

ANNUAL REPORT 2014 TRANSPORTATION RESEARCH GROUP

Prof Nick Hounsell, Head, Transportation Research Group, Engineering and the Environment, University of Southampton, Boldrewood Innovation Campus, Southampton, SO16 7QF.

Tel: 023 8059 2192; Fax: 023 8059 3152;
e-mail: nbh@soton.ac.uk; web: www.trg.soton.ac.uk

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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 now 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 2014.

TRG academic staff members during 2014 were:

- Nick Hounsell, Professor of Highways and Traffic, and Head of TRG
- John Preston, Professor of Rail Transport and (to August 2014) Head of CMEES
- Neville Stanton, Professor of Human Factors in Transport
- Mike McDonald, Emeritus Professor of Transportation Engineering
- Dr Tom Cherrett, Senior Lecturer specialising in freight and logistics
- Dr Ben Waterson, Lecturer specialising in modelling and simulation

Dr Simon Blainey was appointed Lecturer, specialising in rail transport and modelling, during this period.

Research Staff in TRG during 2014 included Dr Simon Box (New Frontiers Fellow), Dr John Armstrong, Adrian Hickford, Fraser McLeod, Dr Jinan Piao, Katie Plant, Dr Aaron Roberts, Dr Birendra Shrestha, Dr Claudia Iacob, Dr Alan Wong, Judit Varga, Dr Alejandro Ortega, Alex Eriksson, Daniel Heikoop and James Pritchard. Their research activities are summarised in later paragraphs. **Technical Staff** supporting TRG included Amish Morjaria, Karen Ghali and Daniel Fay. Melanie Hallford continued in her role as **Senior Administrator** for the Group with Joy Richardson joining 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; Professor John Wootton; Dr John Walker; Dr Terence Bendixson, Dr John Schoon and Dr Mark Brackstone.

We also had some 20 students attached to the Group undertaking PhD or EngD (Engineering Doctorate) research in transport in 2014. PhD degrees were awarded to Byungwoo Gil and Ji Hong Park in this reporting period.

Postgraduate teaching continues to be an integral part of TRG activities, particularly the MSc in Transportation Planning and Engineering. Some 23 new students enrolled in September 2014, 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 2014, winning a number of new contracts relating to Intelligent Transport Systems (ITS) and associated social/sustainability issues. Current research activities, which have a total value of ~£4m, are summarised in later paragraphs in this report.

TRG facilities which have been installed or further enhanced in 2014 include:

- SUDS (Southampton University Driving Simulator)



- The TRG Instrumented Vehicle (IV) for on-road trials



- Our well-equipped transport data analysis facility.
- ComTET – A command teamwork experimental test bed for submarine control rooms.

In May 2014 we moved to new offices at the University's Boldrewood Innovation Campus alongside colleagues working in maritime and aerospace transportation and co-located with the Southampton Global Technology Centre of Lloyd's Register.



In line with the rest of the Faculty, Transportation Research Group staff were entered into Unit of [Assessment 15 \(General Engineering\)](#) in the University's 2014 Research Excellence Framework (REF) submission and led on the Transportation theme. The University's submission topped the results in terms of research power (Grade Point Average times the number of staff returned) and all themes were assessed as having some world-leading outputs.

2. EXTERNAL ACTIVITIES

The following sections summarise the range of external activities undertaken by TRG Academic Staff members in 2014:

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.
- Panel Member REF14 Unit of Assessment 16 (Architecture, Built Environment and Planning).
- 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.

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'.
- Visiting Professor at MIT, Astro and Aero Department
- Key note speaker at the Irish Ergonomics Society Annual Conference
- Chartered Engineer with the Institute of Engineering and Technology
- External expert advisor for Australian Research Council funded rail level crossing project
- Invited speaker at Monash University, Melbourne, Murdoch University, Perth and University of Sunshine Coast, Queensland, Australia.
- Awarded DSc at the Summer 2014 Graduation Ceremony

Mike McDonald:

- Trustee of the Rees Jeffreys Road Fund.
- Transport Research Foundation Fellow.
- Pao Yukong Professor at Ningbo University, China.

Tom Cherrett:

- Chairman of the Editorial Board for the Institution of Civil Engineers Transport Journal
- Editor of the special issue of the ICE Transport Journal on "Transport systems: moving to a low-carbon future"
- Member of the Transportation Research Board's committee on Urban Freight Transportation, AT025

Ben Waterson:

- Member of the EPSRC Peer Review College
- Member of the NEARCTIS Network of Excellence in Cooperative Traffic Management
- 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

Outreach

TRG hosted a Parliamentary Outreach Event on 3 April 2014 on the subject of Intelligent Transport Systems. The event was organised in conjunction with ITS (UK) and chaired by Louise Ellman MP, chair of the House of Commons Transport Select Committee. It featured presentations by several members of TRG staff, along with external speakers from ITS (UK), MIRA, Siemens, Hogia, AECOM and Kapsch, and had 80 attendees including a number of visitors from industry, government and the press.

TRG continued to take the lead and provided many public engagement activities for the University, under the direction of Dr Ben Waterson (for Transportation Research), and Dr Alan Wong (University 'N Cubed' Public Engagement Coordinator): This included:

- demonstrating several exhibitions of Intelligent Transport Systems at the University's Science and Engineering Open Day;
- acting as the Faculty Champion for the Three-Minute Thesis (3MT) Competition, which helped to improve the science communications skills of many postgraduate students;
- assisting Sixth Sense Transport (see further below) with a display of 'intelligent mobility' using sensors mounted on a Scalextric set, as part of the high-profile 'Internet of Cars' Project: <https://connect.innovateuk.org/web/intelligent-mobility/article-view/-/blogs/internet-of-cars-symposium-southampton-university-24-september-2014>;
- helping to establish the 'Researchers' Café' for the University and General Hospital, which is partly sponsored by The Lloyd's Register based at Boldrewood Campus, to enable

early-career researchers and postgraduate students to discuss their research with others in an informal setting, and improve their networking; and

- providing interactive activities to engage the public in our transportation research at the Cheltenham and Winchester Science Festivals, and at the Bestival and Glastonbury Music Festivals.

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 both the engineering and physical sciences and social sciences. 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 and 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 2014 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 is 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 focusses 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 is led by a city which has particular experience on the specific thematic areas and ambitious aims for future developments. The cities are assisted by Thematic Support Partners, who are consultancies and universities with proven expertise in the respective cluster areas. TRG is a thematic support partner for 'network and traffic management to support traveller information' cluster. www.tide-innovation.eu/en/.

Monitoring and Evaluation of Managed Motorway Schemes (EPSRC and Mott MacDonald Ltd. EngD Studentship, from October 2008). 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 is looking into specific aspects of managed motorways, particularly capacity and lane utilisation, the use of Hard Shoulder Running up to 60 mph and the implementation of Through Junction Running (i.e. the use of the hard shoulder through the junction).

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

This research project is investigating the potential improvements in traffic signal control systems that can be enabled through richer data sources. Focussing specifically on the benefits of knowing, in advance, a vehicle's intended route through an isolated

junction. The research involves 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). 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) 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.

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) and private sector organisations such as DP World, ABP, Steve Porter Transport Group, and more recently Old Mutual Wealth.

3.2 Bus Operations and Priority

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

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 to improve speed and reliability, thus improving passenger service quality

and operational efficiency. Traditional forms of priority at traffic signals (e.g. Selective Vehicle Detection (SVD)), currently implemented in London, gives priority to all detected buses. At signalised junctions, priority can be given by altering signal timings in favour of approaching buses. Such methods reduce junction delays. However, bus priority benefits and impacts on general traffic depend mainly on priority parameters used and priority strategies implemented. In this study existing priority parameters for VA signal controllers are being evaluated and new parameters are being explored using a VISSIM microscopic simulation model. This research is also investigating ways of enhancing priority strategies to improve bus travel time savings.

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)

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). Further analysis will then be undertaken to explore any correlations between JTV and EWT, using iBus data for a variety of bus routes across London.

3.3 Energy & Environment

LSTF Case Study on Carbon Impacts and Congestion Relief (DfT, from August 2013 to July 2015). A.J. Hickford, Dr A. Wong, K. Ghali, Prof I. Williams. *Contract Holder:* Prof J.M. Preston

This case study is to provide evidence of the effect of Local Sustainable Transport Fund (LSTF) schemes on carbon impacts and congestion relief. This will be achieved by analysing the extent to which LSTF programmes reduce carbon emissions and congestion through reducing and/or modifying patterns of car use, and generating mode shift towards more sustainable travel modes such as public transport or active travel. The study will be based on a longitudinal case study approach, building on current work being undertaken by the University of Southampton on monitoring and evaluating the LSTF programmes in South Hampshire. It also builds work being undertaken by the project partners: Solent Transport, Transport for Greater Manchester, Leicestershire County Council and Loughborough University. Baseline data collection was carried out in five case study areas (Rochdale, Hyde, Coalville, Eastleigh, Gosport) and compared to three control areas (Wigan, Hinckley, Locks Heath). Further data collection, including focus group surveys, is ongoing.

Centre for Sustainable Travel Choices

(Solent Transport and SCC, from September 2012 to August 2015). Dr A. Wong, A.J. Hickford, Dr T. Cherrett, K. Ghali *Contract Holder*. Prof J.M. Preston

The Centre is a partnership between Southampton City Council, the University of Southampton and Sustrans. It oversees the work related to two Local Sustainable Transport Fund (LSTF) bids and a Better Bus Area Fund (BBAF) bid and explores related opportunities. TRG leads the monitoring and evaluation of various physical interventions and travel behaviour change schemes that aim to promote sustainable and active travel whilst suppressing private car use. Baseline data were collected in 2012/13 using online and card survey tools, alongside focus groups held throughout South Hampshire. Secondary data has also been collected throughout the project, including traffic flows, measures of congestion and public transport usage. Similar follow-up surveys are currently being undertaken, which will help inform before-and-after comparisons of people's travel behaviour and attitudes.

Intelligent Agents for Home Energy Management

(full-time PhD studentship from October 2010) 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 aims to develop 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. 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

Developing Sustainable Supply Chains for Healthcare (ESPRC and Transport for London). EngD Studentship, from October 2010). 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.

Reducing the Carbon Footprint in the Food Supply Chain (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 and refrigeration technologies could positively contribute to decarbonizing the food logistics supply chain. 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 improve the efficiency of operations through deployment of alternative refuelling infrastructure and vehicles, while at the same time improving energy security and waste management, mitigating volatility of fuel prices and reducing transportation costs and other negative externalities of road haulage such as the impact of transport on global warming and air quality emissions.

Sustainable 'take-back' Logistics for the Charity Sector (PhD studentship, from October 2010). Benjamin Norton.

Supervisors: Dr T.J. Cherrett, Dr B.J. Waterson (University of Southampton), Mr M. George (Oxfam).

Oxfam operates a complex 'take-back' logistics operation, servicing its UK stores and bring-banks. This enables the charity to i) transport goods (primarily second hand clothing) between its stores for re-sale ii) feed recycle generated in stores back into recognised commercial recycling streams iii) take-back low-grade clothing to its sortation facility in Huddersfield for separation and onward processing. The annual transport cost of these operations runs into several million pounds and considerable savings (financial and environmental) could be gained through optimising the use of the current regional and local transport fleets and improving donation bank performance (regarding stock quality and quantity) through informed bank placement techniques. Of real interest is the impact the underlying population characteristics have on the yield volume and stock quality at collection sites, and whether a better understanding of this relationship can be gained using historic fill levels over time, and quality audits of donated stock. If a relationship exists and different postcodes can be shown to yield significantly different weights and quality of stock, then banks can be targeted to certain areas, and the logistics optimised accordingly. This project will quantify and qualify the potential benefits from these proposed approaches.

STRAIGHTSOL (EU 7th Framework, Cooperation Work Programme, from 2011 to 2014). F.N. McLeod. *Contract Holder:* Dr T.J. Cherrett.

The STRAIGHTSOL project brought together seven innovative field demonstrations of various freight initiatives from around Europe, using a common evaluation framework to provide transferable results and conclusions. In the UK, TRG worked with Oxfam, using remote monitoring sensors in textile donation banks to allow more dynamic scheduling of collections. Results suggested that the technology can be used to significantly reduce weekly collection mileage,

particularly when servicing remote bank locations. The extent of the savings depends on whether a more flexible shop servicing strategy can also be adopted. Oxfam's ultimate goal is to maximise profit from donated goods, which involves a trade-off between minimising collection costs and maximising quantity, and quality, of goods collected.

Sixth Sense Transport (Reducing/re-distributing transport options through a flexible interpretation of time) (EPSRC, from 2011 to 2014). F.N. McLeod, K. Ghali. *Contract Holder:* Dr T.J. Cherrett

The 6th Sense Transport project explored the transport and business opportunities that may be gained by improving the temporal and spatial visibility of transport using Smartphones. TRG worked with Oxfam in this research, giving their collection/delivery vehicles and clothing/book banks (the latter equipped with remote monitoring sensors) the properties of a channel within a social network (as in Facebook or Twitter). This enabled them to transmit data about their status, receive data about possible opportunities and carry information for others in the network, so enabling better travel and transport decisions to be made. A Smartphone app was developed to help Oxfam staff to improve the efficiency of their logistics processes. A main interest for TRG is in how such new 'visualisations' of vehicle, bank and shop status given to Oxfam staff (drivers, area managers, shop managers) might enable more effective localised decision making to save time/fuel and lead to more reactive stock management. More details are given at: www.sixthsensetransport.com.

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 cities 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 currently just 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.

Transport Systems Catapult: University Partnership Programme (TSC from 2014 to 2017) B.P. Shrestha Contract holder Prof N.B. Hounsell

The Transport Systems Catapult (TSC) has set up a Universities Partnership programme, involving some 8 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 will undertake 3 main activities: (i) *Knowledge Exchange: Seminars and Workshops:* Activities will 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 will involve 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*. Early work will focus on two IM themes – maritime transport and autonomous transport systems.

Rocket trajectory prediction problems

(PhD Studentship, from July 2014) Willem Eerland. Supervisors: Dr S. Box, Dr A. Sobester (Fluid Structure Interactions)

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

Rail Demand and External Impacts

(Passenger Demand Forecasting Council, Association of Train Operating Companies, from July 2013 to April 2014). Dr S. Blainey, Prof J.M. Preston. *Contract Holder*: Dr S. Blainey, joint with Mott Macdonald

This research project aimed to provide a greater understanding of how factors external to the passenger rail market have been affecting rail demand since the early 1990s, focusing particularly on the likely

reasons for the general durability of rail demand since the economic downturn in 2008. The first stage of the work involved carrying out a literature review alongside backcasting of rail demand over the study period to test the predictive power of the existing Passenger Demand Forecasting Handbook (PDFH) modelling recommendations. This work made use of a comprehensive dataset on rail passenger numbers and on the factors which determine rail demand (RUDD), supplied by the Department for Transport. The results from the first stage of the project fed into a second phase which used sophisticated panel data modelling techniques including fixed effect models and dynamic panel effects models to capture the effects of structural changes in the economy and other external variables on rail demand. This modelling fed into a number of recommendations for revisions to the rail passenger demand forecasting framework.

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

The 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 will be 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 will be 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).

It was found that the mean, median, maximum and minimum 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 optimized 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, from October 2009). James Pritchard.
Supervisors: Prof J.M. Preston (University of Southampton), Dr J. Armstrong (Arup, University of Southampton).

The objective of this project has been to investigate rail's environmental performance and make comparisons with other modes. "Environmental performance" is a broad topic and the decision has been 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 has also been 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 has been 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 has been analysed with a view to validating some of the simulation results and further understanding how energy consumption (and the related GHG emissions).

Some work has also been undertaken to consider embedded energy and carbon in rail infrastructure. The EngD project forms the basis for a further Knowledge Transfer Partnership with Arup, in which it is planned find ways of considering possible trade-offs which may exist between reducing embedded energy and operational energy.

TRACK21: Railway Track for the 21st Century – Work Package 6 (EPSRC Programme Grant from June 2010 to May 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 aims 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.
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.

Impact Acceleration Account Knowledge Transfer Secondment (KTS): Further Development of Railway Capacity Analysis Tools. (EPSRC and Arup, October 2013 – September 2014) Dr J. Armstrong. *Contract Holder:* Prof J.M. Preston

The specific objectives of the KTS are the further development of (i) software developed for Network Rail's Capacity Charge Recalibration (CCR) in 2012/13, and (ii) methods and software developed in the OCCASION project for the capacity assessment of railway nodes (i.e. stations

and junctions). The planned work is a continuation of collaboration between TRG and Arup on the original CCR and OCCASION projects.

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

This KTS builds on earlier work undertaken as an EngD on the energy consumption of rail operations and infrastructure. It will involve enhancements to existing software tools such as RouteMaster, IMPACT and COS2T.

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). 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 is therefore being 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.

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 (Management). *Contract holder:* Prof J.M. Preston.

Building on the OCCASION project, DITTO will continue 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 will primarily focus on computer modelling. We will develop analytical methods to calculate capacity utilisation indices and relate these to the propagation of delays. This will be used to optimise train timetables using a stochastic version of the job shop scheduling algorithm. 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.

Innovative journey planning system for British rail passengers (PhD from October 2013) Yiwei Guo. *Supervisors:* Prof J.M. Preston and Dr S. Box)

This research aims at developing a brand-new multi-criteria, multi-modal journey planning system for British rail users to provide them with more comprehensive and more reliable travel information to help truly increase trip efficiency and to enhance the attractiveness of public transport. This system will explicitly consider the utilisation of multiple modes of public transport in medium-to-long distance inter-urban travel, and will realistically model the involved transport networks. Apart from total travel time, additional criteria such as total walking and waiting time, monetary costs, and service reliability will be modelled or defined mathematically and encapsulated into the corresponding path-finding algorithms. Moreover, solutions to several practical problems arising in the context of inter-urban multi-modal travel will be explored, and speed-up heuristics will be designed to enable real-time interactive query.

3.7 Transport and Infrastructure Policy

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

This research project aims to assess the effectiveness of computer based interactive learning environments in aiding road safety amongst the young. It is focusing 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 is 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.

Integrated 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 has been increased interest in the vulnerability of transport infrastructure to disruptive events, whether scheduled (e.g. planned maintenance) or non-scheduled (e.g. natural hazards, terrorist attacks). There is also interest in increasing the resilience of infrastructure systems to such disruption. These issues will be examined in Seoul, South Korea, with reference to studies of eight radial corridors served by the subway. This will combine Stated Preference surveys of traveller behaviour in the face of disruption with traffic models developed with TransCAD.

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 is informing 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 is: developing new methods for analysing performance, risks and interdependencies; providing a virtual environment in which to test strategies for long term investment; and increasing 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 is currently in development to be published by Cambridge University Press. For details, see: www.itrc.org.uk

Low cost infrastructure free form 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 Tom Cherrett, Dr Gary Wills (Electronics and Computer Science)

This research will examine the extent to which mobile phone apps can affect local travel behaviour. 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 will be investigated in subsequent field work.

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

3.8 Human Factors

ALICIA ((EU, from November 2009 to August 2014). Dr A. Roberts, K. Plant
Contract Holder: Prof N. Stanton

The ALICIA project (All Condition Operations and Innovative Cockpit Infrastructure) is led by Augusta Westland Helicopter Company (UK) and involves forty-two partners from fourteen countries of the European Union. The research outcomes will be used to improve flight safety and extend the range of operations. The University of Southampton has undertaken an analysis of the cockpit architecture using Cognitive Work Analysis to model the demands and constraints of normal and non-normal operations. This work informed the development of new design proposals for glass cockpits, including a Head up Display (HUD) concept to assist helicopter pilots landing in degraded visual environments. This is the final year of the project and so efforts were focused on analysing the data from the HUD studies and writing project reports and journal submissions. The project was completed in August 2014.

Exploring Aeronautical Decision Making with the Perceptual Cycle Model (part-time PhD student from April 2010). K. Plant.
Supervisors: Prof N. Stanton, Prof J.M. Preston

This research explores how the Perceptual Cycle Model (PCM) and Schema Theory can be applied to understand and explain the pilot decision making processes in the cockpit. The perceptual-cycle models the interaction between a person and their work environment and it is being used to show why actions and assessments made sense at the time in order to offer a causal explanation of phenomena such as human errors. A literature review of Schema Theory has been conducted in which its role in Ergonomics research was addressed. A case study followed, in which it was demonstrated how the PCM and Schema Theory could be used to explain the actions of the pilots involved in the Kegworth aviation accident. Critical decision method

interviews have been conducted with pilots and the data thematically analysed according to the principles of the Perceptual Cycle Model. This data will feed into understanding influences on decision making when dealing with critical incidents. Data from a 4-man helicopter crew has also been collected in order to begin researching team decision making processes, i.e. team perceptual cycles. In 2014, data were analysed and written up and two journal papers were published.

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 2015). 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. 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. The University of Southampton will provide advanced Human Factors methods to analyse the activities of the pilot and co-pilot during various phases of flight and operating conditions in a virtual reality-based aircraft cockpit.

Optimising In-vehicle Information Presentation to Mitigate Driver

Distraction (EngD studentship sponsored by EPSRC and Jaguar Land Rover from October 2013). Katie Parnell. *Supervisors:* Prof N.A. Stanton, Prof J.M. Preston, Ms K. Plant, Mr D. Thomas (Jaguar Land Rover Ltd.)

More technologies are entering road vehicles that offer secondary functions alongside the primary driving task. The variety of activities new technologies offer are multiple however there is likely to be some adverse effects to driver safety. The presentation of information on in-vehicle interfaces requires careful consideration by manufacturers.

This project aims to investigate the characteristics of interface design that may attenuate or intensify distraction from the road. Eye tracking methods will be used to determine how drivers allocate attention towards tasks that are secondary to the driving task. Novel approaches to Human Machine Interface design will be sought 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) 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). 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.

4. TRANSPORTATION RESEARCH GROUP PUBLICATIONS

2014

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2. Bailey, Gavin, Cherrett, Tom and Waterson, Ben (2014) [Does mobile consolidation solve the traditional consolidation centre conundrum? A feasibility study in the context of UK healthcare](#). In, *19th Annual Logistics Research Network Conference, Huddersfield, GB, 03 - 05 Sep 2014*.
3. Bailey, Gavin, Cherrett, Tom and Waterson, Ben (2014) [A simulated annealing approach to explore temporal consolidation of healthcare courier services to reduce carbon emissions](#). In, *IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI), Qingdao, CN, 08 - 10 Oct 2014*. , 260-265. (doi:10.1109/SOLI.2014.6960732).
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5. Baruah, P., Qadrdan, M., Eyre, N., Chaudry, M., Blainey, S.P., Tran, M. and Hall, J. (2014) [Energy system impacts from heat and transport electrification](#). *Proceedings of the ICE - Energy*, 167, (EN3), 139-151. (doi:10.1680/ener.14.00008).
6. Blainey, S.P. (2014) [Construct or constrain? Intermodal inconsistencies in infrastructure interventions](#). In, *ITRC Conference on the Future of National Infrastructure Systems and Economic Prosperity, Cambridge, GB, 27 - 28 Mar 2014*.
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10. Cherrett, T.J., Shingleton, Duncan and Norton, Ben et al. (2014) [Developing a smartphone app to enhance Oxfam's supply chain visibility](#). *International Journal of Logistics: Research and Applications* (doi:10.1080/13675567.2014.980794).
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13. Grote, Matt, Williams, Ian and Preston, John (2014) [Direct carbon dioxide emissions from civil aircraft](#). *Atmospheric Environment*, 95, 214-224. (doi:10.1016/j.atmosenv.2014.06.042).
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19. Hammond, James (2014) [Child pedestrian road safety: practical training and interactive learning environments to improve road safety](#). *University of Southampton, Engineering and the Environment, Doctoral Thesis* , 266pp.
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31. Park, Ji Hong (2014) [Transport PPP decisions in Korea: value for money assessment and risk quantification](#). *University of Southampton, Engineering and the Environment, Doctoral Thesis*, 355pp.
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34. Preston, John (2014) [Editorial. Thredbo 13 workshops](#). [in special issue: Competition and Ownership in Land Passenger Transport (selected papers from the Thredbo 13 conference)] *Research in Transportation Economics*, 48, 3-8. (doi:10.1016/j.retrec.2014.09.025).
35. Preston, John and Almutairi, Talal (2014) [Evaluating the long term impacts of transport policy: the case of bus deregulation revisited](#). [in special issue: Competition and Ownership in Land Passenger Transport (selected papers from the Thredbo 13 conference)] *Research in Transportation Economics*, 48, 263-269. (doi:10.1016/j.retrec.2014.09.051).
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