ANNUAL REPORT 2019
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.

TRG is located at the University's Boldrewood Innovation Campus where the £46 million National Infrastructure Laboratory (NIL) was completed in May 2019 (see below). The facility was officially opened by Andrew Haines, Chief Executive of Network Rail on 27 September 2019.

National Infrastructure Laboratory at Boldrewood

This report covers the research activities within TRG during the calendar year 2019.

TRG academic staff members during 2019 were:

- John Preston, Professor of Rail Transport and Head of TRG
- Neville Stanton, Professor of Human Factors in Transport
- Tom Cherrett, Professor of Logistics and Transport Planning
- Ben Waterson, Associate Professor, specialising in modelling and simulation
- Simon Blainey, Associate Professor, specialising in rail transport and modelling
- Ioannis Kaparias, Lecturer in transportation engineering
- Katie Plant, Lecturer in Human Factors Engineering
- Shahram Heydari, Lecturer in Transportation, specialising in safety.

Research Staff in TRG during 2019 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, Dr Alan Wong, Dr Vicky Banks, Rich McIlroy, Dr Matt Grote, Dr Marcus Young, Dr Yiyang Chen, Dr Jisun Kim and Leonie Webster. During the year we welcomed Matthew Webster. and said farewell to Dr Craig Allison and Dr Milan Lovric.

Their research activities are summarised in later paragraphs. **Technical Staff** supporting TRG included Chris Fenton, Karen Ghali, Daniel Fay, Peter Moore, Kiome Pope and Sarah Twist. During the year, we said farewell to Chris Fenton, Peter Moore and Sarah Twist.

Melanie Hallford continued in her role as **Senior Administrator** for the Group, with Joy Richardson as administrator for Human Factors projects.

Mike McDonald continues as Emeritus Professor in Transportation Engineering and Nick Hounsell as Visiting Professor. We have a number of other 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 (formerly of TRL); 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 Shahjahan Miah, Professor Paul Salmon, Iain MacGregor, Dr Birendra Shrestha, Dr Alejandro Ortega-Hortelano Oliver Davey and Dr Milan Lovric. Visitors from Korea included He Chul Lee, Sangok Lee and Junhong Park and Henrik Johansson from Sweden. Freke Caset from the University Ghent/Vrije Universiteit Brussel and Stephan Zieger from RWTH Aachen, Germany.

We also had over 30 students attached to the Group undertaking PhD or EngD (Engineering Doctorate) research in transport. In 2019, PhD degrees were awarded to Amanda Haylett, Jongjoon Song and Marcus Young.

Postgraduate teaching continues to be an integral part of TRG activities, particularly the MSc in Transportation Planning and Engineering. The course celebrated its 50th anniversary in 2019, with all alumni invited to a commemorative event held at Boldrewood on 28th June 2019. This included a range of talks and activities, and attendees included all those who had acted as programme lead over the life of the course so far. We continue to offer three pathways through the course, offering students a choice of specialising in Infrastructure, Behaviour or Operations on either a full time or part time basis, and 29 new students enrolled in September 2019.

Overall, we have maintained a healthy portfolio of research in 2019. 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.

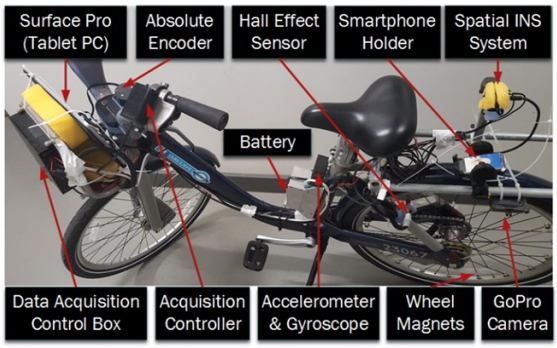
TRG facilities include:

- 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 (IV2) for on-road trials and new garage facility in Building 185 of Boldrewood. Procurement for a replacement to IV2 commenced in 2019, following a successful bid to the University's Research Equipment at Southampton: Delivering Innovation to the Next Generation (RESOUNDING) Fund.

The IV2 and an instrumented bicycle (iBike) for on-road trials, are hosted in the garage facility in Building 185 at Boldrewood.



The TRG Instrumented Bike

- 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

TRG continued to take the lead in delivering several high-profile public engagement and outreach activities and events in 2019, under the coordination of Dr Alan Wong. This included:

- running a major Lantern Festival Parade through Guildhall Square, West Quay, Bargate and the central Parks to encourage more walking and exploration of the centre of the City, which was attended by over 2,000 people
- providing a discussion at the John Hansard Gallery on how the work of Leonardo da Vinci can help to inspire city transformations and improve transport links, as part of the UK 'Leonardo 500' Festival (and displays of his original drawings at the City Art Gallery);
- coordinating one of the six strands of the City's popular 'Pint of Science' festival, including dissemination of the work of the EU Metamorphosis and DfID-sponsored Metamorphosis Global Projects, to help transform our cities into more vibrant, healthier and safer neighbourhoods for children and people;
- collaborating with the City Council, British Cycling and other community partners to organise the major Let's Ride Southampton Festival, which was attended by 10,000 people, and included family-friendly activities and live music at St. Mary's Stadium, Queens' Park, and Hoglands Park, as well as the usual popular cycling-associated activities;
- contributing a series of talks (in conjunction with Environmental Sciences) to the 'Sustainability' Spotlight' event given to the University's students, as requested by the Student Union (SUSU) President.

Let's Ride 2019, where a conscious decision was taken for the route to run through St. Mary's Stadium (home of Southampton Football Club)

2. EXTERNAL ACTIVITIES

The following sections summarise the range of external activities undertaken by TRG Academic Staff members in 2019:

John Preston:

- Member of the EPSRC Peer Review College.
- External examiner for Masters level courses at Cardiff and Leeds Universities.
- Chaired the 15th World Conference on Transport Research Rail Special Interest Group sessions at Mumbai 26-31 May.
- Committee Member of the International Association of Rail Operations Research (IAROR) and the International Conference on Competition and Ownership in Land Passenger Transport.
- Member of the Future Traffic Regulation Optimisation (FuTRO) Project Control Board and the Vehicle/Train Control and Communications Systems Interface Committee.
- Editorial Board Member: Journal of Transport Policy and member of the Scientific Committee of the World Conference of Transport Research Society.

Neville Stanton:

- Associate Editor, IEEE Transaction on Human-Machine Systems.
- Member, Editorial Board, Theoretical Issues in Ergonomics Science.
- Member, Editorial Board, Safety Science.
- Book series editor of "Transportation Human Factors" with CRC Press.
- Chair of the Honourable Company of Air Pilots and the Air Pilots Trust Annual Aviation Safety prize.
- Chartered Engineer with the IET
- Visiting Professor at the University of the Sunshine Coast, Queensland, Australia

Visiting Professor at Tsinghua University, Beijing, China

Tom Cherrett:

1. Member of the U.S. Transportation Research Board's, Standing Committee on Urban Freight Transportation (AT025).
2. Member of the Editorial Board, Proceedings of the ICE: Transport Journal.
3. Member of the Logistics Research Network (LRN) committee.
4. Member of IET's (The Institution of Engineering and Technology) Transport Policy Panel.
5. External Examiner, MSc Transportation Planning and Engineering course at Newcastle University (2015-2019).
6. External Examiner; UG Logistics and Operations Management courses at Cardiff University (2017-2021).

Simon Blainey:

- Secretary of the Royal Geographical Society's Transport Geography Research Group (to August 2019).
- 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.
- Member of the Editorial Board for the Journal of Transport Geography

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 submitted to the Horizon 2020 programme
- External PhD examiner, University College London
- 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)

Katie Plant (on maternity leave Jan-Dec 2019):

- Associate member of the Chartered Institute of Ergonomics and Human Factors (CIEHF).

Shahram Heydari:

- Member of the editorial board of Analytical Methods in Accident Research.
- Collaborative member of the Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT)
- Member of the Network of Excellence in Air Quality at Imperial College London

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 strong 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 2018 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

Road Safety in Low Income Countries: State of knowledge and future directions (IMC Worldwide Limited on behalf of the Department for International Development, November 2018 to July 2019). *Contract holder:* Dr S. Heydari.

This project undertook a systematic review and produced a state of knowledge paper on road safety in low income countries. Particular focus was placed on underreporting, limited data conditions, unobserved heterogeneity, emerging technologies and new forms of data, novel approaches, expected increases in traffic volumes, dumping of old vehicles and advanced vehicle safety features. This work was part of the High Volume Transport applied research programme and involved a collaboration with the Johns Hopkins International Injury Research Unit.

Measuring riding comfort on a street in Southampton using an instrumented bicycle (Southampton City Council, from January to June 2019). Dr S. Miah. *Contract Holder*: Dr I. Kaparias

Cycling is an increasingly popular mode of travel in cities due to the great advantages that it offers in terms of space consumption, health and environmental sustainability. Yet, the low perceived safety and riding comfort of cyclists is a hurdle to the desired uptake of cycling as an alternative to the car, with a particular deterrent being poorly maintained infrastructure, including road pavement defects, such as fretting, ravelling, rutting and potholes. As a result, several city authorities worldwide are presently undertaking schemes aiming at improving cycling infrastructure.

One such scheme has recently been implemented in Millbrook Road East (MRE) in Southampton. Opinion surveys with cyclists regularly using MRE had identified that a series of pavement defects on the road surface affected the overall cycling experience, which was generally rated very poorly. This prompted the local authority to resurface the road, with works having been recently completed. However, even though the perception of the cyclists continues to be analysed through surveys with cyclists post-completion of the works, establishing its relation with actual objective riding comfort measurements is challenging.

The aim of this study is, hence, to investigate changes in riding comfort as a result of the resurfacing of the MRE site on the basis of objective vibration measurements collected using the iBike instrumented bicycle. The project involves riding the iBike on MRE at periods before and after resurfacing to collect mapped vibration data from the sensors, and then drawing comparisons between the two periods with respect to the riding comfort, both in terms of individual locations/hot-spots and the road in its entirety.

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, Prof J.M. Preston, Prof. C. Deakin (Medicine), Prof P. Roderick (Medicine).
Extended to July 2021. *Contract Holders:* Prof N. A. Stanton, Dr K.L. Plant, Dr R.C. McIlroy

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 original GHRG had 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). Following a successful bid for a 12-month extension to the project, two new project partners will also be included; Ecuador, via the Universidad de las Americas in Quito, and Brazil, via the Pontifical Catholic University of Rio de Janeiro.

During the first two years of the project, three research streams were been undertaken: (1) conducting a large cross-cultural comparison survey to explore attitudes to road safety and risk perception; (2) Applying Accimaps as a systems-based accident analysis method for three high risk accident hot spot sites in each country, and using the findings to develop systems-based safety recommendations; and (3) conducting a naturalistic 'think aloud' study with country-specific road users (e.g. moped riders in Vietnam, cyclists in the UK) in order to understand decision making processes from the perspective of road users. During year three, whole-system analyses using the STAMP methodology will be undertaken, and a programme of driving simulator research will commence.

The extension period, year four, will see driving simulation work continue, and will also see the development of systems-based collision report forms, drawing on systems analyses undertaken in years one to three. Questionnaire work will also be undertaken during year four, with dissemination in Brazil and Ecuador.

Optimizing Social Utility for Demand Responsive Shared Transport (DRST)

(Ph.D. Studentship from September 2019), Fawzan Alfawzan. Supervisors: Dr B.J. Waterson, Dr S. Blainey

Shared mobility services should result in more carpooling, ride splitting, public transit, and other modes and services which do not increase VMT, shared mobility would contribute to enhancing the performance of the transit system. Even though there are social and environmental benefits to such a shared transit system, such as congestion mitigation or emission reduction, user's self-interest is the primary motive for participate in ridesharing. Indeed, it is unclear whether the new forms of Demand Responsive Shared Transport (DRST) systems can derive the same benefits to the transportation system. This project will investigate the potential for cost-sharing strategy induces sustainable ridesharing services that improve mobility, reduce VMT, and enhance social welfare.

Cost-sharing rules for successfully organizing ridesharing for one O-D pair may not be reliable and effective for large scale adaptation. Thus, when considering dynamic ridesharing apps in general networks, different cost-sharing strategies should be presented for several shared services. Given our current level of understanding of ridesharing, we can point to some considerable critical concerns for ridesharing services which include:

- The impacts of different subsidy/incentive strategies on travellers' mode choices and the design of appropriate subsidy strategies.
- Ridesharing efficiency index and other mechanisms that assess the penetration of ridesharing and encourage ridership.
- Ridesharing impact on social welfare: how fares might be structured to distribute additional social benefits to riders, other groups, or more broadly.

Developing a traffic flow controlling method using autonomous vehicles to dissipate congestion on motorways

(PhD Studentship from September 2019), Hassan Abu Saq. Supervisors: Dr I. Kaparias, Dr B.J. Waterson

Reducing congestion is a key challenge for any road transport system operator. Traffic congestion is estimated to cost the UK around £7.9 billion per year (with drivers spending an average of 178 hours per person per year in traffic congestion). Congestion also leads to more acceleration and deceleration of the vehicles, which results in greater fuel consumption and higher pollutant emissions. As it is now widely recognised that building new roads can only offer short-term relief to the problem of congestion, efforts have more recently shifted to the solutions in the domain of technology. Current techniques for controlling the traffic flow and for reducing and dissipating congestion include predominantly infrastructure-based systems, such as Variable Speed Limits and Lane Advisory Information. However, these techniques have limitations, in particular as concerns static control and

lack of adequate enforcement, which often reduce their effectiveness. This project attempts to overcome these limitations by investigating whether alternative dynamic control approaches using autonomous vehicles (driverless cars) could be more effective.

Development of Travel Time Estimation Models: Consideration of Link Geometry for Korean Motorways (funded by the Korean Government, PhD Studentship from September 2016), Sungbae Yoon. *Supervisors:* Prof J.M. Preston, Dr I. Kaparias.

Link cost functions have been used to estimate travel time depending on the assigned traffic flow. Current models include free-flow travel time (FFTT) and road capacity in order to cover various link characteristics. However, both values have uncertainties in two aspects: measurement and spatial transferability.

The aim of this study is, therefore, to develop feasible travel time estimation models that can replace existing approaches with FFTT and road capacity. Three statistical methods for modelling were introduced in this study: ordinary least squares (OLS) linear estimation, generalised least squares (GLS) linear estimation and nonlinear least squares (NLS) estimation. The case study of 72 Korean motorway sections was implemented based on the empirical traffic data from ITS and geometric data from design drawings.

This study concludes that new types of travel time estimation models with geometric features (without FFTT and road capacity) can replace current models. The application to transport appraisal shows that the newly developed model has a significant impact on the feasibility of transport projects by changing the total benefit compared to current Korean models.

Improving Automatic Incident Detection Algorithms (ESPRC and Siemens, PhD Studentship, from July 2016). Jonny Evans. *Supervisors:* Dr B.J. Waterson, Prof T.J. Cherrett, *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 has been created that can learn the patterns between the traffic state and context by analysing historical data. An AIDA with this insight can then raise alerts to Transport Operators more quickly and with less false alerts, ultimately aiding in mitigating the consequences of incidents on the road network.

3.2 Energy & Environment

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 2021).

Dr A. Wong, A. Hickford, K. Ghali; *Contract Holder*: Prof J.M. Preston.

The Centre is a partnership that works with the City Council and the wider region to promote local sustainable travel, walking and cycling, whilst suppressing private car use. This project continues on from the collaborative work originated through the Local Sustainable Transport Fund, with TRG leading on the monitoring and evaluation of physical interventions and travel behaviour change, as well as advising and supporting the City Council to develop an active travel culture that enriches lives, provides realistic travel choices, and tackles the pressing air quality problem in the Southampton region. This includes the development of segregated cycling 'Freeways' as part of building a 'cycle-to-work' network, running from the centre of Southampton westwards towards Redbridge and Totton (SCN1), northwards towards Eastleigh and Chandlers Ford (SCN5), and eastwards towards Botley and Hedge End (SCN3): https://transport.southampton.gov.uk/connected-southampton-2040/southampton-cycle-network/. This Network is part of a wider 10-year cycling strategy (from 2017) to develop a Southampton Cycle Network (SCN) that also includes cycling 'Cityways' linking to other parts of town and across the region, and TRG also played a major role in assessing the effectiveness of the marketing campaigns and other promotional activities devised by the City Council in promoting these networks.

Decarbonising Transport through Electrification (DTE) (EPSRC Network+ Grant. September 2019 – August 2022). *Contract Holder:* Prof. J. Preston.

This network is led by Prof L. Cipcigan of Cardiff University and also includes Birmingham, Bristol and Cranfield Universities. The DTE Network+ brings together academia, industry and the public sector to address the challenges limiting the current implementation of an electrified, integrated transport system across the automotive, aerospace, rail and maritime sectors. The DTE Network+ will explore drivers for change within the transport system including technological innovation, individual mobility needs and economic requirements for change, alongside environmental and social concerns for sustainability and consider the role, social acceptance and impact of policies and regulations to result in emissions reduction. It will adopt and integrated whole system approach that will address short, medium and long-term time-frame challenges, using a multi-layered approach that considers vehicles and technology, charging infrastructure, the supply of electricity and smart mobility. For more details see: https://dte.network/

Centre for Re-Engineering for Electric Mobility (RE4EM) (Faculty of Engineering and Physical Sciences, January 2020 to December 2021) *Contract Holder:* Prof. J Preston with Prof. A. Cruden (Energy Technology Group) and Prof L. Wang (nCATS – National Centre for Advanced Tribology at Southampton).

With the climate emergency high on the global agenda, and many nations planning to prohibit the sale of new diesel and petrol cars within the next two decades, there is an urgent need for progress towards cleaner transport systems – in particular, electrified systems.

This Centre of Excellence will accelerate the pace of change through advances in energy storage technology, the development of digital tribology to

optimise electric vehicle (EV) components, the redesign of human–machine interfaces and a systems approach to infrastructure planning.

RE4EM's approach involves re-engineering existing infrastructure and vehicles to deliver a more sustainable, interconnected transport system, with a focus on road transport as well as the transition to electric rail, air and sea transport systems. For more details see: https://www.southampton.ac.uk/re4em

3.3 Freight & Logistics

Southampton Delivery and Servicing Plans (Southampton City Council, from September 2019 to August 2020). Dr M. Grote. *Contract Holder*: Prof T.J. Cherrett.

The aim of the Southampton Delivery and Servicing Plans (DSPs) project is to conduct DSPs on organisations located in Southampton for Southampton City Council (SCC) via a sub-contract arrangement with the Transport Research Laboratory (TRL). A DSP is a flexible plan to minimise the costs, impacts and number of deliveries and servicing visits to an organisation, and is developed through an audit of the current situation, analysis of the audit's results, and the formulation and implementation of a plan-of-action. DSPs are widely seen as an effective method to reduce (*inter alia*) harmful emissions from delivery and servicing vehicles, and SCC's desire to improve air quality in Southampton is the background to the project.

The project consists of four DSPs. The first involves a survey of deliveries by Carnival UK's (CUK) local suppliers to Meachers Global Logistics' (MGL) warehouse facilities in Southampton prior to consolidation for delivery to CUK's cruise ships at the dockside. The possible benefits of a milk-round collection service operated by MGL as an alternative to supplier deliveries are being investigated, including the potential for shared fleet operations utilising spare capacity in SCC's electric van fleet to provide vehicles for the milk-round.

The second DSP is investigating the possible benefits of installing parcel collection points (e.g. Amazon Lockers) on University campuses, consolidating the delivery of personal parcels and reducing the incidence of failed deliveries. The analysis is based on the results of a survey of online shopping habits of staff and students at the University of Southampton (UoS), but the outcomes are likely to be transferable to other Higher Education Institutions (HEIs) or other organisations of a similar size.

The third DSP is based on the same staff/student survey and considers the potential benefits of implementing a consolidated delivery service for students resident in University Halls. The service involves students using a local logistics firm (MGL) as the address for delivery of their online orders, which are then consolidated for delivery to Halls, thereby reducing delivery vehicle traffic to Halls.

The final DSP concerns the provision by SCC of the special needs transport service for schools in Southampton. This DSP is investigating the opportunities for, and possible benefits of, implementing a plan to provide the transport service utilising schools' minibuses or spare capacity in SCC's own vehicle fleet, whilst accommodating the needs and characteristics of the children involved.

FLIPGIG (Digitally transforming deliveries and collections in the gig-economy: fairer and more sustainable last mile parcel logistics) (EPSRC, from 2019 to 2021). F.N. McLeod. *Contract Holder:* Prof T.J. Cherrett

Gig-economy couriers form an integral part of many last-mile logistics operations, but the industry has come under increasing scrutiny due to concerns about poor working conditions. This project aims to: identify any inefficiencies or inequities arising from existing operations; develop algorithms and dynamic models to optimally balance fair work with job availability and service level, while choosing the most sustainable mode for delivery; empower gig-economy couriers to better meet their personal working preferences; explore how we can enable end-to-end trust relationships and practices between consignors and consignees using gig-economy workforces; use simulation modelling and trials to evaluate potential impact and uncover barriers to adoption of the new models we propose at scale. Project website: http://www.flipgig.org/

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.

Working with major parcel carriers in London, this project examined the potential for closer operational collaboration to reduce urban traffic, energy demand and vehicle emissions. Initiatives included: carriers dropping off parcels to porters or cycle couriers for the final delivery; an operating model in which one carrier delivers parcels in a given area on behalf of others; and green delivery strategies where better coordination of deliveries is planned. Project website: http://www.ftc2050.com/

Multi-Modal Shared Logistics in an Urban Setting – Unlocking the Potential of the NHS Same Day Delivery Network (PGR student, from October 2016) Andy Oakey. *Supervisors*: Prof T.J. Cherrett, Dr A. Martinez-Sykora, Prof J.P. Scanlan.

The demand for same day deliveries is ever growing, whilst journey times in urban areas continue to worsen as a result of increasing congestion. Typically, little thought is given to logistics in urban planning, nor the environmental burden faced by everyday deliveries. Transfer to more sustainable practices across multiple, cleaner transit modes can help to relieve some of these pressures.

This research aims to investigate the potential for a multi-modal logistics fleet to operate across many applications in an urban and peri-urban environment, using NHS same day delivery systems in the Solent region as case studies.

This includes: the transfer of equipment and defibrillators between ambulances and incident sites by drone – a shorter distance logistics network; movement of pathology samples for analysis from GP surgeries to hospitals by a combination of cargo cycles, drones, and electric vans – a medium distance logistics network; and movement of ad-hoc and emergency blood stocks from Southampton Blood Centre to recipient hospitals by drones and electric vans – a longer distance logistics network.

To optimise the use of these vehicle assets, an allocation system will be developed, considering factors such as time criticality, cost, and routing

restrictions. In the NHS setting, improving delivery timescales is a key target. Across all three scales of case study, there is potential to create knock-on savings across the NHS, improve quality of care, and save lives.

To further improve the sustainability of multimodal fleets, this research will consider how such a fleet could be shared by multiple parties in a collaborative partnership.

Restructuring the Supply Chain to Better Serve Rural Farmers: A Case Study of Thailand's Mango Supply Chain PGR student, from October 2017) Korawit Fakkhong. *Supervisors*: Prof T.J. Cherrett, Prof J.M. Preston, Dr Antonio Martinez-Sykora (external).

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. However, the constrained by general poverty assets particularly lack of effective transportation system remain the main obstacle for rural farmers to move their products in efficient way and temperature to comply with the market requirements. This research has expressed a need to create a more exclusive operating environment for rural farmers to ensure that they can remain competitive going forward. The two different potential operating scenarios; optimisation of transportation routing and micro-consolidation as extended consolidation point will be used to investigate how different transportation and distribution approach could improve overall logistics performance, as well as, business opportunities for rural farmers.

Demand Forecast and Capacity Appraisal of the United Kingdom Lift-on Lift-off Container Ports System **(**SMMI PhD studentship from January 2016). Manuel Buitrago. Supervisors: Prof J.M. Preston, Prof T. Bektas (University of Liverpool).

The maritime sector is of the utmost importance for the United Kingdom's economy. Great Britain relies heavily on the use of sea-borne transport for most of the freight commodities. Airfreight is mainly used for high-value and time-sensitive products and the capacity of the Channel Tunnel railway is constrained. For bulk and containerised commodities, which usually present a lower value density and higher volume, maritime transport is the only feasible option. As a result, up to 96% of the volume of all UK import/export trade flows use the UK ports. Roll-on roll-off (ro-ro) and lift-on lift-off (lo-lo) container terminals are essential to accommodate container flows. Besides, amongst lo-lo terminals, the UK also needs a certain deep-water capacity to be able to cater for ultra-large container ships (ULCS) that are deployed to the main maritime route that links the Far East with Northern Europe. Ensuring the availability of enough spare deep-water capacity has become even more important on the eve of Brexit.

Apart from enabling the trading capability of the nation, the ports are crucial for the UK's economy in, at least, two other important ways. Efficient ports increase the competitiveness of the UK economy, reducing dwell times and facilitating trade. Secondly, ports generate important spill overs. These include value generation, creation of jobs and the formation of clusters and industrial poles.
The UK container port system has experienced profound change since the 1980s. The system underwent a change

in two dimensions. Firstly, all major UK container ports are privately-owned, after a privatisation wave during the 80s and 90s. Secondly, the container traffic is concentrated in just three major ports of the south-eastern coast of the UK, which handle more than 70% of the total yearly throughput.

This research project develops new models to assess capacity and demand for the lift-on lift-off container seaports in the United Kingdom. The evolution of the UK container port system has been analysed. Besides, the system capacity has been analytically appraised using a system of systems approach.
An aggregate forecast of the demand for lo-lo container traffic of the United Kingdom system of container ports has been calculated up to the year 2050, using econometric models that incorporate economic growth and the cost of energy as predictors. Several scenarios have been incorporated to reflect the uncertainty and the potential disruption caused by the future UK-EU relationship. Finally, the forecast traffic is allocated to the individual UK containers ports by means of a ground-breaking Lotka-Volterra dynamic competition model.

This research presents insights to decision-makers to base port policy on evidence and informs crucial strategic investment decisions for government and industry alike. This PhD provides a rationale to substantiate where and when to invest in capacity expansion. Finally, the results can be used to signpost risks to the port system, in terms of congestion, loss of traffic and vulnerability of the port infrastructure network.

3.4 Future Technologies

Green Adaptive Control for Future Interconnected Vehicles (G-ACTIVE)

(EPSRC from March 2016 to February 2019). Dr C. Allison, *Contract Holders:* Prof N.A. Stanton.

The project targeted a significant reduction in fuel consumption, CO_2 and NOx emissions in passenger and light duty road vehicles. This was 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.

Examination of the Effects of New Transportation Technologies and Business Models on Urban Structure

(PhD from January 2019). Paraskevi Sarri. Supervisors: Dr I. Kaparias, Prof J.M. Preston

New technologies and business models in transportation will change the way people travel in the future. New technologies such as autonomous, connected, electrical or low emission vehicles and business models like schemes like Mobility as a Service or car sharing, have been researched intensely. The last time that urban mobility had faced such evolution was in 1885 when Karl Friedrich Benz created the first car that could be powered by an internal combustion engine. Since then the car has been the most important component of urban and interurban transportation around the world because it has opened economic opportunities to the population but also it has significantly increased the speed of travelling.

Predicting the impacts of these technologies in everyday life is necessary

at this point. Land use and Transportation Interaction (LUTI) models are an appropriate tool of modelling for the assessment of many kinds of new technologies, business plans and also combination of these and not just in a one- dimensional way. Providing predictions is a practice that is deeply linked to science and is an integral part of the design of urban systems around the globe. In order to integrate new technologies and business models in LUTI models, it is inevitable that the internal mathematical structure of LUTI models has to change and become more adaptable. To achieve this using multidisciplinary models and various mathematical relationships that relate transportation, location and land use characteristics is essential describe and analyse urban systems.

The results of such a study come from both the urban models but also other aspects, such as transportation models and data from new technologies, thus they can be beneficial for both the individual and the society in general. New technologies such as autonomous vehicles, can bring sustainability to mobility solutions in the future and thus being able to predict the impacts of them can prevent possible policy and planning mistakes. The new and more versatile to new technologies framework can be used as a tool for both urban design and transportation planning and engineering.

Incorporating More Connected Vehicle Information into Urban Signal Control Managements (PhD from January 2018). Zongyuan Wu. Supervisors: Dr B.J. Waterson, Dr B. Anvari (external).

This project aims to understand the benefits of adopting comprehensive information obtained from connected vehicles in control strategies. In particular, the impact of considering vehicles different from each other on traffic control is investigated here. The report reviews existing urban signal control strategies, points out their drawbacks and highlights that they fail to realize that vehicles are different. The project will try to identify which methods for recognising individual vehicle information data are useful for adaptive urban signal control using connected vehicle technology. A new adaptive signal control model will be developed, which will incorporate more individual vehicle information with typical connected vehicle data. The research will then investigate how the presence of information about each vehicle will impact the operation of adaptive signal controls using CV technology and identify which kind of factors significantly affected their performances. The end of the research will support the adaptive signal control strategies to respond to different traffic situations on the basis of better understanding of additional information.

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, 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 policymakers 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). Awarded 2019.

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 break down 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 only 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.

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 indefinitely, dependent upon sufficient charging infrastructure. Yet, the detailed vehicle interactions of both users and non-users of a dynamic charging system has received little analysis.

The project 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. This research has seen the development of both traffic and energy models to analyse various deployment scenarios and to understand the limitations of taking laboratory prototype systems to full scale deployment. Whilst the traffic modelling has involved both microscopic and macroscopic simulation, the development of instantaneous energy consumption, power transfer and emission programs were significant contributions of the research. The study concludes with the necessary tools to quantify the optimisation of deployment scenarios.

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

Connected intelligent transport systems contain a wealth of data accessible to traffic signal controllers. However, algorithms that use data from a connected environment do not fully exploit the potential of this new data source. Instead, traffic signal controllers rely on speed and position data to supplement data from infrastructure. This research aims to understand which data that are available from connected vehicles are useful for traffic signal control in urban environments. Vehicle positions and speeds fit well into our current understanding of traffic theory, but more abstract data such as passenger counts and stop frequencies may offer new ways to optimise traffic signal controllers to reduce traffic delays.

This research shows how data connected vehicles can be exploited to improve urban traffic signal control, and how using connected vehicle data differs from traditional sources. The outcomes of this research have a significant impact on the implementation of connected intelligent transportation systems and policy for the transportation industry.

3.5 Rail

IntelliDwellTime (RSSB from November 2019 to June 2020). Dr J. Pritchard and staff from GeoData Institute. *Contract Holder:* Dr S.P. Blainey.

This project is being undertaken in partnership with Porterbrook, Elastacloud and Abellio Scotrail as part of the RSSB Data Sandbox+ programme. It builds on modelling and visualisation work carried out during the 'Predicting and Mitigating Small Fluctuations in Station Dwell Times' project. The project will collate and analyse on-train monitoring data from the Scotrail fleet and use this to create a pre-commercial product capable of understanding and predicting variations in train performance which are likely to cause dwell time exceedances. This should help to reduce delay minutes and thus increase the cost-effectiveness of fleet operation. Southampton's role centres on data integration, modelling and visualisation for the software product.

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

This programme grant follows on from the Track21 project (2011-2015) and involves addressing additional research questions with the aim of delivering improved railway infrastructure performance, as well as further research based on some of the key outputs from Track21. 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 involves 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 and the use of fibre-reinforced ballast and on comparing ballasted and non-ballasted track systems. TRG are currently developing (in partnership with the Institute for Sound and Vibration Research) a more accurate and spatially detailed socio-economic assessment of changes in noise and vibration from railway track systems using GIS to combine and process a range of datasets. A generalised socio-economic assessment methodology for track system interventions based on data ontologies is also being developed in conjunction with researchers at the University of Birmingham.

Improving Customer Experience While Ensuring Data Privacy ('DICE') (EPSRC, September 2016 to February 2020). 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 anonymisation; 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.

Our initial focus, working mainly with the team from Loughborough, was 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 helped build up a picture of where the potential trade-offs between data privacy and customer experience might lie. The second phase of our research involves carrying out on-train stated preference surveys to assess the trade-offs passengers are prepared to make between provision of personal data and an improved journey experience during times of disruption.

Predicting and Mitigating Small Fluctuations in Station Dwell Times

(RSSB from April 2018 to March 2019). Dr J. Pritchard, Dr B.J. Waterson and staff from GeoData Institute. *Contract Holder:* Dr S.P. Blainey.

This joint project between TRG and the University's GeoData Institute developed models which are potentially capable of making real time predictions of expected variations in railway station dwell time, along with an interface capable of communicating these variations to railway operating staff so that they can implement appropriate mitigation measures. Variations in station dwell times can have a significant effect on network capacity, with previous analysis of dwell time variations indicating that even small delays can adversely affect overall network performance. The lack of information and understanding of these variations makes it difficult to implement effective mitigation measures to reduce the occurrence and impact of such delays. This project addressed this problem by developing an interactive map-based visualisation tool for dwell time data, and a model explaining the causes of small fluctuations in station dwell time based on a range of datasets. The research focused particularly on dwell time variations of less than three minutes duration at station stops, as this is where previous knowledge was most lacking. However, the tools developed during the project could also potentially provide insights into longer delays. The project involved working in partnership with South Western Railway, who supplied the key datasets for the project.

An Automated Demand Forecasting Model For New Local Railway Stations

(EPSRC IAA from July 2018 to December 2019). Dr M.A. Young. *Contract Holder*: Dr S.P. Blainey.

The considerable growth in passenger rail use in the UK in recent years has been accompanied by a large number of

schemes to construct new stations and railway lines. However, analysis has shown that the accuracy of the forecasting tools conventionally used to assess such schemes leaves a lot to be desired. Recent PhD research has developed integrated railway station choice and demand models capable of producing forecasts of passenger numbers at new station locations anywhere in Great Britain, and of estimating the levels of demand abstraction at nearby existing stations. This project has developed a software tool based on this research which is hosted at the Data Analytics Facility for National Infrastructure (DAFNI), and can in future made available to transport planners working for industry and government stakeholders. This tool provides forecasts of the demand impacts of new railway stations sited at any location in Great Britain, suitable for use in the business case appraisal process for such stations. It is currently being tested by Transport Scotland, with the underlying models having been used previously by the Welsh Government, and presentations on the tool have been given to a number of industry audiences.

Data-Driven Robust Timetabling (RSSB from November 2019 to October 2020). Dr J Armstrong, S. Zieger (Visitor from RWTH Aachen University). *Contract Holder*: Prof J.M. Preston.

Britain's railways carried a record number (1.759bn) of passengers in 2018-19. As traffic grows on the network, it becomes increasingly challenging to operate trains punctually, as even a small initial, or primary, delay to one train can quickly cause knock-on, secondary delays to other services, and delay and congestion can spread rapidly across the network as a result. The industry thus faces the twin challenges of providing capacity to accommodate traffic growth, while operating the additional services punctually and reliably. Primary delay levels have remained fairly constant in recent years, while secondary delay is increasing and now forms approximately 70% of recorded delays. Unattributed, small delays (less than three minutes) now make up approximately 35% of all delay, and need to be better understood, both in terms of their causes and as a source of larger, secondary delays. This project is investigating the timetabling process and the relationship between the timetable and the rules underpinning it and the resulting performance in terms of train punctuality. The findings will be used to identify the sources and causes of small, timetable-related primary and secondary delays, which will in turn be used to modify the timetable planning process to reduce and eliminate these delays. This will improve the punctuality and reliability of train services, making better use of the available network capacity and, where possible, providing the certainty needed to introduce additional services without causing delays to existing trains.

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. Awarded 2019

This project sought to improve the aggregate models that are typically used to forecast demand for new local railway stations in the UK, by incorporating more realistic representations of station catchments. These models have previously assumed that the choice of station is a deterministic process, for example station catchments are often defined by assigning each zone (such as census output area) to its nearest station.

Using origin-destination survey data from Scotland and Wales, station choice models were developed that, given a set of alternative stations for each unit postcode, could predict the probability of each station being chosen, thus defining probabilistic station catchments at a high spatial resolution. Trip end models were then calibrated using a dataset of all local railway stations in mainland GB. The models with probabilistic catchments performed better and gave greater weight to the population variable, indicating that they can better account for differences in station usage that are explained by station catchments and their generation potential. Therefore, they should be more robust and transferable, and better suited for use as a national predictive model. The models were applied to predict demand at several recently opened stations, including the new Borders Railway line. The model with probabilistic catchments produced more accurate forecasts which, in many instances, were better than the official forecasts produced when the schemes were appraised.

A Comparative Assessment of Intercity Transport Technologies: A Saudi Arabian Case Study (PhD from September 2016). Hamad Almujibah. *Supervisors:* Prof J.M. Preston, Dr S.P. Blainey.

With increasing urbanisation worldwide, the passenger demand for inter-urban travel has grown and the development of new transport technologies is needed, such as High-Speed Rail (HSR), Magnetic Levitation (Maglev), and Hyperloop. This thesis describes the development of the comparative assessment of these three intercity transport technologies, in terms of their service characteristics. In this case, the comparative assessment is made up of four models. The first model is the Spreadsheet Total Cost Model (STCM), which focuses in calculating the social and financial costs according to the vehicle characteristics and unit costs for each of the transport technologies studied, including operator cost, user cost, and external cost. Secondly, a Demand Forecast Model (DFM) is needed to forecast travel demand of HSR flows. This model includes different parameters such as population along the corridor, GDP per capita, generalised journey time, percentage of unemployment, and number of years since opening lines. The third model is a Stated Preference Model (SPM) to examine the choice of Hyperloop over all other transport modes to gain an understanding of how the decision can be made when faced with a number of transport alternatives. The fourth model is the Elasticity Demand Model (EDM) to determine the existing mode flows, in terms of generalised journey travel time, including conventional rail, aircraft, automobile, and bus. The comparative assessment is applied on the Riyadh-Dammam corridor, Saudi Arabia to determine the most suitable transport mode, in terms of level of service, total social and operator costs, and forecast passenger demand level.

Streamlined Train Travel: Assessing and Reducing Door-To-Door Journey Times Associated with New Rail Infrastructure (funded by the Turkish Government, PhD Studentship from September 2018) Emine Tugba Yazici. *Supervisors:* Dr S.P. Blainey and Dr M. Young

There are many reasons for investment in high-speed rail (HSR), such as increasing transport capacity, enhancing network, supporting mode shift from air travel to HSR, but often one of the primary reasons for promoting HSR investment is

a reduction in journey time. While HSR services are usually able to achieve a reduction in on-board time between major centres, not all HSR services are necessarily successful in achieving reductions in door-to-door journey time. Therefore, this research reviews high-speed rail routes and their stations around the world to investigate factors affecting the door-to-door journey time such as station connectivity, accessibility, location, HSR route alignment and service operation. Then, with the assessment of the existing applications, for the future HSR construction, a guideline will be provided to help transport planners on the provision of HSR services in a way which maximises the potential journey time benefits.

A Reform Assessment to Optimise the Railway Organisation in Saudi Arabia
(PhD from April 2018). Sultan AlSaedi. Supervisors: Prof J.M. Preston, Dr S.P. Blainey.

The Saudi government has started to reform its railway industry by following the international trends in railway reform. The initial stage of railway reform that has occurred was the ownership reform when the government created a new railway company, Saudi Railway Company (SAR), for the North-South Railway project rather than constructing and operating this project under Saudi Railway Organisation (SRO) responsibility. The reforms also involved privatising Haramain High-Speed Rail (HHSR) under a build-operate-transfer (BOT) contract with a Saudi-Spanish alliance. Most recently, there has been a merger in which SRO assets have been transferred to SAR. Despite these reforms, the railway's industrial organisation can be seen as not fully developed compared to the other industries. In addition, the rail infrastructure is not yet fully developed. The current rail network has a total network-line length of 4,580 km, and the planned rail projects will expand the network up to 9,900 km by 2040. Therefore, the aim of the research project is to determine the optimal organisation of rail services in Saudi Arabia that has not fully developed its rail network. Moreover, the project assumes different forms of railway reform to achieve the optimisation.

The railway reform can be described as any changes in the rail policies, investment plans and the structure of the rail industry. Practically, the railway reform can be clustered in three blocks based on country experiences. The first block is the regulation reform, which aims to introduce different forms of competition, to impose different levels of economic regulation, to create regulatory bodies, etc. The second block is the structural reform, where the railway organisation is restructured horizontally and/or vertically in two models. A vertical separation model is a form of separating the rail infrastructure from train operation. A horizontal separation model is a form of segregating passenger from freight rail services and/or regional division. The last block is the ownership reform, which takes a form of explicit privatisation or deregulation of the rail market.

To deliver the assessment, the project sets three measures to select the optimal railway organisation. The first measure is the technical efficiency, which aims to identify the most railway reform option that can maximise production technology. The second measure is the cost efficiency, which aims to select the optimum railway reform that can achieve cost minimisation. For these two measures, the project will develop a benchmark by using the Data

Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The last measure is the socioeconomic efficiency, which means that different forms of railway organisation will be assessed with respect to welfare economics. At the end, the project will draw some conclusion and recommendations regarding the rail policies, and these recommendations will be validated by interviewing the railway industry experts.

A Whole Life Carbon Model for Railway Track System Interventions (EPSRC and Network Rail Sustainable Infrastructure Systems iPhD from January 2018). Georgios Rempelos. *Supervisors:* Prof J.M. Preston, Dr S.P. Blainey.

The UK's rail network consists of approximately 20,800 miles of track and estimates suggest that the volume of maintenance and renewal required results in approximately 430,000 to 934,000 t CO_2 per annum. This project aims to develop a cost and carbon emissions model framework for railway track systems, covering the whole life of the infrastructure. The model will be capable of modelling the impacts of a wide range of track system interventions, including the full range of engineering solutions developed during the Track21/Track to the Future (T2F) research programmes. In essence, this project aims to produce a framework which will work as an analytical tool to better understand the carbon footprint of today's rail industry and, subsequently, assist the decision-making process on both minimising CO_2 and realising sizeable financial/social benefits. The results from this work are purposed to be fed into a wider Cost Benefit Analysis (CBA) framework, in order to objectively assess different track interventions qualitatively and quantitatively at a macro level and subsequently assist stakeholder decision-making.

Presently, the project is focussed on analysing a range of future track systems, but in order to establish the extent to which these are an improvement over existing ones, it is necessary to undertake a whole-life environmental appraisal of their relative performance. Aside of the environmental externalities of the infrastructure, the project attempts to provide a link between both cost and carbon, examining prospective trade-offs between the upfront and the on-going financial and environmental externalities throughout the useful life of these structures. Of particular interest are potential performance comparisons between different optimised ballasted track forms with interventions developed during Track21/T2F.

Work so far focussed on individual life cycle cost (LCC) and carbon foot-printing studies based largely on existing embodied carbon factor databases such as the 'Bath Inventory of Carbon and Energy', the 'Rail Carbon Tool' by Rail Safety and Standards Board (RSSB), and a rail industry-specific software, VTISM. In detail, this includes a streamlined LCA study to evaluate and compare the lifecycle Greenhouse Gas (GHG) emissions associated with the four most common sleeper types present in the UK rail network. This work is now extended with a focus on LCC and GHG emissions modelling of optimised ballasted track forms (e.g. fibre-reinforced ballast, under sleeper pads, twin-block sleepers, composite sleepers, re-profiled shoulder track, and finer ballast gradings, etc.) through route-based case studies.

Future work will attempt to divert from traditional modelling methods by moving towards an asset management approach having the capability of predicting the forthcoming demand for interventions over the long-term, both at an asset and individual component level. This will enable the evaluation of whole-life financial and environmental impacts of different track section types basing such analysis on real historical records rather than guesstimates of technical life of different track elements.

The Project Economics and Management of Railways in the Middle East (PhD (Part-time) from October 2018). Fawad Munir. *Supervisors:* Prof J.M. Preston, Dr S.P. Blainey.

The focus of this research is the "Investment choice" of establishing a modern rail, and other transport, networks in the Gulf region. From a recent open source literature (www.meed.com) and media review (Gulf News) it emerges that almost all Gulf Cooperation Council (GCC) authorities are seeking alternatives to state investment in major transport projects. An example of this could be the ambitious yet hugely delayed GCC rail project. It is unclear if, or how, an investment model has been considered in the strategic decision of the GCC rail network, but it seems that any such studies have only been done at a rudimentary level. It is argued by Harry Markowitz that stock investors with sufficient computational resources can be compared with government bodies and client organisations and therefore it is feasible to assume that portfolio theory can either be utilised prior to the investment decision or soon after the feasibility study and decision to go ahead with one or the other project. Therefore, in the context of GCC rail projects, this research will draw parallels with the investment portfolio theory and look at alternative models such as Public Private Partnerships (PPPs).
At first, a comparative and parametric study for existing economic models of long-distance railways and/or Metro in modern western countries may be carried out. This will provide a benchmark for comparison with the current GCC practices. Then this study would critically analyse financial studies of GCC region railway projects regarding their investment policy.

The study will provide recommendations, a framework and a model for transport infrastructure investment. This study will be useful for government organisations and other stakeholders for investment choice for a new railway network. Additionally, this research work can also recommend on existing networks in order to establish network wide polices of freight and passenger movement, for a viable business case.

3.6 Transport and Infrastructure Policy

Potential future updates and enhancements to the Solent Sub-Regional Transport Model (SRTM) (Solent Transport. February – May 2019) Dr S. Blainey, Prof. T. Cherrett, Dr I. Kaparias and Dr B. Waterson. *Contract Holder:* Prof. J. Preston.

The objectives were to:

1. Review modelling platforms and their capabilities with respect to transport technologies, socio-demographic change, air quality, self-service and real time traffic management;
2. Review new data sources such as Mobile Network Data (MND), GPS, Bluetooth and Wi-Fi.;

3. Undertake consultation with expert stakeholders; and
4. Draw conclusions concerning future updates and enhancements to the SRTM.

It involved eight subject matter reviews, 13 in-depth interviews with 19 participants (9 Local Government, 3 National Government, 7 Private Sector) and a synthesis report.

A workshop was held on 27 November 2019 in conjunction with the Transport Planning Society and the Chartered Institution of Highways and Transportation. It was chaired by Nick Richardson (Mott Macdonald) and speakers included: Richard Pemberton (Solent Transport), Ian Burden (Systra), Soraya Thompson (Vivacity), Oliver Charlesworth (Bentley/Citilabs), and John Preston (TRG).

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 now implemented 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, and providing innovative approaches to local urban design, which engages both children and adults as stakeholders and participants in the development and building process, as well as enabling and simplifying city planning procedures for the implementation of child friendly neighbourhood measures and activities, which has now been adopted in Southampton, e.g. for 'Street Party' applications: https://www.southampton.gov.uk/people-places/community-involvement/community-street-closures.aspx. TRG has also provided a systematic review of the interventions and measures that are being applied through different local case studies in the cities. This includes in the case of Southampton, the implementation of 'School Streets' beginning in the Old Town at the end of 2018 and now rolled out to five other schools across the City, which has been seen as a success, along with trial street closures and local community interventions in the neighbourhood of Sholing, which has resulted in greater levels of walking and cycling, particularly to the local school, and reduced car use.

Metamorphosis Global (IMC Worldwide Limited on behalf of the Department for International Development, in partnership with SCC, from October 2018 to May 2019). Dr S. Miah, Dr A. Wong. *Contract Holders*: Prof J.M. Preston, Dr I. Kaparias.

This project, which was undertaken in conjunction with the Bangladesh University of Engineering and Technology, took the ideas and concepts developed through the EU Metamorphosis project (see above) to Low Income Countries. In particular, further trials were conducted to make the neighbourhoods around two schools in Bangladesh more child-friendly, through contributory activities developed with the schools and local parents and children. This was supplemented by the development and implementation of an on-line 'Toolkit', which provided practical case studies as well as very useful guidance for the further development of child-friendly neighbourhoods, and that acted as a local language prototype for other Low and Middle income Countries to adopt (see . http://metamorphosis-global.org). This research was conducted as part of the High Volume Transport applied research programme in Transport – Technology Research Innovation for International Development (T-TRIID).

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.

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.
In 2019 an assessment of the infrastructure investment planned for the Oxford-Cambridge was undertaken by the consortium. The results have been disseminated widely and have generated interest from a range of stakeholders.

Work at TRG has focused on enhancing the transport models developed during ITRC phase 1. This centred on building an integrated framework covering capacity, demand and risk, and incorporating a network-based representation of the British transport system. Tasks have included 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 road model and updated rail and air models, 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). This aims 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. This includes 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 has subsequently been undertaken for Curacao.

ACHILLES (Assessment, Costing and Enhancement of Long-Life, Long-Linear Assets) (EPSRC Programme Grant, July 2018 to December 2022). Dr J. Armstrong. *Contract Holder:* Prof J.M. Preston.

ACHILLES is led by Newcastle University and also includes universities at Bath, Durham, Leeds and Loughborough, as well as the British Geological Survey. TRG will be working closely with the Infrastructure Group at the University of Southampton. ACHILLES is focussed on long-linear assets that are critical to the delivery of services over long distances such as road and rail embankments and cuttings, pipeline bedding and flood protection structures. TRG's work will provide economic forecasting and decision support at the network level. More specifically, a model of Whole Life Costs of interventions will be developed and the social costs of service disruptions examined. Risks and uncertainty will be considered using Monte Carlo Simulation within a Bayesian hierarchical structure. A fast track analysis of road and rail infrastructure on the London – Bristol corridor is being undertaken.

Comparative Economic Assessment of Urban Transport Infrastructure Options in Low and Middle Income Countries (PhD Studentship, from April 2017, funded by the Vietnamese Government and Faculty of Engineering and Physical Sciences), Minh Tam Vu.

Supervisors: Prof J.M. Preston, Dr S.P. Blainey.

Powered two wheelers (PTWs) are dominant in mixed traffic environments in developing countries and in particular in East Asia. Furthermore, significant increases in PTWs and Demand Responsive Rapid (e.g. Taxi and Uber) in urban areas pose 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 evaluation methods of motorcycles, cars and public transport to analyse feasibility of a new PT mode. Hence, the main aims of this thesis are to (i) Analyse the feasibility of new PT technologies in mixed traffic environments with a dominance of PTWs; and (ii) Identify the most cost-effective mixed transport system.

To achieve these aims, the research develops a comparative economic assessment for comparing public transport technologies, Demand Responsive Transit and private transport for a local transport corridor. 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, incremental nested logit models, incremental elasticity analysis 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.

Future Funding for Highways (part-time PhD from January 2014) Katherine Tegerdine. *Supervisors*: Dr I. Kaparias, 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. Awarded 2019

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

C:TTIME (BAE Systems from May 2018 to May 2019). L. Webster, S. Twist, D. Fay, K. Pope, C. Fenton, *Contract Holders*: Dr A. Roberts, Prof N.A. Stanton.

The armed forces are required to build Collective Training (CT) capability in a climate of increasing constraints on time, money and resources. This has fuelled a drive to identify and validate innovative training interventions that maximise collective performance. The Defence Human Capability Science and Technology Centre (DHCSTC) issued a statement of requirement to assess ways in which novel methods could be utilised to accelerate and enhance team performance. The Collective Teamwork Training Intervention Measurement and

Evaluation project (C:TTIME) was a program of work designed to address this requirement. To be achieved via identification of a wide range of interventions and measures of teamwork to inform rigorous experimental evaluation of their effectiveness. To date the C:TTIME team have completed a literature review of teamwork measures and intervention which has been accepted as the basis of a 'State of Science' publication with world leading co-authors in a high impact journal in the field of Human Factors. The team have also designed and developed a novel experimental protocol to assess the performance of augmented teams during submarine control room and domain agnostic operations. The work has been appraised by military stakeholders with clear avenues of exploitation having been identified depending on the success of the testing process.

Open Flight Deck (OFD) (Innovate UK from March 2017 – February 2020) Dr V.A. Banks, Dr 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 to extend safe aircraft operations. Further it also seeks to integrate new and existing applications to add functionality, simplify the flight deck, reduce error potential and harness big data opportunities. 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.

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.

ComTET2 (BAE Systems from 2017-2020). D. Fay, K. Pope, C. Fenton., *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.

Training Implications for Drivers of Automated Vehicles (funded by Institute of Advanced Motorists RoadSmart and EPSRC Centre for Doctoral Training at the University of Southampton, from September 2019), Siobhan young . *Supervisors:* Prof N.A. Stanton, Dr K.L. Plant, Dr K.M.A. Revell.

Autonomous Vehicles are expected to bring society a huge number of benefits. These include improved safety (fewer accidents and traffic law violations), efficiency, and mobility on the road, however these benefits will only be realised if drivers are trained in how to use them.

There have been a number of high-profile accidents involving Autonomous Vehicles in the last few years (e.g. The Uber Level 3 Autonomous Vehicle crash in Tempe Arizona which killed a pedestrian). In this particular incident, the driver was looking down at her phone rather than at the road at the time of the collision. It is well known in the research community that when Autonomous Vehicles are introduced onto the market, the driver's job will change from an active role of vehicle manoeuvring and control to a passive role of supervising and monitoring the vehicle and the road environment. As demonstrated clearly in the crash example above, drivers do not know how their job will change when Autonomous Vehicles are introduced, therefore they need to be properly trained.

Most manual driver training programs are based on the IPSGA (Information, Position, Speed, Gear and Acceleration) system of vehicle control. However, as the nature of the driving task will change when Autonomous Vehicles are introduced onto the market (see above), a new driver coaching system needs to be developed. This PhD project will attempt to address these issues and problems by designing, developing, testing and validating a new driver coaching system for drivers of automated vehicles.

Applying a Sociotechnical Systems Approach to Improve Cycling Road Safety and Increase Cycling Participation (funded by Southampton University, from October 2018), Matthew Webster. *Supervisors:* Dr K.L. Plant, Prof N.A. Stanton.

Cycling provides many benefits, such as increased physical health, a positive contribution to the economy and reduction in air pollution. Despite this, cycling still is involved in a constant battle to be seen as a positive activity amongst the media and non-cyclists and cyclists too. On top of this, a huge gender divide with the majority of cyclists being male creates a struggle to ensure that

infrastructure is inclusive towards women. Furthermore, the low participation levels of younger children riding a bike to and from school within the UK is considerably small when compared to the Netherlands (2.5% vs 30%). Finally, the number of cycling accidents throughout Britain is worryingly high being around 18,477 in 2016, this number made up around 8% of all modal accidents within the UK which, when comparing the number of cyclists against vehicles, highlights a need for change.

This research begins to tackle cycling by treating it as a system and taking a sociotechnical approach, by researching into social (News, Social media, Neighbourhoods, Peoples views), technical (legislation, economic, accessibility), hardware (Signs, potholes, roads, cycle lanes, theft/safety) and organisational (Government, Council, Schools, Emergency Services) features of cycling to create a safer cycling Britain and increase participation across all levels of cycling, ages, and gender.

In time this research hopes to join forces with other organisations such as British cycling, local governments and high-profile company's and public figures involved within cycling to allow a stronger reach and implementation of interventions to be tested and improved to allow them to be as effective as possible and provide a strong set of recommendations that can ultimately be used and applied within the UK.

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 (part-time) 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.

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 CO_2 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, 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 CORSIA will impact the major UK/Chinese airlines from 2021. In addition, this research will also explore the potential cost-control strategies in the post-implementation phases that can be leveraged to gain competitive advantage by major international airlines.

Maritime Command and Control Human-Machine Interaction (sponsored by DSTL and BAE Systems, PhD (part-time) 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.

Dynamic Risk Assessment: A Systematic Review (Funded by the Royal Navy, PhD from January 2018) Mark Sanderson. Supervisors: Prof N.A. Stanton, Dr K.L. Plant

Dynamic Risk Assessment (DRA) is synonymous with decision making under changing conditions in order to maintain a safe working environment. It is a concept typically used in industries such as aviation, oil and gas exploration, health care and the emergency services. More recent work has broadened into outdoor adventure activities and military leadership. However, it is argued that DRA has far wider utility and should be considered a key aspect of any safety management system.

Commencing with a systematic review, the initial aim of this study is to determine the key factors of DRA in a safety context. Although in its infancy, the study already finds there to be several recurring themes including Situational Awareness (SA), resource constraints, complexity, loss of control, uncertainty and environmental influences.

Once complete, the data will be used to develop a network model and illustrate the contribution of each element by weighting them based on their frequency of occurrence. This will be achieved for individual factors as well as the inter-connections to present DRA in an entirely new way. This should enhance contemporary understanding and improve safety performance where work is conducted at the sharp end.

Subsequent research will use a case study of a recent military accident to validate this model. Beyond this the work may bridge into established fields such as Distributed Situational Awareness (DSA), Naturalistic Decision Making (NDM), error and violation, risk perception, risk assessment and safety management.

4. TRANSPORTATION RESEARCH GROUP PUBLICATIONS 2019

1. Allison, C & Stanton, N 2019, 'Eco-driving: the role of feedback in reducing emissions from everyday driving behaviours' *Theoretical Issues in Ergonomics Science*, vol. 20, no. 2, pp. 85-104. DOI: 10.1080/1463922X.2018.1484967
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3. Almujibah, H & Preston, J 2019, 'The total social costs of constructing and operating a high-speed rail line using a case study of the Riyadh-Dammam Corridor, Saudi Arabia' *Frontiers in Built Environment*, vol. 5. DOI: 10.3389/fbuil.2019.00079
4. Almujibah, HR & Preston, J 2019, 'High-speed rail forecasting demand model, using Riyadh-Dammam corridor, Saudi Arabia as a case study' Paper presented at Universities' Transport Study Group - 51st Annual Conference, Leeds, United Kingdom, 8/07/19 - 10/07/19, .
5. Almujibah, HR & Preston, J 2019, 'Modelling of intercity transport mode choice behaviour: case study of Riyadh-Dammam corridor, Saudi Arabia' Paper presented at Railway Engineering 2019, Edinburgh, United Kingdom, 3/07/19 - 4/07/19, pp. 1-13.
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11. Armstrong, J., Preston, J. & Bektas, T., 2019. 'Improving the Trade-Offs Between Network Availability and Accessibility.' Paper presented at the 8th International Conference on Railway Operations Modelling and Analysis (RailNorrkoping2019), Norrkoping, Sweden, 17-20 June 2019
12. Armstrong, J., Raine, R., Draper, S. & Preston, J., 2019. 'Developing Objective Timetable Quality Metrics.' Paper presented at the 12th World

Congress on Railway Research (WCRR 2019), Tokyo, Japan, 28 October – 1 November 2019
13. Armstrong, J., Zieger, S., Preston, J. & Niessen, N., 2019. 'Identifying and Reducing Performance Uncertainty in UK Railway Timetables.' Paper presented at the 2nd International Railway Symposium Aachen (IRSA 2019), Aachen, Germany, 26-28 November 2019
14. Banks, V, Plant, K & Stanton, N 2019, 'Driving aviation forward: contrasting driving automation and aviation automation' *Theoretical Issues in Ergonomics Science*. DOI: 10.1080/1463922X.2018.1432716
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