Seoul Capital Area, South Korea.** (PhD Studentship from September 2014, funded by the Korean Government), Wonman Oh. *Supervisors:* Prof J.M. Preston, Dr S. Blainey.

There have been increased interests in the vulnerability of transport infrastructure to disruptive events and in increasing the resilience of infrastructure systems to such events. The primary purpose of this research is to assess the vulnerability of public transport networks with integrated analysis between subway systems and road networks in the Seoul Capital Area (SCA), Korea. Reflection of personal preferences to transport modes and routes is second target of this study in specific disruptive environments in the process of vulnerability appraisal. Another goal of this study is finding out the weakest transport axis and the strongest one among 10 transport axes around SCA from the perspective of vulnerability to disrupting events. Lastly, this research will establish management strategies to increase resilience of the transport networks in SCA and to suggest a guideline for the users in disorderly situation.

**UK Infrastructure Transitions Research Consortium** (EPSRC, from January 2011 to December 2015). A.J. Hickford, Dr S. Blainey, X. Li, F.N. McLeod, Dr A. Ortega. *Contract Holder*: Prof J.M. Preston

This multi-institutional and multi-disciplinary project has helped inform the analysis, planning and design of national infrastructure, through the development and demonstration of new decision support tools, and working with partners in government and industry. The research deals at a national scale with energy, transport, water, waste, and information and communication technologies (ICT) systems. For these systems, the programme has: developed new methods for analysing performance, risks and interdependencies; provided a virtual environment in which to test strategies for long term investment; and increased understanding of how alternative strategies perform with respect to policy constraints such as: reliability and security of supply, cost, carbon emissions, and adaptability to socio-demographic, economic and climate change.

Following on from the Fast-Track Assessment (FTA) undertaken during the first year of the project, TRG have produced a model capable of forecasting transport demand and capacity within and between 142 UK zones for the period up to 2100, which includes 'soft' interactions with models of other infrastructure sectors to allow interdependencies between systems to be explicitly considered. The model includes road, rail, air and sea passenger and freight transport, and can capture the impact of a number of potential policy and technological options such as infrastructure construction, alternative pricing regimes and improved vehicle fuel efficiencies. The ITRC transport model has been used together with the other sectoral models to forecast the impact of a range of different transport strategies under different future scenarios for population, energy prices and the economy. Recent work on the project has focused on cross-sectoral interactions, across a range of future strategic options. Visualisation tools have also been developed within the consortium to allow future analysis of these results. A book giving further details and results from the project was published by Cambridge University Press in February 2016.

TRG staff were also involved in a 4-month collaboration with Infrastructure UK, using the ITRC models, databases and visualisation tools to assess the impact of the National Infrastructure Pipeline, helping to inform decision-makers and planners on

how future investments should be prioritised. For details, see: www.itrc.org.uk

**Low cost, infrastructure free forms of indoor localization** (PhD Studentship, from January 2012) Shashank Gupta
*Supervisors:* Dr. Simon Box, Prof R. E. Wilson (Bristol University)

Despite innovative research in indoor positioning, it is still not in the mainstream. In trying to trace the reasons, we identify two main reasons: (1) An indoor positioning application may require aisle-level precision (2) While such precision is attainable with pervasive radio based systems – Wi-Fi, however they come at a prohibitively high cost, mostly in the form of meticulous (signal) calibration. Therefore, this research aims to develop a self-contained low cost infrastructure free form of indoor positioning solution.

Recently smartphones have redefined the notion of mobile computing platforms. Ever improving features of affordability, ubiquity, and portability, increased sensory and computational power along with low power consumption fuelled by readily available batteries, have opened up a number of interesting applications. One such application is location based application. Therefore, this motivated us to use smartphone for our research. Primarily this research will investigate the techniques/algorithms that can assist in locating the position of the pedestrian based on the contextual information collected by several sensors in the smartphone. Moreover, this research will also be aimed to understand the movement pattern of the pedestrian. The smartphone's sensory signals would be collected and analysed. Various machine learning algorithms would then be employed to identify whether the pedestrian is walking, running, jogging, standing, going straight, turning, etc. based on the collected sensory signals - accelerometer and heading measurements.

**The delivery of bespoke travel information through ubiquitous computing as a potential mechanism to support nudging traveller behaviour**



(EngD studentship from October 2013, sponsored by EPSRC and Southampton City Council). Amanda Haylett. *Supervisors:* Dr T. Cherrett, Dr G. Wills (Electronics and Computer Science)
This research is examining the extent to which travel information mobile phone apps can affect travellers decision making and the extent to which their design and function caters for the range of traveller types seeking assistance on different journeys at different times. A literature review has highlighted the inter-relationships between traveller information needs, trip planning methods and technical innovations. Exploratory analysis has developed a schema of traveller types and these are being used as part of a Delphi study to further identify traveller information needs and how these can be better catered for in future app design.

**Road infrastructure requirements and funding for Intelligent Mobility and Low Carbon Transport** (part-time PhD from January 2014) Katherine Tegerdine
*Supervisors*: Prof N.B. Hounsell and Dr S. Blainey

The overall aim of this research is to devise and recommend one or more practical and acceptable methods for funding road transport in the UK in the short/medium term future given progress towards intelligent mobility and a low carbon transport system.

More specific objectives to achieve this aim are to:

- Evaluate road transport scenarios up to 2050, reflecting all important trends in traffic growth, vehicle composition and characteristics, infrastructure changes, technological developments, legislation, societal changes and so on;
- Analyse and understand the cost and revenue implications of these road transport scenarios on Governments and road users;
- Explore and develop new ways of funding transport infrastructure, including new ways raising the revenue required to fund the scenarios presented, whilst identifying the impacts of this on all concerned;

Make recommendations to Governments on transport infrastructure funding requirements and revenue raising options and implications, on the basis of this research.

**Port Redevelopment Decisions in Korea: An Economical Assessment of the Relations between City and Port** (PhD studentship funded by the Korean Government, from September 2015) Jong Soon Park. *Supervisors:* Prof J.M Preston, Dr S. Blainey.
This research's starting point is the Anyport model developed by James Bird in the 1960s. This will be updated in order to explore the development and redevelopment process of several ports including Busan port which is the biggest in S. Korea. It will evaluate both common and different factors for ports in the developing countries compared with ports in developed countries. In addition, a comparative study of ports in Korea and in the UK will be conducted in order to examine the characteristics of the environment and the relationship of ports and cities. Using the results of the developed models and case studies, the performance of the redevelopment projects and the key factors that determine the performance will be investigated. A conceptual model of decision making mechanism for port redevelopment in the developing countries will be proposed and evaluated in real practice in ports in Korea.

## 3.8 Human Factors

**Encouraging Eco-driving with Multisensory Feed-forward and Feedback Information** (EngD studentship sponsored by EPSRC and Jaguar Land Rover, from October 2011). Rich C. McIlroy.
*Supervisors:* Prof N.A. Stanton, Prof J.M. Preston.

The way in which a car is driven has a significant effect on the amount of fuel that is used. Given the issues of the over use of resources and the emission of large volumes of carbon dioxide (and equally damaging pollutants), the aim of this project is to encourage energy-conserving driving behaviours through the design of an in-vehicle information presentation system. While there have been a number of studies investigating the use of visual tools to help drivers save fuel, with varying success rates, each of these tools carry with them the issue of visual distraction. Considering that usage of the accelerator and decelerator pedals is a haptic task (i.e. of or relating to the sense of touch), can we provide information haptically to guide the driver's behaviour? To address these questions, a driving-simulator based study is planned that will make use of variety of different information presentation methods, including visual, auditory and haptic information, and all combinations thereof. Theoretical justification and design rationale find basis in the principles of Ecological Interface Design, an approach to design rooted in Gibsonian ecological psychology.

**Human Factors in the Design of Traffic Management Systems** (EngD studentship from October 2011). Joshua Price.
*Supervisors:* Prof N.A. Stanton, Dr B.J. Waterson (University of Southampton), Mr I. Snell (Siemens).

This research project investigates the potential benefits a human factors design approach can have when applied to the development of the next generation of traffic management systems. The systems used by Traffic Management Centres to manage congestion were assessed in the early stages of the project using Event Analysis of Systematic Teamwork (EAST) based on observational data. Focus was then shifted to the specific tools used to validate SCOOT controlled traffic signals, with Cognitive Work Analysis (CWA) used to assess the existing textual tool and develop a graphical alternative. The project's final stages are concerned with testing this new design empirically.

**Automatic Cars are Safer and more Efficient** (EPSRC and Jaguar Land Rover Ltd. EngD studentship, from October 2011). Victoria Banks. *Supervisors:* Prof N.

Stanton, Prof J.M. Preston, Mr D. Robertson (Jaguar Land Rover Ltd.)

With systems design plagued by criticism for failing to adequately define the role of the human operator within the system as a whole, there is lasting concern amongst the Ergonomics and Human Factors community that automated sub-systems in driving may contribute to safety concerns rather than overcome them. Failing to acknowledge the role of the driver in an automated vehicle system may lead to undesirable behavioural adaptation as a result of inadequately controlling for the changing role of the driver within the control-feedback loops. Adopting a systems-theoretic approach, this project aims to address the issues surrounding task sharing between the driver and automated subsystems by analysing the interaction that takes place within the driving system at different levels of automation in a simulated driving environment.

**i-VISION** (EU, from October 2013 to October 2016). K. Plant *Contract Holder:* Prof N. Stanton

The i-VISION project (Immersive Semantics-based Virtual Environments for the Design and Validation of Human-Centred Aircraft Cockpits) is made up of a consortium of seven partners, both academic and industrial, from five countries of the European Union. The aim of the project is to design a tool for use in rapid prototyping for the design and evaluation of aircraft cockpits in order to reduce product development times and costs. i-VISION will combine methods and technologies from three distinct areas of research, namely Human Factors, Semantics and Virtual Reality, into advanced design and validation tools. In 2015 effort was focused on assisting the technical partners integrate the Human Factors methods into the tool. By the end of the year two key methods: Hierarchical Task Analysis and Error Analysis had been implemented and were being tested in the virtual reality environment. The i-VISION tool will enable designers and engineers to visualise, manipulate and interact with a digital mock-up to allow key design decisions to be taken early in the process.



**Exploring How Optimising In Vehicle Information Presentation Can Mitigate Driver Distraction**
(EngD studentship sponsored by EPSRC and Jaguar Land Rover from October 2013). Katie Parnell. *Supervisors:* Prof N.A. Stanton, Dr K. Plant, Prof. J Preston (University of Southampton) and D. Thomas (Jaguar Land Rover Ltd.)

Technologies are increasingly entering road vehicles that offer secondary functions alongside the primary driving task. The variety of activities available are multiple, however their nature of being available to the driver while on the move also make them likely to have adverse effects on driver safety. The presentation of information on in-vehicle interfaces requires careful consideration by manufacturers in order to prevent advances in technology from having adverse effects on driver safety.
A systems approach is applied to the issue to identify all elements within the road transport system that play a role in developing and allowing the presentation of information that could be potentially distracting to the driver. Rather then focusing blame on the driver as is the traditional approach, this project hopes to look for facilitators of driver distraction. This hopes to bring a novel approach to the issue and highlight elements higher up in the causal chain that play a part in distraction related incidents through facilitating technology use in vehicles. Qualitative insight into driver's attitudes towards in-vehicle technology and the regulations surrounding it will be sought in order to inform future legislation and design principals. Novel approaches to Human Machine Interface design will be investigated to determine how to optimise the presentation of information required by the driver while in motion. The Southampton University Driving Simulator (SUDs) will enable the distractive potential of in-vehicle technology to be tested across different contexts.

**Latent Error Detection & Recovery in UK Naval Aircraft Maintenance** (PhD funded by Royal Navy from October 2013). Commander Justin Saward. *Supervisors:* Prof N.A. Stanton, Prof J.M. Preston

Human error is the most significant factor in aircraft accidents for both military and civilian aviation organisations. A task carried out in error creates a latent condition that can result in a future undesirable outcome if the error is not detected later. Detection of typical latent errors, post-task completion, has been observed amongst UK naval air engineers and is reported to be a result of some seemingly spontaneous recollection of past activity. Despite an extensive literature review, the nature and extent of this phenomenon is not understood fully and appears to be an under-researched area; causes of error and proximal error detection having been researched widely. To research this phenomenon, the systems view of human error has been combined with a multi-process approach to post-task latent error detection (LED). Early findings suggest that distributed cognition across the entire socio-technical system may be influential and that time, location and systems cues appear to account for LED amongst naval air engineers who have experienced the phenomenon. Since the concept of human error has broad applicability, it is anticipated current research will benefit the wider community interested in safety resilience using a systems approach to minimise the consequences arising from latent error.

**Human Factors of Highly Automated Driving (HF Auto)** (EU Marie Curie ITN from June 2014 to June 2017) Alex Eriksson, D Heikoop. *Contract holder* Prof N. Stanton.

Road transport is an essential part of society but the burden of traffic crashes, congestion, and pollution is enormous. Highly automated driving (HAD) has the potential to resolve these problems and major car makers foresee that HAD will be technically ready for commercialisation within one decade from now. However, before automated driving can be safely deployed on public roads we have to deal with imminent human-error and legal consequences.

HF Auto will answer crucial human-factors questions, such as: How should human-machine-interfaces (HMI) be designed to support transitions between automated and manual control? How can the automation understand the driver's state and intentions? What are the effects of HAD on accident risk and transport efficiency?

HF Auto aims to bridge the gap between engineers and psychologists through a multidisciplinary research and training programme. We will combine engineering domains such as simulator hardware, traffic flow theory, control theory, and mathematical driver modelling with psychological domains such as human action and perception, cognitive modelling, vigilance, distraction, psychophysiology, and mode/situation awareness, to optimally address the interdisciplinary domain of human factors.

**Who's in control? Lessons from human-human interaction applied to Human Computer transfer of control** (PhD funded as part of HFAuto - Human Factors of Automated Driving PITN-GA-2013-605817 from June 2014). Alexander Eriksson. *Supervisor:* Prof N.A. Stanton, Dr S Box

This work will develop a human-machine interface (HMI) supporting the operator of the future highly automated vehicle. The interface shall intuitively guide the operator during platooning and transient manoeuvres such as joining or leaving a platoon, lane changes and merging. The new HMI shall support human-to-vehicle instruction (setting and changing of automation modes and driver preferences) as well as multimodal (e.g. visual, haptic, and auditory) vehicle-to-human semantic information and status feedback (e.g., about automation status, change of automation mode, and environmental information like road infrastructure and surrounding vehicles) during highly automated driving.

**TASCC: Human Interaction: Designing Autonomy in Vehicles (HI:DAV)** (EPSRC, December 2015 to November 2018) *Contract Holder: Prof N. Stanton*

Cars that can drive themselves have been predicted for some time, but they are nearly with us. Highly automated vehicles are likely to be on public roads within the next ten years. The largest gap in our understanding of vehicle automation is how drivers will react to this new technology and how best to design the driver-automation interaction. Our project will answer these questions by studying a wide range of drivers with different driving experience in simulators, or test-tracks and in road going vehicles.

We will start by modelling driver behaviour in our laboratories in order to help us design inclusive, user-centered, interfaces with vehicle automation. We plan to learn from different situations where automation is already used (such as the Boeing versus Airbus design approach of 'soft' and 'hard' automation). Then we will test the designs out in our driving simulator. We will test drivers of different ages, gender, experience and capabilities, in a range of scenarios (e.g., different road types and environmental conditions) with different automation systems (e.g., autonomous driving, auto 'valet' parking, adaptive vehicle personalization, off-road assistance) and different interfaces (which we will design).

Our design approach will personalise the driver interfaces to the widest range of drivers possible (e.g., wide ranges of age and driving experience). We want the driver-automation interfaces to be intuitive and the necessary responses to be obvious. We design so that the system adapts to you, not you having to adapt to the system. We will also monitor driver behaviour over successive weeks of use. This will help us to understand how drivers learn to respond to the automation over time. We will be studying how control of the vehicle is handed back and forth between the automation and the driver. We are also interested to know what the driver is doing when the vehicle is under automated control. To help in this understanding, we will be monitoring the driver physiological and psychological states. The idea is to use this information to adapt the automation to the driver and the situation, so that performance of the system is optimised.



This will enhance safety to the benefit of the driver and other road users.

The studies will progress from the simulator to the test-track, as our interaction and interface designs evolve with testing. On the test-track we can record driver behaviour physiological and psychological states to see what further changes are needed and whether the automation can be even more highly tailored to the situation. As the research progresses we will take the revised designs into road going vehicles for the final set of tests. These tests will be used to validate the designs and prepare them for delivery into production vehicles. At the end of the research, we will be able to provide Jaguar Land Rover (JLR) with the design methods and well as the designs themselves. This means that they will be able use the methods we have provided to design new systems into the future.

During the course of the research the Universities of Cambridge and Southampton will be working closely with JLR engineers to ensure that the UK remains at the forefront of technological innovation in vehicle automation. We will have answered the questions about how drivers will react to this new technology and how best to design the driver-automation interaction. The success of vehicle automation design will be on designing appropriate interactions and interfaces that support the driver. Our research will be essential to that success.

### Future Flight Deck Technologies

(Innovate UK (formally TSB) from 2014-2016) Dr. K. Revell. Dr. C. Allison. *Contract holder:* Prof N.A. Stanton

In the next generation of civil aircraft there is a need for a step change in the flight deck capability driven by new operational scenarios coupled with requirements for system and technology transparency. Challenges of the future relate to Aircraft, Crew and, Operators. Aircraft will be operating in an increasingly congested airspace, will be operating at new locations, undertaking self-assured separation and landing and taking off with degraded vision to optimise separation. Crew will have an increased reliance on flight aids and decision support. They will expect to operate technology with increase functional capability with intuitive interfaces. As a result, they will need reduced training. In addition, future crewing is likely to reduce the number of pilots in the cockpit and rely on greater ground support, following the concept of 'distributed crewing'. Operators will expect reduced acquisition costs and the introduction of efficient technology to minimise re-certification costs. The Future Flight Deck Technologies project is a collaboration with industry partners (GE Aviation, BAE systems) and academia (University of Southampton and Coventry University). This project has focussed on human factors driven technology solutions such as Novel Interface Design, Multiple display cockpit design, Future Technologies evaluation and exploration of distributed crewing and its effects on function allocation, task performance and safety.

### Investigations into Aeronautical Decision Making using the Perceptual Cycle Model

(part-time PhD student, April 2010 to July 2015). K. Plant. *Supervisors:* Prof N. Stanton, Prof J.M. Preston

This research was completed in 2015 and K.Plant received her PhD in the July 2015 graduation ceremonies. The research project explored aeronautical decision making from the perspective of the Perceptual Cycle Model which models the interaction between a person and their work environment. In 2014 the research was awarded the Honourable Company of Air Pilots prize for aviation safety research and this was presented at a ceremony in 2015. Outputs of the research include seven journal publications and numerous conference presentations.

# 4. TRANSPORTATION RESEARCH GROUP PUBLICATIONS

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