ANNUAL REPORT 2017
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. This year we celebrated our 50th Anniversary with a "Pioneers Dinner" at Chilworth Manor Hotel, attended by Lois Williams, the wife of Professor Tom Williams, who founded the Group in 1967. This was followed by an event held at our Boldrewood Campus on 10th July to which all past visitors, research students and staff were invited.

Pioneers of TRG attending the Dinner

Presentation by Emeritus Professor Mike McDonald, who joined Professor Williams at TRG in September 1967

You can't have a celebration without cake...

Enjoying the band at the social event at the end of the day

TRG 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). TRG is located at the University's Boldrewood Innovation Campus where the £46 million National

Infrastructure Laboratory is currently under construction (see below).

Artist's Impression of the National Infrastructure Laboratory at Boldrewood

This report covers the research activities within TRG during the calendar year 2017.

TRG academic staff members during 2017 were:

- John Preston, Professor of Rail Transport and Head of TRG
- Nick Hounsell, Professor of Highways and Traffic
- Neville Stanton, Professor of Human Factors in Transport
- Tom Cherrett, Professor of Logistics and Transport Planning
- Mike McDonald, Emeritus Professor of Transportation Engineering
- Ben Waterson, Lecturer specialising in modelling and simulation
- Simon Blainey, Lecturer, specialising in rail transport and modelling.
- Ioannis Kaparias, Lecturer in transportation engineering.
- Bani Anvari, Lecturer, specialising in intelligent mobility
- Katie Plant, New Frontiers Fellow in Human Factors Engineering.

Research Staff in TRG throughout 2017 included Dr John Armstrong, Dr Craig Allison, James Brown, Dr Milan Lovric, Adrian Hickford, Fraser McLeod, Dr James Pritchard, Dr Kirsten Revell, Dr Aaron Roberts and Dr Alan Wong. We welcomed Dr Vicky Banks, Dr Matt Grote, Dr Forough Goudarzi and Dr Bo Gao.

During the year, we said farewell to Gavin Bailey, Louise Coutts, Alejandro Ortega Hortelano, Alex Eriksson, Dan Heikoop and Nick Hounsell (who retired in October). Their research activities are summarised in later paragraphs. **Technical Staff** supporting TRG include Karen Ghali and Daniel Fay with Kiome Pope, Peter Moore and Chris Fenton arriving during the year. Melanie Hallford continued in her role as **Senior Administrator** for the Group, aided by Kelly Carter, with Joy Richardson as administrator for Human Factors projects.

We 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 Alan Stevens of TRL (Transport Research Laboratory); Professor Julian Hine of Ulster University; Professor Mike Browne (Professor of Industrial and Financial Management & Logistics), University of Gothenburg; Professor Johan Woxenius (Professor of Industrial and Financial Management & Logistics), University of Gothenburg; Professor David Jeffery; Dr John Walker; Dr Terence Bendixson, Dr John Schoon, Dr Simon Box and Dr Birendra Shrestha.

We also had over 30 students attached to the Group undertaking PhD or EngD (Engineering Doctorate) research in transport. In 2017, PhD degrees were awarded to Siti Ab Karim, Yuji Shi, Shashank Gupta, Alex Eriksson and Chris Osowski, with Jennifer Ogawa and Matt Grote being awarded an EngD.

Postgraduate teaching continues to be an integral part of TRG activities, particularly the MSc in Transportation Planning and

Engineering. Some 33 new students enrolled in September 2017, both full-time and part-time.

Overall, we have maintained a healthy portfolio of research in 2017. By the end of the year, our research grants and contracts had a total value of over £10 million, with over £4 million of this from EPSRC.

TRG facilities include:

- SUDS (Southampton University Driving Simulator), located in Building 176 at Boldrewood and equipped with a Land Rover Discovery (see below).

The Southampton University Driving Simulator (Mark 2)

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

The TRG Instrumented Vehicle.

- Our 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.

The ComTET Submarine Control Room Simulator

Outreach

In 2017, TRG was again active in delivering high impact public engagement and outreach events and activities, under the coordination of Dr Ben Waterson and Dr Alan Wong. This included:

- Being part of the core team which oversaw the University's Science and Engineering Festival, which attracted over 7,000 visitors from all over the region this year, and included public demonstrations of the driving simulator lab (see above) and TRG's rail research capability;
- providing interactive research activities to engage the public at the South Downs Green Fair, the local Bitterne Park 'Riverfest' community festival, the Cheltenham Science Festival, Bristol Festival of Nature, and BBC Countryfile;
- running Researchers' Cafés sessions for the University, which highlighted the research being conducted by early-career researchers and postgraduate students;

- continuing to act as the Faculty Champion for the Three-Minute Thesis (3MT) Competition, to improve the science and research communications skills of postgraduate students;
- establishment of a (Southampton) Future Cities Community Engagement Hub, involving several cross-discipline University research groups as well as the central Public Engagement with Research unit, for which a series of outreach events and activities during 2018 is planned (as part of the Metamorphosis project - Section 3.6).
- Our Outreach activities include demonstrations based on Scalextric and Model Train sets.

TRG's Model Train Set at the University's Science and Engineering Festival.

2. EXTERNAL ACTIVITIES

The following sections summarise the range of external activities undertaken by TRG Academic Staff members in 2017:

John Preston:

- Member of the EPSRC Peer Review College
- External examiner for Master's level courses at Cardiff and Leeds 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.
- Workshop Chair at the 15th International Conference on Competition and Ownership in Land Passenger Transport, Stockholm, 13 - 17 August 2017.
- Member of the Future Traffic Regulation Optimisation (FuTRO) Project Control Board and the Vehicle/Train Control and Communications Systems Interface Committee.
- Winner of the 2017 William W. Millar Award for the best TRB paper in the area of public transportation (with J. Pritchard and B. Waterson).
- Editorial Board Member: Journal of Transport Policy.

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
- Chair 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

Neville Stanton:

- Associate Editor. IEEE Transaction on Human-Machine Systems
- Member, Editorial Board, Ergonomics
- 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 Bachelor and Master level degrees in Occupational Health and Safety at the National University of Ireland, Galway.
- Chair of the Honourable Company of Air Pilots and the Air Pilots Trust Annual Aviation Safety prize
- Chair of the fifth International Conference on Human Factors in Transportation, 22-26 July, 2017, Orlando, USA.
- Scientific Committee of the 11th International Conference on Naturalistic Decision Making (NDM-2017) held in Bath, UK, June 20-23, 2017
- 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
- 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.
- Opening Plenary Keynote speaker at the 8th International Conference on Applied Human Factors and Ergonomics (AHFE2017) in Los Angeles, USA (17-21 July, 2017).
- Plenary Keynote speaker at the 10th Congress on Work, Organizational and Business Psychology of the German Psychological Society 2017 in Dresden (13-15th September).

Mike McDonald:
- Transport Research Foundation Fellow.
- Visiting Professor at Ningbo University, China.
- Advisor to the EC WIKI project dealing with the implementation advice for transport innovations.
- 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.

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).
- External Examiner; UG Logistics and Operations Management courses at Cardiff University (2017-2021).
- Invited witness to the Transport Select Committee's session on Urban Congestion 30/1/17.

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

Simon Blainey:
- Secretary of the Royal Geographical Society's Transport Geography Research Group.
- Member of the Rail Research UK Association Executive Committee.
- Member of the Governance Board for the Data Analytics Facility for National Infrastructure (DAFNI)
- Member of the EPSRC Associate Peer Review College.
- External examiner for MSc, BSc, DipHE and CertHE courses in Railway Operations Management, Glasgow Caledonian University

Ioannis Kaparias:
- Honorary Lecturer at the Department of Civil and Environmental Engineering of Imperial College London.
- Independent expert for the European Commission on research and innovation activities, acting as an evaluator of proposals and reviewer of running projects for the FP7 and Horizon 2020 programmes
- Commissioned by Atkins and Connect Plus Services to carry out an independent technical assessment of the M25 mobile-phone-based travel time monitoring system
- Elected member of the Executive Committee of the UK Universities'

Transport Study Group (UTSG), acting as Honorary Treasurer
- Member of the US Transportation Research Board's Standing Committee on User Information Systems (AND20)
- Deputy Editor-in-Chief of the IET Intelligent Transport Systems journal (Institution of Engineering and Technology)
- Member of the editorial board of the "Recherche Transports Securité" journal (NecPlus)
- Member of the scientific committee of the 8th International Conference on Transportation Research in Greece, 27-29 September 2017, Thessaloniki, Greece

Bani Anvari:
- Contributed to the Pedestrian Dynamics: Modeling, Validation and Calibration Conference, Brown University, Providence, 21st-25th August 2017.

Katie Plant:
- Associate member of the Chartered Institute of Ergonomics and Human Factors (CIEHF)
- Associate Editor for Human Factors and Ergonomics for Manufacturing and Services Industries journal
- Technical committee member for the Fifth International Conference on Human Factors in Aviation Transportation, 17-21 July, 2017, Los Angeles, USA
- External Examiner for PhD thesis for University of Sunshine Coast, Australia

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 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 2017 within different topic areas. Research titles listed in **blue** represent contract (funded) research, whilst those in **green** are studies by Postgraduate Research students (PhD, iPhD or EngD).

3.1 Traffic Operations and Safety Management

Transport Systems Catapult: University Partnership Programme

(TSC from 2015 to 2017) Dr B. Gao, Dr A. Wong, Dr B. Anvari, Dr I. Kaparias. *Contract Holder:* Prof N.B. Hounsell.

The Transport Systems Catapult (TSC) set up a Universities Partnership Programme (UPP) in 2014/15, involving eight Universities actively working in Intelligent Mobility (IM) and who cover the different geographical 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, where one major activity at Southampton is the development of a traffic control testbed using open source software. The aim here is to support the evaluation of new traffic control strategies in traffic streams containing connected and autonomous vehicles. See www.tscatapult.org.uk

Traffic Lights: Harnessing Distributed Control Intelligence

(WebScience Institute and CobaltOtter, November 2016-July 2017). *Contract Holder:* Dr B.J. Waterson.

Modern urban traffic light control systems control thousands of traffic signals, but their core algorithms are based on first principles developed in the early 1980s.

In many cases therefore they cannot reflect modern trade-offs between delays to different vehicle streams. While it is often shown that humans can out-perform current algorithms for a single road junction, the interactions between people controlling close proximity junctions where the decisions of one controller affect the situation faced by others, has never been formally investigated.

The Web enables users to experience issues from new standpoints, and researchers to understand how users respond in such situations, both individually and collectively. This project therefore creates a proof-of-concept of an interactive traffic simulation where road junctions are simultaneously and independently controlled by multiple humans in real time. Providing players with a bird's eye view of approaching vehicles enables them to experience the complexity of balancing everyone's needs at a junction, not just their own desires; analysing the red/green light decisions that they want to make in response to this view enables a better understanding of their priorities and what they perceive as a 'fair to all' system; and recording communications and interactions between users controlling adjacent junctions will form the basis of research into the next generation of real life traffic light control algorithms.

STARS: Socio Technical Approach to Road Safety. NIHR Global Research Group on Global Road Safety (National Institute for Health Research, August 2017 to July 2020) Dr R.C. McIlroy**.** *Contract Holders;* Prof N. A. Stanton, Dr K.L. Plant, Dr B. Anvari, Prof J. Preston, Prof. C. Deakin (Medicine), Prof P. Roderick (Medicine), Dr G. L. Yao (Medicine).

Low- and Middle-Income Countries (LMICs) see more than twice as many road traffic fatalities (per head of population) compared to high-income countries. Whilst these countries represent 82% of the global population, they are home to only 54% of the world's registered motor vehicles. The overall goal of our Global Health Research Group (GHRG) is to reduce the number and severity of road accidents in LMICs through our underpinning philosophy of "local solutions for local problems".

The GHRG has the University of Southampton collaborating with a least developed country (Bangladesh via Bangladesh University of Engineering and Technology), a low-income country (Kenya via Strathmore University), a lower-middle income country (Vietnam via National University of Civil Engineering), and an upper-middle income country (China via Tsinghua University). Using tried and tested human factors and sociotechnical systems methods we seek to capture the current challenges facing these countries and, in collaboration with our LMIC partners, develop and evaluate relevant and realistic solutions.

Reappraisal of Cost Benefit Analysis Through Improved Traffic Demand Forecasting Reflecting Motorway Geometry including Tunnels (funded by the Korean Government, PhD Studentship from September 2016), Sungbae Yoon. *Supervisors:* Prof J.M. Preston, Dr I. Kaparias.

Traffic demand forecasting in South Korean Cost Benefit Analysis (CBA) assumed that all planned roads will have level terrain even though 70% of Korea's land mass is covered with mountains. In other words, traffic demand forecasting that is independent of unusual road geometry could affect the result of CBA

because it will lead to inaccurate travelling time predictions.

The aim of this study is therefore to improve the accuracy of CBA by developing a new traffic demand forecasting model considering a hilly road with a tunnel, which is one of the most common configurations in South Korea. As a result, this study has the four detailed objectives as below:

- To identify the different traffic characteristics for motorway tunnel segments.
- To develop a new traffic demand forecasting model by calibrating volume delay functions.
- To validate the newly developed model.
- To reappraise the past results of CBA.

Improving Automatic Incident Detection Algorithms (ESPRC and Siemens, PhD Studentship, from July 2016). Jonny Evans. *Supervisors:* Dr B.J. Waterson, Prof T.J. Cherrett (University of Southampton). *Industrial Sponsor:* Dr Andrew Hamilton (Siemens).

Incidents are events that disrupt the normal flow of traffic such as vehicle impacts, breakdowns, illegal parking/unloading and emergency roadworks. They cause significant costs to road network users in the form of delay, vehicular damage, air pollution and personal injury.

Automatic Incident Detection algorithms (AIDAs) have been developed to analyse traffic data, and inform users of potential incidents on the road network. However, many AIDAs fail to differentiate between an incident, and recurring congestion (e.g. from major events or rush hour). This project seeks to improve AIDAs by understanding the context surrounding the traffic data.

A machine learning algorithm will be created that can learn the patterns between the traffic state and context by analysing historical data. An AIDA with this insight will then be able to raise alerts to Transport Operators more quickly and with less false alerts, ultimately aiding in mitigating the consequences of incidents on the road network.

The Improvement of Bus Networks Based on GIS Technology (PhD Studentship, from October 2013 – Awarded 2017).Yuji Shi. *Supervisors:* Dr S.P. Blainey, Prof N.B. Hounsell.

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, privatisation and bus deregulation have contributed to some problems concerning bus network structure, fares, demand, and service quality. The aim of this research project was 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. This service improvement problem was solved by making use of an optimisation technique, the tabu search algorithm, developed under the environment of ArcObjects for Java.

3.2 Energy & Environment

Alternative Fuel Feasibility Assessment (Southampton City Council, from October 2017 to October 2018). Dr M. Grote. *Contract Holder*: Prof T.J. Cherrett.

The aim of the Alternative Fuel Feasibility Assessment project is to support

Southampton City Council (SCC) in the development and adoption of an Electric Vehicle Action Plan (EVAP) setting out the infrastructure requirements to support the uptake of Electric Vehicles (EVs) across the city over the next five years, and of a Fleet Replacement Plan (FRP) setting out the requirements for the modernisation of the Council's own vehicle fleet.

The project consists of a set of discrete tasks agreed with SCC according to their priorities. The first task involves analysis of the provision of residential EV charge points in urban areas where residents do not have access to off-street parking for over-night charging, and identification of trial areas for provision of such charge points in Southampton. The next task comprises calculation of baseline figures for the number of EVs using Southampton's road network and car parks to provide a basis for undertaking future, repeat assessments of the situation. Other tasks include: development of a methodology for monitoring the charge point network to provide a guide for future investment in network expansion beyond the 5-year timescale of the EVAP; establishing reasonable targets for the EVAP by comparison to what has been achieved by other Local Authorities; and reviewing the success (or otherwise) of initiatives designed to produce behaviour change in terms of switching from conventional vehicles to EVs. Tasks in support of the FRP include: providing evidence to support the target of at least 20% of the Council's fleet comprising of zero emission EVs by 2020; and assessing the infrastructure requirements and procurement options for alternatively fuelled (e.g. natural gas or hydrogen) Heavy Duty Vehicles within the Council's fleet, with provision for other key organisations and fleet operators (e.g. the city's bus operators) where opportunities for collaboration arise.

Centre for Sustainable Travel Choices (DfT Access Fund, through SCC in conjunction with British Cycling, Cycling UK, Hampshire County Council and Sustrans, from April 2017 to March 2020). Dr A. Wong, A. Hickford, K. Ghali; *Contract Holder*: Prof J.M. Preston.

The Centre is a partnership that aims to promote local sustainable and active travel, whilst suppressing private car use. This project continues the collaborative work initiated originally through the Local Sustainable Transport Fund. TRG is leading on the monitoring and evaluation of physical interventions and travel behaviour change as part of Southampton and Hampshire Councils' 'cycling ambition' plan for promoting active travel, in particular cycling, into local towns, schools, colleges and workplaces. This is with the aim of developing a sustainable travel culture that enriches lives, provides realistic travel choices, and tackles the pressing air quality problem in the Southampton region. The major schemes planned include the development of wholly or partly segregated cycling 'Freeways' running from the centre of Southampton northwards towards Eastleigh and Chandlers Ford, westwards towards Redbridge and Totton, and eastwards towards Botley and Hedge End. This is part of a wider 10-year cycling strategy (from 2017) to develop a Southampton Cycle Network that also includes cycling 'Cityways' linking other parts of town.

Towards a Verifiably Robust Cycle Microsimulation Model (EPSRC DTC PhD Studentship, from October 2012 – Awarded 2017). Chris Osowski. *Supervisors*: Dr B.J. 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 developed and validated 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 - Awarded 2017). Matthew Grote. *Supervisors*: Prof I.D. Williams (Centre for Environmental Science), Prof J.M. Preston, Prof 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 has developed a new EM that can predict emissions from road traffic at the 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, induction loop data on vehicle traffic operations have been collated and data on over 500 GPS based driving cycles have been collected. A Practical Emissions Model for Local Authorities (PEMLA) has been calibrated and tested.

3.3 Freight & Logistics

Freight Traffic Control 2050 (Transforming the Energy Demands of Last-mile Urban Freight Through Collaborative Logistics) (EPSRC, from 2016 to 2019). F.N. McLeod, K. Ghali. *Contract Holder:* Prof T.J. Cherrett.

With van traffic predicted to increase by 20% in London by 2030, and slow uptake of electric or alternatively-fuelled goods vehicles, more radical strategies are needed to reduce the numbers and impacts of freight vehicles in our cities. Working with some major parcel carriers in London, this project is examining the potential for closer operational collaboration between carriers to reduce urban traffic and energy demand. This is expected to be done whilst maintaining customer service levels, and evaluating to what extent such relationships can develop naturally within a commercial setting or whether a third-party 'Freight Traffic Controller' would be needed to ensure equitable distribution of demand

across a city. A further aspect of collaboration being trialled is the concept of 'portering' whereby the parcel carrier delivers bags of parcels to roadside porters who make the final deliveries. This would replace the existing practice where the carrier's vehicle is typically parked for 70% of the time while the carrier is walking to, and spending time at, delivery points. Portering would make more efficient use of vehicles and would release valuable kerbside space.

Delivery and Service Plan Project (Southampton City Council, from 2014 to 2017). Dr Gavin Bailey, *Contract Holder:* Prof T.J. 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 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 leads to the generation of orders and freight activity.

To date, this project has engaged with and delivered DSPs for 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 and West Quay Shopping Centre. Notable ongoing works are as follows:

NHS Isle of Wight (IoW) Trust: The key recommendation for the NHS IoW Trust was the implementation of mainland consolidation for all goods-in, with an integrated delivery round to distribute medical supplies to the main hospital (St Mary's), and the outlying clinics on the island. The concept, which represents the first of its kind in the UK, is currently under negotiation, and would use the local council funded Sustainable Distribution Centre (SDC) located outside of Southampton City on the M271.

University Hospital Southampton NHS Trust: Following the DSP recommendations issued to the University Hospital Southampton NHS Trust (UHS), the University of Southampton has provided continued support and research into the development of a sustainable medical supply for the hospital, including: economic and environmental appraisals for the consolidation of medical goods, assessment of the benefits that could be achieved through the offsite location of

outpatient pharmacy services, and usability assessments for hospital storerooms to identify key areas for improving the management of inventory.

The aim of these measures is the cumulative reduction of freight travelling to and from the hospital, thereby reducing the volume of vehicles on Southampton's urban freight network, and improving local air quality.

Sustainable Fleet Management: As part of ongoing internal DSP assessments at Southampton City Council a review of the council's vehicle fleet has been undertaken. This work audited the current utilisation of the council's vehicle fleet, and identified and appraised the use of electric vehicles for council services ranging from internal couriers, to parking wardens and service engineers. The output of this research was recommendations for adopting electric vehicles and related infrastructure to enable their implementation within specific areas of the council's fleet operations.

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

The CITYLAB project has adopted living lab methods (joint stakeholder co-operation and innovation) to test various freight initiatives in the cities of Amsterdam, Brussels, London, Paris, Oslo, Rome and Southampton. In Southampton, the overriding objective has been to improve air quality along key transport corridors. Focus has been on large municipal organisations such as Southampton General Hospital, Southampton City Council and Southampton's two universities to investigate opportunities for joint procurement and consolidation of goods to reduce environmental impacts. The Southampton Sustainable Distribution Centre at Nursling, operated by project partner Meachers Global Logistics, has offered a consolidation service, with take up from the hospital for temporary storage and transportation of automated dispensing units and current planning for consolidation of pharmacy goods transport. Consolidations of items delivered to student halls of residence were investigated in case studies although not implemented. Citylab partner Southampton City Council is actively contributing to air quality concerns by putting in place a plan to switch a significant proportion of its own-operated vehicle fleet to electric vehicles, with the first six vehicles arriving in January 2018.

Improving the Productivity of Rural Farmers: Understanding the Scope for Collective Supply Chain Management in Thailand (PGR student, from October 2017) Korawit Fakkhong. *Supervisors*: Prof T.J. Cherrett, Prof J.M. Preston.

The transportation sector plays a vital role in supply chain management by enabling products to be situated in the right place at the right time to meet ever more stringent customer requirements. This is no more prevalent than in Thailand's food industry which is substantially export-dependent, representing one of the main contributors to the country's income. It has recently faced considerable competition from other regional markets with local food producers suffering due to perceived inefficiencies in the local supply chain.

This research aims to investigate the opportunities for improving the logistics of food supply from rural farmers in Thailand into the main export routes and how market opportunities can be increased as a result. Integrated agro-industrial parks

and collaboration models will be used to investigate how different transportation and distribution approaches could improve overall logistics performance, as well as businesses opportunities for rural farming communities.

Capacity and Demand Assessment Models for Container Ports (SMMI PhD studentship from January 2016). Manuel Buitrago. *Supervisors*: Prof J.M. Preston, Prof T. Bektas (Management).

This research project develops new maritime transport models to assess capacity and demand for container seaports in the United Kingdom. These consider competition both in terms of long- and short-haul maritime transport and in terms of hinterland transport within the UK.

The project helps to understand better the role that the UK's port system plays in global logistics networks. The geographical scope comprises initially the British ports. Nevertheless, the models will be applied in a later stage to the Hamburg–Le Havre range seaports, examining how they compete for traffic in heavily contested hinterlands.

In addition, demand side modelling will be used to determine supply-side responses within the system of systems modelling framework developed by ITRC-Mistral. Container throughput capacity will be assessed by considering navigation channels, berths, cranes, storage and onward links.

3.4 Future Technologies

SMArt CitIES Network for Sustainable Urban Futures (SMARTIES Net) (ESRC Newton Fund from May 2016 to April 2017). *Contract Holder:* Dr S.P. Blainey

This multi-institutional project, led by the University of Nottingham, brought together a team of academics and policy makers from the UK and India to create a Smart Cities Network which developed future thinking and new approaches to increase the sustainability of selected cities in both countries. Through networking events, workshops and entrepreneur competitions it focused on addressing the big issues faced by urban planners and governors including traffic congestion, affordable housing, the provision of accessible, resilient and future-proof infrastructure for clean water and sanitation, transport and energy, and waste management and recycling while ensuring all citizens have equal access to, and participation in, a city life which is safe, secure, inclusive, healthy and desirable. It aimed to forge a sustainable community of researchers to develop innovative, future-proof and locally-acceptable solutions to the challenges faced by cities in India and the UK. TRG provided strategic transport modelling expertise to this network.

Incorporating a Structured User-Centred Design Process in Mobile Apps for Transportation (Innovate UK and EPSRC under the KTP scheme, with City University London and Cubic Transportation Systems, from October 2016 to August 2017). *Contract Holder*: Dr I. Kaparias.

Digital journey planning has become an important part of the travel experience. Increased proliferation of mobile devices, coupled with transport data being made available by authorities under an 'open access' model, has created a multitude of websites, apps, and technological platforms that are used by travellers. In particular the use of mobile apps is increasingly becoming a key component

of mobility, with travellers and operators alike recognising their benefits in making trips quicker and more efficient.

Product design is central to this trend, and has been recognised as an important means to improving customer experience. A widely used design approach in the computer science field is the so-called “User-Centred Design” (UCD), which places end-user needs, rather than engineering goals, as the starting point and as the central driver of system design requirements. UCD also defines an iterative process, through which these user needs can be embedded into both system functionality and user interface. When it comes to the development of transport mobile apps, however, examples of a structured, well-defined UCD process are rare, with the approach adopted usually being largely “ticket-oriented” and often prioritising system interoperability and the demands of numerous stakeholders over the needs of end-users.

The objective of this project was to create a mobile transportation app prototype within a structured and methodical UCD process in order to give user needs a more central role in the design. This approach holds the potential to make digital services, such as journey planning, more responsive to user habits and needs, as demonstrated in other domains such as healthcare and e-commerce. This in turn will make user interactions more efficient, benefitting the individual traveller, but also the transport system as a whole.

Green Adaptive Control for Future Interconnected Vehicles (G-ACTIVE) (EPSRC from March 2016 to February 2019). Dr C. Allison, Dr F. Goudarzi. *Contract Holders:* Prof N.A. Stanton, Dr B. Anvari

The project targets a significant reduction in fuel consumption, CO_2 and NOx emissions in passenger and light duty road vehicles. This will be achieved by implementing new Energy Management control systems that are inclusive, predictive and adaptive. This has been investigated through the application and development of car following models and human factor methods.

Collecting and Analysing Traffic Data through Drone Vision (Associate Dean Research Fund, July to December 2017). *Contract Holders:* Dr B. Gao. Dr B. Anvari, Prof J.M. Preston, Prof S. Prior (Aero and Computational Engineering) and Dr J. Hare (Electronics and Computer Science).

This project investigated the potential benefit of using Unmanned Aerial Vehicles (UAVs) equipped with Computer Vision software in the development of future Intelligent Transport Systems (ITS). In particular, a drone was used to collect traffic count and speed data at sites in Milton Keynes and Southampton and the concept of the virtual induction loop was developed.

Addressing the New Reality of Vehicle Automation in Highway Design (sponsored by the EPSRC Sustainable Infrastructure Systems CDT, iPhD studentship from September 2017). Hameed Jehanfo. *Supervisors:* Dr I. Kaparias and Prof J.M Preston.

Since the first mass-produced cars entered the open market in the early 20th century, transport technology has developed considerably. Whereas early vehicles had zero automation, there are now vehicles fitted with equipment to carry out automatic braking, lane-keeping and speed-control.

In the last decade, there has been a drive towards automating more, and eventually all, driving tasks. Several trials and research studies have taken place around introducing Connected and Autonomous Vehicles (CAVs) onto public roads. This, coupled with progress made in developing and testing technologies, has engendered confidence in policy-makers to accept the imminence of this transport revolution. In his 2017 Autumn Budget, the UK Chancellor of the Exchequer announced that self-driving vehicles will be allowed on British roads by 2021.

Although current highway standards still rely on 100% driver input, CAVs will reduce or exclude human control of driving tasks. This shifts the dynamics of road engineering principles, which draw on driver psychology and morphology. Introducing CAVs will impact on fundamental highway parameters such as visibility, headways and reaction times. A review of design standards is overdue as a result of partial automation on our roads now. With full automation on the horizon, this research will assess the potential for revising design standards for various degrees of vehicle automation.

Designing Public Transport Travel Information that Meets the Travellers' Information Needs, According to the Fourth Rule of Citizenship (sponsored by EPSRC and Southampton City Council, EngD studentship from October 2013,) Amanda Haylett. *Supervisors:* Prof T.J. Cherrett, Dr G. Wills (Electronics and Computer Science)

In 1977, The National Consumer Council expressed that among the rules of citizenship, information provision must conform to two fundamental principles; (1) continuous access to information to assist in the decision making process and (2) the necessary support and advice that can convert that information into effective action. In line with this particular rule of citizenship, the aim of this research is to stipulate the best approach for satisfying this fourth rule. To do this the research will breakdown what travel information is, how it has developed in light of rapid technological advancement in delivery. Moreover, it will draw conclusions on how well we are meeting this fourth rule of citizenship through present day travel information provision techniques such as journey planners. The outcome of this research will be the production of specific travel information delivery standards to both ratify present day solutions, and improve future information delivery strategies.

Electric Vehicle Drivers and their Use of Digital Media (part-time PhD, from December 2013). Farah Alkhalisi. *Supervisors*: Dr B.J. Waterson, Prof 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'. Although 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). Richard Deacon. *Supervisors*: Prof J. Preston, Prof T. Cherrett.

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). Luke Hutchinson. *Supervisors*: Dr B.J. Waterson, Dr B. Anvari. *Industrial Sponsor*: Transport Research Laboratory.

Wireless Power Transfer offers a viable means of charging Electric Vehicles (EV) whilst in a dynamic state, mitigating issues concerning vehicle range, the size of on-board energy storage and the network distribution of static based charging systems. Such charge while driving technology has the capability to accelerate EV market penetration through increasing user convenience, reducing EV costs and increasing driving range infinitely, dependent upon sufficient charging infrastructure. While much research has taken place examining the optimal location distribution of traditional (plug-in) charging points, 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 optimise the distribution of both wireless charging systems and plug-in charging stations within the network. The project also intends to identify the potential of the dynamic charging situation, how it could be implemented into the existing charging infrastructure, and the issues that could be encountered during deployment. The interaction environment between the driver, vehicle and infrastructure has been identified as the key component of the system and achievable energy transfer efficiencies are dependent upon such aspects. Further exploration of these factors, both as individual entities and as a wider concept, will be undertaken to assess methods that can be applied, considering

the global aim of maximising transfer efficiency.

Integrating Automated Vehicles into the Transport Network (EPSRC CDT in NGCM Studentship from September 2015) Craig B. Rafter *Supervisors*: Dr B. Anvari, Dr B.J. Waterson. *Industrial Sponsor*: Transport Research Laboratory.

Recent government investment in driver-less car trials is accelerating us towards a future of greater automation in the transport network. As a direct result of this investment, investigating how transportation infrastructure can sustainably support high numbers of automated vehicles in the network is imperative.

Existing transportation infrastructure is designed around non-automated vehicles. This includes not just the road-space, but also the many thousands of traffic sensors, the control infrastructure (traffic lights, variable speed limits), the refuelling infrastructure and the integration between modes of transport (airports, train stations etc.). This research investigates strategies to redesign infrastructure to support automated vehicles and deliver improvements in sustainability.

This research considers scenarios ranging from low to high numbers of automated vehicles in the transportation network using computational modelling, and experiments on simulated and instrumented vehicles. Ultimately, the outcome of this research will be innovative new designs to transportation infrastructure - with a strong evidence base - that will support automated vehicles to maximize sustainability in the transport network.

Low Cost, Infrastructure Free Forms of Indoor Localization (PhD Studentship, from January 2012 - Awarded 2017) Shashank Gupta**.** *Supervisors:* Dr S. Box, Prof R. E. Wilson (Bristol University)

Despite innovative research in indoor positioning, mainstream applications are rare. In trying to trace why this is the case, two main reasons were identified: (1) an indoor positioning application may require aisle-level precision (2) while such precision is attainable with pervasive radio based systems such as Wi-Fi, 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 the use of smartphones in this research. Primarily this research investigated 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 developed an understanding of the movement pattern of pedestrians by collecting and analysing the smartphone's sensory signals. Various machine learning algorithms were 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.

Transport and the Grid: Integrating the Charging of Electric Vehicles (EPSRC DTC EngD Studentship, from September 2013). Steve Broderick *Supervisors*: Dr B. Waterson, Dr A. Chipperfield. *Industrial Sponsor*: Scottish and Southern Energy.

The rapid integration of Electric Vehicles (EVs) (substituting cars in the transport system) raises significant questions as to the means and manner by which they charge. The concern regards the UK domestic Low Voltage (LV) network. The network was not designed to support transport load – which, with home charging, it now must do. Some networks are already known to be incapable of supplying EV populations beyond several 10's of percent.

Modern Electric Vehicles have many control options, yet a holistic simulation of large populations connected to the LV system is not presently available.

A goal of this study is to construct a realistic simulation tool, modelling EV and other electrical dynamics (primarily the supply of pre-existing electrical loads). The EV model includes EV characteristics and battery state, travelled distances and timings, driver charging connection habits and expectations of future trips.

The work is focussed on a real-world UK LV network and explores the capabilities/ constraints on the system. Charging control options and methods will be assessed, so to best satisfy conflicting load demands.

The output of the study will include a simulation tool, key learning points and an assessment of options to manage the electrical network, given a growing EV population.

The work has relevance for countries which use a substation-fed LV (230 V) domestic power system and allow EV charging at home. This includes most of Europe, India and other countries.

3.5 Rail

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

This programme grant follows on from the previous research programme Track21 project, and will involve further research based on some of the key outputs from Track21, as well as addressing additional research questions with the aim of delivering improved railway infrastructure performance. As train frequencies and speeds continue to increase over time, railway track is being more intensively used, which leads, in turn, to increased maintenance requirements. Combined with the urgent need to reduce the railway system's costs and environmental impacts this places great pressure on railway infrastructure operators. Alongside this, it will also be necessary to mitigate the impacts of climate change on railway track systems, with coastal railways potentially particularly vulnerable in this regard.

In order to help the rail industry tackle these challenges relating to track maintenance and performance, T2F is addressing three key research challenges. The first is to develop low maintenance and long life track systems with optimised use of materials. The second is to design crossings and transitions so as to optimise vehicle behaviour and consequently maximise

the service life of trains, and the third is to develop an integrated approach to the design of low-noise and low-vibration track. TRG's contribution to the project involves the calculation of the economic and environmental impacts of such interventions. This will involve working in partnership with Network Rail (with whom the University of Southampton has a Strategic Partnership), and with other T2F researchers at the universities of Southampton, Birmingham, Nottingham and Huddersfield. Work so far has focused on life cycle cost and carbon modelling of the installation of under-sleeper pads on two UK case study routes, and of the use of fibre-reinforced ballast. Some work has also been undertaken comparing ballasted and non-ballasted track systems.

Developing Integrated Tools To Optimise Rail Systems (DITTO) (RSSB, September 2014 to September 2017). Dr J. Armstrong and Dr B. Anvari, Prof C. Potts (Maths), Prof T. Bektas (Management), Dr A. Kovacs (Management). *Contract Holder:* Prof J.M. Preston.

Building on the OCCASION project, DITTO continued the process of developing optimisation formulations, algorithms and processes that make better use of existing capacity without compromising service reliability. It was part of an industry wide initiative called FuTRO (Future Traffic Regulation Optimisation) and was related to the development of in-cab signalling and the adoption of the European Rail Traffic Management System (ERTMS). It had 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 involved a consortium of three Universities (Southampton, Swansea and Leeds), with industrial support from Arup, Siemens Rail Automation and Tracsis.

The work at Southampton focussed primarily on computer modelling. Analytical methods were developed to calculate capacity utilisation indices and relate these to the propagation of delays, with encouraging results. A stochastic version of the job shop scheduling algorithm was developed in parallel, to optimise train timetables by identifying and adding additional potential train paths. A dynamic simulation model, Trackula, developed by the University of Leeds and based on their car following model, Dracula, was used to adjust train running speeds in real time. This micro-simulation was linked to a macro-assessment of the network, originating with solutions to the Multi-Commodity Network Design Problem.

The outputs of these tools were integrated, and some of the results were demonstrated in public domain software called OnTrack developed by Swansea University, the primary purpose of which is to undertake safety analyses. The potential benefits of Artificial Intelligence and machine learning applications in the domain of railway traffic management were assessed. 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. The results of the work will be taken forward and developed further by the collaborating institutions individually and in further collaboration as opportunities arise.

Very Light Rail Shuttle Between Dudley's Tourist Attractions (RSSB from June 2016 to January 2017) *Contract Holders:* Dr M.J. Fernandes De Pinho Lopes (Infrastructure), Dr S.P. Blainey, Prof J.M. Preston, Prof W. Powrie (Infrastructure), joint with University of Warwick and industrial partners.

This research project undertook a feasibility study for a Very Light Rail shuttle service connecting three tourist attractions in Dudley: Dudley Zoo, the Black Country Museum, and the Dudley Canal Trust visitor centre. TRG work focused on passenger forecasting. The project was undertaken in conjunction with the University of Warwick and several industrial partners, with the study covering all aspects of scheme construction and operation. If constructed, this would be the first UK application of a number of technologies associated with Very Light Rail systems.

Improving Customer Experience While Ensuring Data Privacy ('DICE') (EPSRC, September 2016 to August 2019. Dr J. Pritchard. *Contract Holder:* Dr S.P. Blainey, jointly with University of Surrey, Loughborough University, and Royal Holloway University of London.

This project is investigating the trade-offs rail passengers might face between data privacy and improvements to the customer experience. Particular attention is paid to passengers with special journey requirements and to future ticketing systems. Research areas include: the development of an effective trust framework to enable customer control over data privacy; the development of data aggregation techniques which aid the provision of an improved customer experience without compromising data anonymization; testing the applicability of these frameworks and techniques to potential future ticketing solutions; developing use case scenarios for systems to improve the rail customer experience; and assessing the demand and environmental impacts of providing an improved customer experience enabled by these systems.

The current focus, working mainly with the team from Loughborough, is on analysing a set of customer complaints in order to ascertain the factors which can lead to a degraded customer experience, and understand how individual context can make a difference. This will help us to understand where knowing something about the passengers could help rail operators improve the customer experience. This will help build up a picture of where the potential trade-offs between data privacy and customer experience might lie.

Understanding Passenger Loadings and Providing Better Information (Govia Thameslink Railway (GTR), November 2016 – December 2018) Dr J. Pritchard, Dr K.M.A. Revell. *Contract Holder:* Prof J.M. Preston

This project builds on the earlier RRUKA funded work looking at the use of passenger loading data to influence behaviour and mitigate crowding. It is funded as part of Future Rail's TOC'15 initiative.

On the basis that providing better crowding data to passengers seems desirable, the first aim is to identify the most suitable data sources for counting passenger numbers. A range of data sources have been obtained, which vary in terms of accuracy, cost and other practical limitations (for example, not all sources can be read in real-time), and work is ongoing to assess their relative merits. It may be that an optimal solution is found by using some combination of the available data sources.

The second aim is to develop the methods used to accurately predict passenger loadings from the data available, developing algorithms and working with GTR's appointed developer to ensure that they can be implemented.

The final aim is to determine how best crowding information should be presented to the travelling public and to implement a small-scale trial in order to further assess the benefits.

A set of manual counts were commissioned by GTR in order to be able to calibrate a set of models, and regression models have been developed to estimate the number of people currently on a train from a number of factors, including the recorded weight of the carriages. A Minimum Viable Product (MVP) of the software package required to provide live estimations and predictions is currently in the testing and integration phase, whilst work is currently ongoing to develop the algorithms which predict how many people will be on a train in the future.

Crossrail Revenue Model Review (Transport for London, April – September 2017). Dr S.P. Blainey, Dr A. Ortega Hortelano, M. Young. *Contract Holder:* Prof J.M. Preston.

This research validated the processes by which Transport for London determined the Crossrail passenger demand and revenue forecasts. It then assessed the robustness of the Crossrail revenue model and established acceptable levels of tolerance using Monte Carlo Simulation techniques.

Improving Quality of Rail Service in Kuala Lumpur, Malaysia (PhD Studentship, from October 2008 - Awarded 2017). Siti Nurbaya Ab Karim. *Supervisors:* Prof J.M. Preston, Dr S.P. Blainey.

Passenger Boarding and Alighting surveys were undertaken to gauge optimal headway, optimal fleet size, optimal vehicle capacity and optimal pricing based on an economic optimisation approach. These optimisation models were used to produce 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 directions. This will provide an economically efficient operation and an adequate quality of service. 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.

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

This project is exploring the factors that influence railway station choice decisions

made by passengers, and applying 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. Using data from Scotland and Wales multinomial and mixed logit choice models of station choice have been developed. These models have then been incorporated into trip end station demand forecasting models. An application to the Borders rail line shows that these models lead to a substantial improvement in forecasting accuracy compared to conventional approaches.

Total Social Costs Associated With The Development of High Speed Rail Using Saudi Arabia as a Case Study (PhD from September 2016). Hamad Almujibah. *Supervisors:* Prof J.M. Preston, Dr S.P. Blainey.

With the increasing rate of economic development and urbanisation in Saudi Arabia, the application of new transport technologies, such as High-Speed Rail (HSR), Magnetic Levitation (Maglev), and Hyperloop, is being considered. The main aim of this research is to develop a general method to analyse the feasibility of different high-speed ground transportation technologies and to compare their forecast demand, as well as financial and social costs. This will be done by using a forecasting travel demand model, a total social cost model, and by determining the choice between modes by using a Stated Preference model. This thesis will focus on comparing transport technologies, to determine the best option that can be applied for a case study of Saudi Arabia. In this case, the objectives of the research are to compare HSR with existing technologies (airline, classic rail, road transport) and with alternative technologies (Maglev and Hyperloop). This will be to determine the total social costs of intercity travel by existing modes and by new modes such as HSR and Hyperloop, and to determine the circumstance in which HSR is the most appropriate mode for intercity travel (in terms of total travel time, total travel costs travel and service frequency. In order to achieve the objectives, there are some tasks which need to be done, such as reviewing the existing transport modes for Riyadh-Dammam Corridor in Saudi Arabia, with respect to costs, prices, levels of service, designing the SP questionnaire to gather data on preference of passengers on preferred transport mode for the Riyadh-Dammam Corridor, in terms of travel journey time, cost, frequency, etc.

Improving Pre-trip Information About Transfer-involved Rail Journeys (PhD from October 2013). Yiwei Guo. *Supervisors*: Prof J.M. Preston, Dr S.P. Blainey.

With the development of information and communications technology, rail passengers' experience of punctuality and reliability relies increasingly on the quantity and quality of the available passenger information.

Although passenger information is viewed as an important influencing factor on customer experience and rail patronage, the quality of the pre-trip information about certain transfer-involved, delay-sensitive routes (called Critical Routes) is often disregarded due to the limitations of current technologies. On the one hand,

the accuracy of pre-trip timetable information is prone to train delays and cancellations. On the other hand, real-time disruption alerts contribute little to the pre-planning of the transfer activities involved in a given journey and the relevant activities before and after the journey.

This research explores the possibility of enhancing the management of delays by improving the pre-trip information about transfer-involved journeys. A set of novel timetable-information algorithms and passenger-centric analytical methods are developed to provide technical solutions and to quantify the expected gains from these novel solutions. Empirical evidence from a number of identified Critical Routes (containing critical transfer-involved journeys) in British railways reveals the efficiency and effectiveness of the proposed methodology.

3.6 Transport and Infrastructure Policy

Metamorphosis (EU Horizon 2020, in partnership with SCC, from June 2017 to May 2020). Dr A. Wong. *Contract Holder*: Prof J.M. Preston.

This H2020 project consists of 13 consortium partners, including seven city authorities in the UK and Continental Europe, who are committed to transforming parts of their neighbourhoods from being car orientated to being child-friendly and community-oriented places. The partner cities were chosen to represent a wide variety of demographic and location characteristics, and each works with an academic or enterprise partner to take the lead for a different strand of the project, with the overall aim of improving quality of life, and the physical and mental health of their citizens. The seven cities are (1) Graz, Austria; (2) Meran, Italy; (3) Munich, Germany; (4) Tilburg, Netherlands; (5) Alba Iulia, Romania; (6) Zurich, Switzerland; and (7) Southampton, UK, with TRG taking the lead on the 'user analysis and involvement' work package. Each partner city has plans to implement a series of trials to encourage more 'child friendly neighbourhoods', to show what can be achieved, and build on the availability of shared space, play streets, living laboratories, crystallisation points, and use of other public spaces and associated interventions. This includes encouraging integrated planning that promotes walking and cycling (and sustainable travel generally) instead of using the car, as well as developing innovative approaches to local urban design, that engages both children and adults as stakeholders and participants in the development and building process, as well as enabling and simplifying city procedures for the planning and implementation of child friendly neighbourhood measures and activities.

UKCRIC Strand C: Data Analytics Facility for National Infrastructure (DAFNI) (EPSRC from April 2017 to March 2021). *Contract Holder:* Dr S.P. Blainey, jointly with eleven other universities.

DAFNI is a major UK facility which aims to advance infrastructure research. Based at Science and Technology Facility Council (STFC Harwell), DAFNI will host national infrastructure datasets and provide a complex system science driven platform for modelling, simulation and visualisation. These capabilities will be underpinned by the high throughput data interconnectivity and integrated high performance computing facilities required for multi-scale infrastructure system

modelling, linked with a unique national infrastructure database. DAFNI will be implemented and tested over the four year period from 2017 to 2021, enabling significant new advances in infrastructure research and facilitating access to tools and methods capable of addressing real-world challenges at a range of scales. It will therefore provide world-leading capability to support UK research, business and government in infrastructure systems analysis, modelling, simulation and visualisation. The University of Southampton is one of 12 partner institutions overseeing the delivery and management of the programme, with the university's input being provided by representatives from TRG.

A Review of Resilience in Interdependent Transport, Energy and Water Systems (Arup/Lloyds Register from March to June 2017). A.J. Hickford, Dr A. Ortega Hortelano, Dr R. Pant (University of Oxford). *Contract Holder:* Dr S.P. Blainey.

This project undertook a review of definitions, methodologies and current practice relating to resilience engineering and performance-based engineering in the energy, transport and water infrastructure sectors. A range of national and international programmes were discussed, and key gaps in theory and practice identified. The project was one in a series of scoping studies commissioned as part of the Arup/Lloyd's Register 'Resilience Shift' programme, which focused on developing understanding of how resilience is currently seen in engineering practice.

Multiscale Infrastructure Systems Analytics (MISTRAL) (EPSRC Programme Grant from January 2016 to June 2020). Dr M. Lovric, A.J. Hickford. *Contract Holders:* Prof J.M. Preston, Dr S.P. Blainey, Prof R. Nicholls (Energy and Climate Change), jointly with six other universities and industrial and government partners.

MISTRAL is phase 2 of the Infrastructure Transitions Research Consortium (ITRC), expanding the scale and reach of the NISMOD (National Infrastructure Model) system. ITRC's vision is for complex infrastructure decisions to be guided by systems analysis. Using the pioneering tools developed by the ITRC team, decision-makers are able to visualise and assess how all of their infrastructure systems are performing, help to pinpoint vulnerabilities and quantify the risks of failure. The tools are capable of performing 'what-if' analysis of proposed investments and exploring the effects of future uncertainties, such as population growth, new technologies and climate change. A key feature of the ITRC projects has been a high level of engagement with industry and government, and the modelling tools produced as part of ITRC and MISTRAL have been used by the National Infrastructure Commission to inform their National Needs Assessment.

Work at TRG is focusing on enhancing the transport models developed during ITRC phase 1 and developing novel transport models. This centres on building an integrated framework covering capacity, demand and risk, and incorporating a network-based representation of the British transport system. The scope of the model will also be extended to cover key international linkages. Tasks include generating a base year OD matrix for Great Britain, parameterising transport interventions and policies for inclusion in the model using the best available evidence, constructing a flexible network-based

national transport model, developing meta-models or emulators to represent local transport within this model, and integrating risk and resilience modelling into the wider framework.

TRG staff members are also involved in other MISTRAL work, together with researchers from the University of Oxford, and in collaboration with the United Nations Office for Project Services (UNOPS), aiming to adapt and apply the systems-of-systems infrastructure assessment capabilities and analysis tools for the application of evidence-based decision making in other international contexts, including developing countries, regions undergoing post-conflict or post-disaster recovery, and rapidly developing city-states. The initial focus was a 'fast-track' assessment of the infrastructure needs of Palestine, and a second assessment is now being undertaken for Curacao.

A Comparative Assessment of Public and Private Transport in Hanoi, Vietnam (funded by the Vietnamese Government and Faculty of Engineering and the Environment, PhD Studentship, from April 2017) Minh Tam Vu. *Supervisors:* Prof J.M. Preston, Dr S.P. Blainey.

Powered two wheelers (PTWs) are dominant in mixed traffic environments in developing Asian countries and in particular in Vietnam. Furthermore, their significance increases in urban areas, which poses a challenge to planning authorities and policy makers. A popular solution is to invest in urban public transport (PT) schemes such as Bus Rapid Transit (BRT), Urban Rail Transit (URT) and Monorail. However, many investments in PT have been ineffective. Additionally, there seems to be very little evidence on the comparative assessment of motorcycles, cars and public transport. Hence, the main aims of this research are to (i) analyse the feasibility of new PT technologies in mixed traffic environments with a dominance of PTWs and (ii) identify attributes of public and private transport systems, which can be considered to attract private vehicle drivers and passengers to use PT.
To achieve these aims, the research develops a comparative assessment for comparing public transport technologies and private transport for a local transport network. Comparisons among the existing conventional bus service, cars, motorcycles and a new innovative PT technology (such as BRT, URT or Monorail) are assessed using social cost models, multinomial incremental logit models and microscopic simulation models. These models can consider demand effects (such as trip generation and modal shift), congestion and environmental effects, as well as present these effects on the existing mixed traffic conditions.

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

Transport networks can be unavailable suddenly due to diverse causes like natural disasters or intended attacks, even though transport networks are ubiquitous infrastructures in a modern society. Malfunctioning transport networks may produce considerable travel costs from the perspective of the whole society as well as an individual traveller. The primary purpose of this research is to assess the vulnerability of

public transport networks with integrated analysis between railway systems and road networks in the Seoul Capital Area (SCA), Korea. Stated intentions concerning mode and route choice in the event of a disrupted Seoul Metropolitan Railway Systems (SMRS) were determined through an online survey. The impact of the disruptive event on the SMRS was identified using a TransCAD model that takes into account both the SMRS and the adjacent road networks. Based on in-depth interviews, this research also suggested management strategies to increase resilience of the transport networks in the SCA and to recommend a guideline to travellers in disrupted situation.

Future Funding for Highways (part-time PhD from January 2014) Katherine Tegerdine. *Supervisors*: Prof N.B. Hounsell, Dr S.P. 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:

1. 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;
2. Analyse and understand the cost and revenue implications of these road transport scenarios on Governments and road users;
3. Explore and develop new ways of funding transport infrastructure, including new ways of raising the revenue required to fund the scenarios presented, whilst identifying the impacts of this on all concerned;
4. Make recommendations to Governments on transport infrastructure funding requirements and revenue raising options and implications, on the basis of this research.

Objectives 1 and 2 have been completed, with research currently focussing on objective 3.

A Dynamic Analysis of the Economic Impacts of a Major Port on its City, South Korea (funded by the Korean Government, PhD studentship, from September 2015) Jongjoon Song. *Supervisors:* Prof J.M Preston, Dr S.P. Blainey.

This research aims to get a better understanding of the dynamic changes over time in terms of the economic impacts of the port industry, especially major container ports in South Korea.
To be specific, this study focuses on the changes in the economic impact of ports over time with particular reference to the regional economy. This research reviews the development history of four major ports in South Korea: Busan, Incheon, Gwangyang and Ulsan, focused on their spatial enlargement and functional progress. Based on an understanding of the development process, it analyses the changes of gross value-added (GVA) per worker in transportation from 1990 to 2015 from the regional accounts. This is done through applying shift-share analysis which has strengths in being able to understand the changes of a specific industry in a specific region compared to the sectoral changes in the national economy. This empirical analysis enables an understanding of how the economic performance in port-related industries has changed over time with

respect to both the national economy and the regional economy. From the results, this research will suggest the major characteristics in terms of the economic contribution of port industry and supply several recommendations for port policy in South Korea.

Modelling Land Use and Transport Evolution in Port Cities (sponsored by the Education Endowment Fund, Republic of Indonesia, PhD studentship, from September 2016) Aditya Tafta Nugraha. *Supervisors:* Dr B.J. Waterson, Dr S.P. Blainey.

With the exception of modern specifically created 'superports', most of the world's major ports are located close to the heart of urban areas (indeed the growth of the surrounding city is often a result of the port location). While such proximity to an urban area enables the plentiful supply of workers and accommodation facilities for travellers through the port, it also provides large challenges to enable ports to handle an increasing throughput of goods and travellers without overloading the already congested urban transport system. This research therefore seeks to review port-city situations around the world, to investigate issues such as constraints on port operations, impacts on urban traffic networks, best practices on port-city transport scheduling, operation, and coordination, as well as the consequences for the economic benefits of port-city prosperity. This project examines the dynamics between port and urban development through cellular-automata (CA) based land use and transport simulation model.

3.7 Human Factors

Open Flight Deck (OFD) (Innovate UK from March 2017 – February 2020) Dr V.A. Banks, K. Parnell. *Contract Holders:* Prof N.A. Stanton, Dr K.L. Plant.

Next generation civil aircraft require a step change in the capability of the flight deck to deliver new operational scenarios in a more transparent way. Flight deck technology will need to incorporate the latest developments in computing platform, Human-Machine Interface (HMI), crew aids and pilot interaction technologies. The aim of the Open Flight Deck project is to develop an open, accessible and standardised avionic platform for the flight deck which can support the introduction of such technologies, new software applications and peripheral devices. With the flight crew remaining central to aircraft operations, the project also seeks to develop new crew aids that can both optimise crew workload but also improve situational awareness. Working with GE Aviation, BAE Systems, Rolls Royce and Coventry University, Human Factors expertise is provided in the design and evaluation of these future flight deck innovations.

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.

In the HF Auto project, experiments in driving simulators and on the road were performed to investigate human interaction with various levels of automation including full-range ACC (Adaptive Cruise Control), SAE (Society of Automotive Engineers) level 2 automation with drivers monitoring the automation, and SAE level 3 automation allowing drivers to take their eyes off the road. Studies focussed on passenger cars but also included truck platooning. HF Auto bridged the gap between

engineers and psychologists through a multidisciplinary research and training programme. HF Auto trained 13 Early Stage Researchers and one Experienced Researcher, clustered in five synergistic work packages, learning and collaborating by means of secondments in the automotive industry, road safety institutes, and academia. HF Auto has led to 24 international journal papers, while another 16 papers have been submitted for journal publication, or are in progress. Furthermore, 29 papers have been published at reviewed scientific conferences/meetings.

TASCC (Towards Autonomy - Smart and Connected Control): Human Interaction: Designing Autonomy in Vehicles (HI:DAV) (Jaguar Land Rover (JLR)/ EPSRC, April 2016 to April 2020) Dr K.M.A. Revell, James Brown**.** *Contract Holder:* Prof N. A. 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. This project will answer these questions by using Human Factors methodologies to model driver behaviour for level 3 semi-autonomous vehicles. It will study a wide range of drivers with different driving experience in simulators, on test-tracks and in road going vehicles.

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. Questions will be answered 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 reliant on designing appropriate interactions and interfaces that support the driver. Our research will be essential to that success.

ComTET1 (BAE Systems from April 2014 to March 2017). Dr A. Roberts, D. Fay. *Contract Holder:* Prof N. A. Stanton.

Four experimental studies examining new configurations and ways of working within command teams were completed. This required the recruitment, training and testing of over 240 participants. The findings have been presented in five (to date) peer-reviewed. Importantly, the Royal Navy's Flag Officer Sea Training (FOST) organisation has taken steps to incorporate recommendations from ComTET1 into their training programs. This will ensure the findings of the program have real world impact.

ComTET2 (BAE Systems from 2017-2020). D. Fay, K. Pope, C. Fenton, P. Moore. *Contract Holders:* Prof N. A. Stanton, Dr A. Roberts.

Due to the success of ComTET1, funding for a further three year program of work was attained. The team will continue to provide evidence based recommendations from well-controlled experimental studies to demonstrate the benefits and pitfalls of new team structures, allocation of system functions, ways of working, communication media, interfaces, job aids and work design. The ComTET2 team will also undertake new avenues of work including investigation of optimal deployment, operation and utilisation of data derived from unmanned underwater vehicles by command teams.

Ready to Take Back Control – Assessing the Optimal Way to Monitor Driver States Using a Variety of Cognitive and Psycho-physiological Methods (funded by Jaguar Land Rover, PhD studentship from October 2017) Sylwia Kaduk. *Supervisors:* Prof N.A. Stanton, Dr A. Roberts.

A new generation of half-automated vehicles will allow automated driving in some circumstances, for example on certain highways. New technologies could increase safety and the efficiency of transport, but might also create some challenges. One of the challenges is the moment of transition from automated to manual driving. Some physical and mental states of the driver at this moment might highly jeopardise safety. This research is part of the HI:DAV project that explores human factors in transition from automated to human driving in automated vehicles. It is investigating the possibility of using various psychophysiological measures to detect drivers' states that could be potentially dangerous for safety of take-over and further driving. Issues identified from the literature include sleep, sleep inertia, drowsiness, sleepiness, fatigue, mental workload, inattention, lack of situation awareness, stress, anger, motion sickness, bad health state and behavioural distractions. The most reliable methods of detecting these states will be established. Example of measures that might be used are electroencephalography (EEG), electrocardiography (ECG) and acoustic voice analysis.

Handover Interactions and Interfaces in Autonomous Vehicle Design: How can Handover Assistants be Usable, Sufficiently Raise Situation Awareness, and Appropriately Calibrate User-trust? (funded by Jaguar Land Rover as part of the TASCC: Hi:DAV project, PhD studentship, from January 2017) Jediah Clark. *Supervisors:* Prof N.A. Stanton, Dr K.M.A. Revell.

In automated vehicles that require a human-driver to be present, the transition of control (whether planned or unplanned) marks a profound vulnerability in the driving-system. As drivers remain 'out-of-the-loop' for an extended period, issues such as loss of 'situation awareness' may occur. Handover assistants have been proposed as a solution to such issues. However, how and what to present to the driver during these transitions remains unclear, and issues such as safety, usability and user-trust must be considered. This project attempts to address these issues through iteratively generating design concepts and testing them experimentally. By doing so, it is hoped that well-considered and refined designs can be provided as a result of this research."

Optimising Steering Wheel Based Controls in Motorsport (PhD from October 2017). James W H Brown. *Supervisors:* Prof N.A. Stanton, Dr K.M.A. Revell.

The interfaces of cars within the higher echelons of motorsport are highly complex as a result of the need to be able to maximise performance. However, there are multiple known instances of driver errors occurring, costing them time and, in some cases, loss of control of the vehicle, due to interface design issues. Motorsport is both high-risk and high-cost and drivers are frequently exposed to high cognitive and physical workloads. This combination of factors represents a significant challenge in terms of interface design. Identifying and prioritising the primary usability aspects relevant to racing drivers aids the definition of the unique problem domain. The subsequent

application of Human Factors methods to the specific area of steering wheel based controls aims to optimise control locations, attributes and layouts. This project hopes to generate a hybridised methodology for the creation of idealised interface designs within motorsport. The production of prototype steering wheels based on the methodology's outputs allows experimental testing and validation. The project output should additionally provide insight into the generic design of complex interfaces in high risk/high cognitive load scenarios.

A Sociotechnical Systems Approach to Driver Distraction (sponsored by EPSRC and Jaguar Land Rover, EngD studentship from October 2013). Katie J. Parnell. *Supervisors:* Prof N.A. Stanton, Dr K.L. Plant, R. Whitford (Jaguar Land Rover).

The impact of driver distraction on road safety has been a focus of Human Factors research for over half a century. Over this time, developments in technology have served to increase the impact of driver distraction. Mobile phones have attracted much attention within the field, however other technological tasks that are brought into the vehicle by the driver, as well as those that are built in to the vehicle by manufacturers, also negatively affect the driver's safe monitoring of the road environment. Traditional methods employed to manage the issue have been critiqued for being too focused on the individual. It is argued that the focus should be on the role of the wider sociotechnical system within which the behaviour occurs. This project seeks to explore the issue of driver distraction from technological devices by taking a sociotechnical systems approach.

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

System-induced human error is the most significant factor in aircraft accidents, for which errors are both inevitable and a frequent occurrence. Human error is a by-product of performance variability caused by system failures, for which undetected error becomes a latent error that can impact system safety and therefore contribute to a future undesired outcome. The phenomenon of Individual Latent Error Detection (I-LED) was proposed. I-LED refers to the detection of workplace latent errors at some point post-task completion through the recollection of past activity by the individual who suffered the error. An extensive literature review shows the phenomenon to be a novel concept, indicating a clear gap in knowledge requiring research to explore the nature and extent of I-LED events. A multi-process theory is developed and combined with the system's perspective to provide a theoretical framework upon which to conduct real-world observations of I-LED events in cohorts of naval air engineers. Collected data indicate time, location and other system cues trigger I-LED events, for which the deliberate review of past activity within a time window of two hours of the error occurring and whilst remaining in the same sociotechnical environment to that which the error occurred appears most effective. Several practicable interventions are designed and tested, from which the overall benefit of integrating the I-LED phenomenon as an additional safety control within an organisation's safety system is assessed. This research was completed in September 2017 and shown to contribute

to knowledge on workplace safety by applying systems thinking to understand the nature and extent of I-LED and its benefit to safety resilience in naval aircraft maintenance. I-LED research arguably offers a step-change in safety thinking by offering a level of resilience within the workplace that has not previously been accounted for in organisational safety strategies.

Application of the Perceptual Cycle Model and Schema Theory to Automobile Driving Behaviour (PhD studentship from June 2017) Jamal Kinsella. *Supervisors* Dr K.L. Plant, Prof N.A. Stanton.

Specific automobile driving behaviours, such as speeding behaviours and non-compliance with road signs, are believed to contribute to driving collisions, one of the leading causes of death worldwide. According to Neisser's Perceptual Cycle Model, human decision-making is influenced by our schema (anticipations developed through experience and activated in specific contexts) which, in the case of driving, will be informed by training and personal experiences with roads, cars and driving in general. Through applying this model researchers have found an explanation for the differences in specific driving behaviours found in different demographic groups of drivers. The aim of this project is to apply verbal protocol methods to elicit and infer schema to investigate differences in driving behaviour across different demographic groups, with implications for improving the training and systems designed to encourage safe driving behaviour.

Alternative Safety Management Techniques for Air Traffic Management (funded by NATS, PhD from September 2017). Craig Foster. *Supervisors:* Dr K.L. Plant, Prof N.A. Stanton.

Air Traffic Management (ATM) exists to support the safe and expeditious flow of aircraft through the world's airspace. However, safety in ATM presents unique challenges due to it being a complex and highly coupled socio-technical system of systems. Despite this, ATM has achieved an ultra-safe level of performance. However, ATM is undergoing unprecedented change and a number of new challenges face the industry. New regulations and regulators, new technologies, changing roles for the human, the desire to reduce the environmental impact of air travel and a demand for further cost efficiencies and commercialisation could all affect the ATM industry's commitment to safety. Against this backdrop, ATM needs to ensure that how safety is understood and managed remains appropriate and safety data continues to deliver information about how safe the operation is and provide an alert to changing risks to inform action. This PhD examines the challenges that arise from the way safety is currently thought about in ATM and considers recent advances in safety science as providing an alternative approach which focusses on successfully harnessing the adaptations present within complex socio-technical systems. A review of the safety literature identifies a need to further elaborate how organisations are to practically apply these emerging ideas within the context of an industry which is characterised by standardisation, procedures and regulation.

Whilst the introduction of new technology presents challenges to safety it also presents an opportunity to marry this alternative safety management approach with the use of data generated from the

delivery of the ATM service to better understand the adaptations that produce safety. The PhD is expected to explore and contribute to research in this area and bridge the gap between grounded safety theory for complex socio-technical systems and novel techniques for understanding data generated by humans adapting whilst doing work in safety-related domains.

CORSIA - A Carbon Offsetting And Reduction Scheme For International Aviation (PhD from September 2017) Liu Tianyi. *Supervisors*: Dr S.P. Blainey, Dr K.L. Plant.

CORSIA is a global market based measure scheme developed by the International Civil Aviation Organisation (ICAO) to address the annual increase in total CO2 emissions from international civil aviation. Overall, CORSIA aims to achieve the aspirational goal of being carbon natural growth from 2020. According to ICAO's assembly resolution A39-3, the CORSIA is structured into three different phases, namely the "pilot phase" (2021-2023), "first phase" (2024-2026) and "second phase" (2027-2035).

The primary objective of this research is to evaluate how exactly CORSIA will impact the three major Chinese airlines (Air China, China Eastern and China Southern) from 2024 onwards. In addition, this research will identify the potential cost-control strategies in the post-implementation phases that can be leveraged to gain competitive advantage in East-Asian market.

Maritime Command and Control Human-Machine Interaction (sponsored by DSTL and BAE Systems, PhD from 2014). Daniel Fay. *Supervisors:* Prof. N.A. Stanton, Dr. A. Roberts.

Future maritime control rooms will be tasked with handling increased data with potentially less crew. User interfaces have evolved to meet current requirements, but this iterative process has propagated legacy design paradigms that may be unsuitable for future requirements. A new design paradigm for user interfaces may be required to maintain effective performance. Ecological Interface Design (EID) is being explored as a theory based approach to design new interfaces. Novel user interfaces will be designed and tested to assess their applicability for future maritime command and control.

Who's in control? Lessons from Human-Human Interaction Applied to Human-Computer Transfer of Control (funded as part of HFAuto - Human Factors of Automated Driving PITN-GA-2013-605817, PhD from June 2014 - Awarded 2017). Alex Eriksson. *Supervisors:* 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

2017

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