ABSTRACTS TEXT AT OR60

The following pages list all the abstracts for presentations to be given at the conference. They are grouped by stream and are listed in the date/time order in which they appear in the full timetable. Please remember that some streams are split over more than one day.

Please note that this order may be subject to change.

To help delegates select relevant and accessible papers, each submitting author was asked three questions. The questions and their range of answers were:

What is the nature of your talk?

- Very practical
- Practical
- A mix of practical and theoretical
- Theoretical
- Very theoretical

Does your talk require prior knowledge of the subject area?

- None
- A little
- Some
- Quite a lot
- Subject experts only

Is your talk accessible and relevant to practitioners?

- Not at all
- Somewhat
- Relevant
- Very
- Highly

The three answers to these questions are listed after the abstract.

Aviation Applications

Organisers: Jamie Fairbrother and Konstantinos Zografos

12/09/2018, 09:00, Room - Faraday 2 Code: OR60A3360

Airline Disruption Management using Symbiotic Simulation and Multi-Fidelity Modelling

Mr Luke Rhodes-Leader *(Lancaster University)*, Prof Barry L. Nelson *(Northwestern University)*, Dr Bhakti Stephan Onggo *(Trinity College Dublin)* and Dr David Worthington *(Lancaster University)*

The airline industry is prone to disruption due to various causes, from weather conditions to airport congestion. Whilst an airline may not be able to control the causes of disruption, it can reduce the impact of a disruptive event by revising the schedule. Potential actions include swapping aircraft, delaying flights and flight cancellations. However, the situation is complex and uncertain, making potential decisions difficult to evaluate by the Operations Control Centre of the airline. A variety of deterministic methods have been proposed to aid the decision process. However, these fail to capture the uncertain nature of the industry. Symbiotic simulation offers a natural decision support system that can account for complex and dynamic behaviour. Symbiotic simulation is a methodology in which a physical system and the simulation model of it have a close interaction. New data from the physical system is fed into the simulation model to update it. In turn, the model outputs are used by an external decision maker to guide improvements in the performance of the physical system. Our research is considering how symbiotic simulation could be used to improve the response to a disruptive airline event by exploring and evaluating potential revised schedules. Due to the large solution space and non-negligible time to perform a high-fidelity simulation, exhaustive searches are infeasible. The simulation must be used selectively on solutions that are worth testing. We are investigating the use of multi-fidelity models to help guide the search of an optimisation algorithm, combining both deterministic models and simulation optimisation methods. The aim of this approach is to produce a set of good solutions within the time constraints of airline disruption management.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 09:30, Room - Faraday 2 Code: OR60A3290

An Approach to Airline Fleet Maintenance Scheduling

Mr David Torres *(STO-i)*

In the competitive aviation sector, airlines have to constantly evolve to keep up. Implementation of operational research methods to daily airline operations has become an integral part of the business. One area that can still be developed is aircraft maintenance scheduling. The focus

here being to schedule different checks and inspections at the most convenient time for both the airlines and maintenance operators. The aim is to aid negotiations between airlines and maintenance providers. We propose a fast maintenance scheduling tool that, while enforcing regulations and workshops constraints, minimises the maintenance costs and disruption to airline operations. Using new mixed integer programming (MIP) formulations based on pre-defined time intervals gives us the ability to deal with a long-term planning horizon. Moreover, by allowing flight re-scheduling and tail assignment on a pre-selected conflicting period, we can preserve efficiency. We are also able to solve the problem exactly. This is shown in our computational tests which, using flight data over a period of a month, through 16 workshops and multiple airlines, only took a few minutes to run. To improve solutions further, we can solve the problem iteratively, which gives us an improved allocation of resources.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 10:00, Room - Faraday 2 Code: OR60A3574

Multi-Objective Routing and Scheduling Algorithm for Airport Ground Movement

Dr Jun Chen and Dr Michal Weiszer *(Queen Mary, University of London)*

Recent research on airport ground movement introduced an Active Routing framework to support multi-objective trajectory-based operations. This results in edges in the airport taxiway graph having multiple costs such as taxi time, fuel consumption and emissions. In such graphs, multiple edges exist between two nodes, which can be traversed with different costs. In this paper, we introduce a multi-objective routing and scheduling algorithm specially for such a multiobjective multi-graph problem. Results using the proposed algorithm for a range of international airports are presented. Compared with other routing and scheduling algorithms, the proposed algorithm can find all optimal solutions in one run. For accelerating the search, heuristic functions and preference-based approaches are introduced.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 12:00, Room - LICA A28 Code: OR60A3694

KEYNOTE: Air Traffic (Flow) Management: Issues, Challenges, and Research Opportunities

Dr Guglielmo Lulli *(Lancaster University)*

Air Traffic Management is the overall collection of the air traffic system's management processes that support the ultimate goal of safe, efficient, and expeditious aircraft movement. Because the growth of demand has not been supported by a corresponding development of the air traffic system, the need of a more efficient use of capacity is imperative. In response of this need, prominent initiatives have been launched to modernize the Air Traffic Management system. In this talk, I provide an overview of some of the issues, challenges and research opportunities that are relevant to the analytics community in order to deploy a more flexible, resilient and scalable air transport system. In particular, I will focus on Air Traffic Flow Management and issues related to i) a wider participation of the airspace users in the decision process; ii) a higher degree of interaction among the different "ATM function" thus providing a seamless solution to air traffic management; and iii) a paradigm's shift from airways system to free airspace.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:00, Room - LICA A28 Code: OR60A3478

Considering Stakeholders' Preferences for Scheduling Slots in Capacity Constrained Airports

Mr Fotios Katsigiannis and Prof Konstantinos Zografos *(Lancaster University)*

Airport slot scheduling has attracted the attention of researchers as a capacity management tool at congested airports. Recent research work has employed multi-objective approaches for scheduling slots at coordinated airports. However, the central question on how to select a commonly accepted airport schedule remains. The various participating stakeholders may have multiple and sometimes conflicting objectives stemming from their decision-making needs. This complex decision environment renders the identification of a commonly accepted solution rather difficult. In this presentation, we propose a multi-criteria decision-making technique that incorporates the priorities and preferences of the stakeholders in order to determine the best compromise solution.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:30, Room - LICA A28 Code: OR60A3355

Optimizing Slot Allocation at Level 3 Airports Using Large Neighborhood Search Techniques

Mr Nuno Antunes Ribeiro *(CITTA, University of Coimbra)*, Prof Alexandre Jacquillat *(Carnegie Mellon University (CMU))*, Prof Amedeo Odoni *(Massachusetts Institute of Technology (MIT))* and Prof António Pais Antunes *(CITTA, University of Coimbra)*

Most of the busiest airports outside the United States, including the major connecting hubs, are classified as Level 3. At these airports, airlines need to be assigned slots by a coordinator to schedule flights. The underlying slot allocation process is very complex, with multiple criteria, rules and priorities, which are specified into the IATA guidelines. Recently, some optimization models have emerged in the literature aiming to support slot coordinators to better accommodate airlines' preferences at these airports. However, these models are not yet compliant with the IATA guidelines, and their application to large-scale airports is very limited. In this research we extend previous work in two major ways. First, we propose a novel integer programming model that optimizes slot allocation decisions at schedule-coordinated airports, while fully complying with the rules specified by the IATA guidelines. Second, we develop a heuristic algorithm based on large neighborhood search techniques to solve the slot allocation problem at large-size airports. We applied our model and heuristic at three Portuguese airports, Madeira (FNC), Porto (OPO) and Lisbon (LIS). Results suggest that our approach can significantly improve the efficiency of current practice by providing slot allocation results that match better the slot requests of airlines.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 10:00, Room - LICA A28 Code: OR60A3571

A Slot Allocation Model with Queuing Constraints Based on the Server-Always-Busy Approximation

Dr Jamie Fairbrother, Prof Kevin Glazebrook, Dr Robert Shone and Prof Konstantinos Zografos *(Lancaster University)*

At congested airports outside the US, airlines must obtain slots in order to land and take-off. Slots must be allocated to airlines in a way which matches their requested times as far as possible, while satisfying operational constraints. A key issue in the allocation of slots is how to construct a schedule which avoids long queuing delays. This can be addressed implicitly through the use capacity constraints which limit the number of runway movements which can take place during a given length of time, or explicitly through the incorporation of queuing dynamics into the slot allocation model. In this work we present approximation to queuing dynamics based on the assumption that the queue is never empty. We demonstrate how this can be used to formulate tractable mixed integer non-linear programs which could be used to set capacity limits, or could be incorporated directly into a slot allocation model.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 11:00, Room - LICA A28 Code: OR60A3449

Biased Randomised Iterated Greedy Search with Local Search for Airline Crew Scheduling

Miss Phornprom Rungrueang, Dr Banafsheh Khosravi and Prof Djamila Ouelhadj *(University of Portsmouth)*

Airline crew scheduling is a complex problem that is faced by airline companies. The crew scheduling problem is divided into two sub-problems: crew pairing and crew assignment. The crew pairing problem defines a sequence of flight legs of the same fleet which begins and ends at the same crew base location. Pairings are controlled by some complex constraints such as flying time restrictions, rest requirements of crew members, daily working hours of the crew and the connection time between two flights. The assignment problem assigns the pairings to crew members. Airline transportation frequently has to deal with disruptions caused by technical problems or weather conditions. This leads to delays between different resources such as aircrafts and crews. In this research, we propose to formulate the problem as a set partitioning model and using a heuristic method to generate the pairing flight schedules, assign the crew, and reschedule disrupted flights after assigning pairing schedules to crew by swapping delayed flights with other flights, in order to minimize total flying time. The heuristic proposed is the Biased Randomised Iterated Greedy Algorithm with local search, which employs destruction and construction phases to generate the flight schedules. The destruction phase removes randomly some flight candidates, and the construction phase inserts new flights in the partial solution to build a complete solution. The biased randomisation is used in the construction phase to select the flights to insert in the partial solution; and local search is used to intensify the search around the complete solution generated. Experimentation with benchmark problem from of real-world flight schedule in Turkey with 38 flights, 58 flights, and 96 flights. The evaluation of the performance shows that the Biased Randomised Iterated Greedy with Local Search outperforms the results in the literature for this case study.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:30, Room - LICA A28 Code: OR60A3378

Airline Crew Scheduling with Re-Timing and Complex Aircraft Connection Rules

Dr Fredrik Altenstedt *(Jeppesen Systems AB)*

Airline crew planning is usually divided into several problems solved sequentially. In this presentation we consider the pairing problem, the task of finding anonymous crew trips covering all flights. Mathematically the pure pairing problem corresponds to the set covering problem. Some of the rules the trips need to respect are influenced by the aircraft routes, typically shorter connections are allowed if the crew does not change aircraft. In addition, small flight re-timings may give cheaper crew solutions. Both re-timings and short connections may potentially make the aircraft routing infeasible, something traditionally addressed using plane count constraints. These constraints work well for simple aircraft connection rules but fail to maintain feasibility for more complex rules. In the Jeppesen Crew Pairing system we maintain aircraft feasibility by the addition of dynamically generated general aircraft feasibility constraints. In this presentation we will give an overview our implementation as well as share our experience from using the system with one of our clients.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

Behavioural Operational Research (BOR)

Organiser: Sally Brailsford

13/09/2018, 09:00, Room - Faraday 2 Code: OR60A3393

KEYNOTE: System Dynamics and Behavioural OR in Management Education

Dr John Morecroft *(London Business School)*

OR60 is a time for reflection. In this talk I revisit a paper I wrote in 1983 entitled 'Administrative Science and System Dynamics: Filling a Gap in Management Education'. In a youthfully ambitious way I identified a key insight and educational objective, under-developed in management education, to make students vividly aware of the sharp distinction between seemingly integrated decision processes used in making personal choices and the loosely coupled, decentralised decision processes that an organisation uses to make business choices. We often complain about organisations, especially our own, where the left-hand doesn't seem to know what the right hand is doing. But we would not want to live in a world stifled by the quest for perfect coordination. System dynamics can help to explain why imperfect coordination is normal and need not be problematic in a well-designed enterprise. In fact loose coordination and freedom for independent action are surely welcome in a complex information-rich world. I begin with a review of the feedback view of management and decisionmaking. In doing so I demonstrate the behavioural underpinnings of system dynamics where bounded rationality limits the flow of information to operating polices that underpin firms' strategies. I show that system dynamics models are essentially behavioural models of the firm. Such models provide a powerful way to understand the coordination of business operations and to improve firm performance through satisficing policy design rather than optimisation. I end with an example of the contemporary use of system dynamics simulators in management education which is where I believe model-based behavioural ideas will thrive. Insights from behavioural simulation models can help inform the next generation of business leaders about the wise design of enterprises to coordinate and inspire the efforts of normally competent people.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 10:00, Room - Faraday 2 Code: OR60A3483

Lessons for Mixed Method Work: Interviews with Experienced OR Modellers

Prof Susan Howick *(University of Strathclyde)* and Prof Fran Ackermann *(Curtin Business School)*

The complexities of real-world problems often mean that OR modellers need to bring together multiple methodologies, methods and tools to effectively tackle these problems. Although

there has been a lot of attention paid to the theoretical issues associated with multi-methodology, there has been limited attention paid in the literature to generic lessons that could be gained from the practice of mixing methods (Howick and Ackermann, 2011). To address this issue, Howick and Ackermann (2011) recommended that "in-depth interviews with experienced facilitators/modellers would help to understand better what takes place when mixing methods and why". In response to this call, in-depth interviews have been carried out with 14 prominent academics and practitioners in the OR community, with an average of 25 years of experience working in OR. The aim of the interviews was to reflect on, and learn from, past practice to identify common lessons about mixing methods that could inform future practice and teaching and provide avenues for future research. Areas covered by the interviews include how the modelling team worked together, the mixed method approach that was used, how the client reacted to the modelling and the perceived value from the intervention. This presentation will describe the research process undertaken to design and code the interviews and will present initial insights that have arisen from the analysis of the interview material. Real-world problems are not getting any less complex, thus working with multiple methods will continue to play a vital role in providing OR support to decision-makers and learning from past practice can contribute to the success of that future practice.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:00, Room - Faraday 2 Code: OR60A3643

Coordination and Risk Preference in a Project Supply Chain Using Project Contracts

Dr Niladri Palit *(Glasgow Caledonian University)* and Dr Andrew Brint *(University of Sheffield)*

Coordination in supply chains has been found to offer optimal individual and overall results. This has attracted considerable attention in the literature in the form modelling of supply chain coordination for product based supply chains (i.e. where demand is the source of uncertainty and the price is the decision variable). A little is known about coordination in project based supply chains. This is a problem as projects are infamous for cost and time overruns and lack of supply chain coordination has been found to be a cause e.g. the Denver airport renovation project (Moore, 2009). Moreover, limited attention has been paid on how the decision-making changes when the risk preferences of the members of the supply chain change. Most of the derived models have assumed that the members of the supply chain are risk neutral. However, in practice, certain non-profit maximizing behaviours have been noted in the literature (Wang and Webster, 2007). While models have been derived for product based supply chains, little is known about coordinating the supply chain in the important area of projects when the members of the supply chain have different risk preference. A model proposed by Lippman et al (2013) considered the case with a risk-neutral project manager and a risk-averse contractor in a bargaining setting. However, there is limited knowledge available when the members of the supply chain make decisions in a take-it-or-leave-it situation. Therefore, we propose a model with differential risk preference in a take-it-or-leave it situation using project contracts. We derive a model using a risk-neutral project manager and a risk-averse contractor, and a risk-averse project manager and a risk-neutral contractor. Certain differences were observed in results from the situation where both the members of the supply chain were risk neutral.
What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:30, Room - Faraday 2 Code: OR60A3407

A Descriptive Analytics Study of Treatment Process Differences with and Without an Ambulance Offload Zone

Dr Peter Vanberkel, Dr Alix Carter and Ms Molly Elliott *(Dalhousie University)*

In this paper we compare the emergency department (ED) treatment processes which occur when an Ambulance Offload Zone (OZ) is functioning and when it is not. An OZ is a monitored waiting space for ambulance patients which is designed to allow ambulance crews to return to service more quickly. The implementation of OZ style concepts has been trialled around the world with mixed results. In this paper we use concurrent comparison data and show how treatment processes and the behaviour of ED actors change when the OZ is functioning. We discuss how these changes in behaviour impact the effectiveness of the OZ.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 12:00, Room - Faraday 2 Code: OR60A3291

Towards an Agent-Based Model of Conflict within the Social Networks of Enterprise System Programmes

Dr Richard Williams *(Lancaster University)*

It is commonly known that the majority of failures within enterprise system programmes are due to human and organizational reasons, and not the technology itself. This is predominantly due to the fact that the implementation and management of large software programmes often becomes the preserve of external service providers. It has been argued that the increasing size and complexity of these enterprise system programmes, leads them to exhibit the behaviours and traits of complex systems. The emergent behaviour generated within the system, may, to a large degree, be due to the complexity stemming from the large number of team members, and the growing trend of using multiple third parties to implement the programmes. Furthermore, individual project teams within these programmes may have competing priorities and objectives, leading to various forms of conflict. As such, the resulting intragroup and intergroup conflict may propagate throughout the wider social network of the programme. We believe that computational modelling and simulation of conflict within the social networks of enterprise system programmes will complement empirical approaches and facilitate a more comprehensive understanding. We have developed an agent-based model of individual team member interactions, focusing on their social behaviours with respect to motivation, commitment, group loyalty, and trust. Our model provides an abstracted view of the emergence and propagation of conflict, which we conjecture is topologically similar to the spread of contagion throughout a pathogenic network. Simulations confirmed the robust yet fragile nature of group dynamics. We have discovered that the programme-level social network is robust to perturbations of task conflict within individual project teams. Conversely however, simulations predict that the pathway is sensitive to increased levels of process conflict, and fragile to relationship conflict outside of a narrow range of probabilities.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

Business Analytics

Organisers: Michael Mortensen and Richard Vidgen

13/09/2018, 09:00, Room - Bowland Hall S Code: OR60A3339

Estimating Small-Area Earned Income Distributions in the UK Using Open Source Data

Dr Colin Stewart *(More Metrics Ltd)*

Organisations frequently use income criteria to help target marketing activity and to check the eligibility of individuals for different services. This is particular so for financial services firms providing consumer credit who need to show they have policies and procedures in place that are effective in mitigating the risks of unaffordable borrowing. This presentation will show how organisations of all shapes and sizes can undertake a validation of an individual's stated level of earned income using only aggregated open source data. The Annual Survey of Hours and Earnings (ASHE) data published by the Office for National Statistics (ONS) is used as the source data for earned income with small area characteristics derived from the 2011 census as model variables. It will be explained how full coverage across the UK down to an individual household is possible using the approach developed by the author. The key steps in the process used to estimate earned income distribution estimates will be described, with particular attention being paid to how to avoid the pitfalls of ending up with an over-fitted and /or poorly specified model. The importance of estimating local income distributions rather than a single central income value will be explained. In addition, the knotty problem of how to account for changes to the make-up of neighbourhoods since the 2011 census will be discussed. Finally, some brief examples of how the modelling approach is and can be applied to real- world decision making will be given.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:30, Room - Bowland Hall S Code: OR60A3458

Design Thinking in Business Analytics Development

Prof Richard Vidgen *(UNSW)* and Dr Giles Hindle *(University of Hull)*

The business analytics methodology (BAM) developed by Hindle and Vidgen is a structured approach that helps organizations define their business analytics projects. It draws on the business model canvas and soft systems to identify value-creating analytics opportunities. In recent developments of the BAM we have introduced design thinking as a way of taking an analytics project identified in the up-stream part of BAM into the next level of design detail. We follow the design thinking process of empathize, define, ideate, prototype, test. In particular we use two well-established techniques in design thinking: persona development and storyboarding. The persona development is used to understand the customer (user) of the

product/service and to map their journey. Storyboarding is used to show how an analytics development is woven into the life of the user and the business processes of the organization to create business outcomes from technical artefacts such as a predictive model. The method has been developed and applied through working with GoGet, an Australian car-sharing service. Examples of BAM and design thinking as developed for GoGet will be presented in the session.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 10:00, Room - Bowland Hall S Code: OR60A3532

The Transformation of 'Big Data' into Market-Level Analytics: A Framework for Clickstream Data

Prof Christopher Holland *(Loughborough University)*

Big data is a term used to describe data with the characteristics of high volume, velocity and variety with the potential for veracity and value. This could include weather patterns, social media exchanges, production data or sales transactions. An important OR and analytics challenge is the analysis and interpretation of big data to support decision-making and shape business strategies. In this paper, clickstream data is used to illustrate the transformation of big data into market-level analytics to measure online performance. Online firm performance can be measured in absolute terms or relative to the market. Analytics software such as Omniture and Google analytics uses clickstream data from a single server, i.e. the focal firm's website, to generate basic statistics such as number of visitors, paid search performance and search trajectory, all within a single website. This is valuable but tells managers nothing about the performance of a firm relative to its competitors and therefore generates few or no strategic insights. In contrast, an online panel creates clickstream data concerning a set of competitors and can therefore be used to develop performance measures such as share of visitors and online sales conversion relative to the market and can be combined with other market-level data such as market research. A hierarchical market-level analytical framework is proposed that helps managers conceptualise and understand the analytical stages involved in moving from raw clickstream data to strategic insights. The US airline market is used to illustrate the application of the framework. The results demonstrate the synthesis of clickstream data with sales information to create an online sales map, measure online sales variability, identify important performance variations between legacy and discount airlines, and to classify strategic groups of competitors. Future research opportunities are outlined.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:00, Room - Bowland Hall S Code: OR60A3545

Principles and Practice of Collaborative Data Exploration: The Case of Transport for the North (TfN)

Mr Aidan Cross and Mr Tim Foster *(TfN)* and Prof Richard Vidgen *(UNSW)*

In this session we will explore how organizations can share data and seek solutions to key business and public policy questions through collaboration with academics, practitioners, and other organizations (e.g. app developers) across multiple disciplines and levels of seniority. To explore the practical issues involved in collaborative data exploration we will focus on

Transport for the North (TfN) and its data opportunities. TfN is the organisation formed to transform the transport system across the North of England, providing the infrastructure needed to drive economic growth. TfN is a unique partnership, with elected and business leaders from all areas of Northern England uniting to work with central government and national transport bodies. In April 2018 it became the first sub national transport body with statutory powers to produce the long term plan for investment in the North to drive economic growth and help rebalance the UK economy. TfN's unique mission has required the development of new thinking, tools and approaches about the impact of transport on the economy of the North of England, and the wider impacts on skills, investment and innovation. To facilitate this, TfN is looking to open up its data to domain experts from across operational research, analytics, economics and transport to collaborate in the construction of an evidence base to support transformation of the economy of the North.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:30, Room - Bowland Hall S Code: OR60A3627

A Methodology for Identifying New US Flying Routes Using Algorithms from Machine Learning

Prof Rafael Carmona-Benítez and Prof Maria Nieto *(Universidad Anáhuac México)*

Airlines and airports are continuously looking to operate new routes. Research on developing models and methodologies for estimating potential route markets allows to make decisions on what routes to operate. In literature, few papers study this problem by developing models for identification of potential air passenger demand (pax). The aim of this paper is to propose a methodology that identifies potential non-stop flight routes as potential markets. The methodology estimates the unmet route pax. The unmet route pax is the pax that has not been satisfied. It is calculated as the difference between the potential market size and the current pax flow. The unmet route pax exists when airlines do not meet total pax. The methodology estimates the unmet route pax and determine what routes represent an opportunity to open new services using the unmet pax. To do so, two mathematical models are proposed. First step allocates airports into homogeneous clusters based on socio-economic factors that determine pax. Clustering methods from machine learning are applied. The socio-economic factors are taken from recent papers on pax forecast, competition and market share. Based on this classification, routes are allocated into homogeneous clusters (O-D pair groups). Second step proposes to model the distribution of each O-D pair group using Bootstrap methods. These distributions are used to estimate routes market size. Third step forecasts route pax using the ARIMA-GARCH-Bootstrap method. Forth step proposes a model that forecast the unmet pax using the route market size (second step) and the route pax forecast (third step). Finally, the proposed strategy determines what routes represent an opportunity to open new services using the unmet pax. The models and methodology are set up by analyzing the U.S. domestic air passenger market. The results show that the methodology identifies routes where an opportunity to open new services may exist.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 13:30, Room - Bowland Hall S Code: OR60A3654

Applying Internet of Things Concept to Study the Bullwhip Effect in Chemical Industry

Dr Christos Papanagnou *(University of Salford)*

Chemical companies are constantly looking for ways to optimise their inventory management performance by improving their relationships with the vendors, investing in new data while minimising the bullwhip effect. Internet of Things (IoT) provides a new platform where the flow of information can be integrated throughout the chain. In this research, replenishment policies are reinforced by IoT and are modelled with the aid of a proportional (gain) controller. Then, a state space model is derived to capture the inventory and information dynamics between neighbouring nodes as a function of information, inventory and a variable representing the absence/presence of IoT practices. Customer demand is represented by a stochastic sequence while the model is analysed under stationarity conditions with the aid of a covariance matrix. This leads to computation and characterisation of the bullwhip effect, which is a function of replenishment proportional gain and the IoT variable. The main objective of the study is not only to gain a comprehensive in-depth understanding of IoT practices and inventory management but also to offer inventory managers an insightful model to (1) tackle inventory fluctuations and associated management, which is currently predominantly manual with heavy reliance on human input to update the inventory status, (2) understand how information sharing and IoT can help to cope with bullwhip effect and (3) reap the benefits of applying IoT practices.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 14:00, Room - Bowland Hall S Code: OR60A3668

Intelligent Automation of Common Sense Mortgage Lending

Dr Swati Sachan, Prof Dong-Ling Xu and Prof Jian-Bo Yang *(Alliance Manchester Business School)*

Some lenders have adopted ‘common sense lending’ approach which involves case by case assessment of individual mortgage loan applications instead of giving weight to some basic facts and credit scores, such as in high street banks and building societies. Individualistic assessment requires underwriters to follow decline and referral rules, affordability factors, repayment and default history, and other loan details. With time a substantial of data is getting accumulated, policies have become more complex and the consequence of noncompliance is getting more severe. A manual decision making by underwriting in such situation causes stress and unrecognized biases or errors. This research proposes a transparent intelligent automation system by an expert rule-based system. It makes joint utilization of expert knowledge and heterogeneous source of credit risk data available from external agencies and internal data of lending institutions. Both expert knowledge and credit data are independent and complementary and are used to train the parameters belief-rule-base system and machine learning model. The proposed methodology can determine the nonlinear relationships between default features and can explicitly represent the underwriter’s domain-specific knowledge as well as the judgment from historical data. The decision of rejecting or funding an application is fine-tuned by aggregating the output from the automated system with machine learning model.
What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

Combinatorial Optimisation

Organiser: Adam Letchford

11/09/2018, 11:00, Room - Welcome 3 Code: OR60A3451

On Matroid Parity and Matching Polytopes

Dr Ioannis Mourtos *(Athens University of Economics and Business)*, Dr Konstantinos Kaparis *(University of Macedonia)* and Prof Adam Letchford *(Lancaster University)*

The matroid parity problem naturally extends the matching problem to the matroid setting and can be formulated as a 0-1 linear program, using the so-called rank and line constraints. We call the associated family of polytopes MP polytopes. We then show the following: (i) when the matroid is a gammoid, each MP polytope is a projection of a perfect matching polytope into a suitable subspace; (ii) when the matroid is laminar, each MP polytope is affinely congruent to a perfect matching polytope; (iii) even if the matroid is laminar, MP polytopes can have facet-defining inequalities with non-ternary coefficients; (iv) for any matroid, the elementary closure of the continuous relaxation of the rank-and-line formulation is equal to its {0-1/2}-closure.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Not at all

11/09/2018, 11:30, Room - Welcome 3 Code: OR60A3367

Towards Primal-Dual Methods for the Binary Multi-Dimensional Knapsack Problem

Dr Stathis Plitsos *(Athens University of Economics and Business)*, Dr Konstantinos Kaparis *(University of Macedonia)* and Dr Ioannis Mourtos *(Athens University of Economics and Business)*

We present a new primal-dual algorithm for the binary multi-dimensional knapsack problem (0-1 MKP). The proposed scheme combines a class of valid inequalities for the 0-1 knapsack polytope known as global lifted cover inequalities and a new variant of the feasibility-pump heuristic. The core idea is the integration of the separation algorithm within the feasibility pump and the exploitation of the synergy that can be achieved between the two schemes. More precisely, the availability of tighter lower bounds leads to the separation of stronger cuts. Note that these cuts are invalid for the integer 0-1 MKP polytope, but they do not cut off the optimum integer solution. The tighter upper bound solution is then utilised by the feasibility pump in order to improve the quality of the lower bound solution. We present preliminary results that illustrate the effectiveness of the proposed scheme.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 12:00, Room - Welcome 3 Code: OR60A3447

On Cut Polytopes and Graph Minors

Dr Konstantinos Kaparis *(University of Macedonia)*, Prof Adam Letchford *(Lancaster University)* and Dr Ioannis Mourtos *(Athens University of Economics and Business)*

Given an edge-weighted undirected graph, the max-cut problem calls for a partition of the vertex set into two subsets, such that the total weight of the edges having one end-vertex in each subset is maximized. The max-cut is NP-hard in the strong sense and is one of the most well studied combinatorial optimisation problems. In this work we analyse the structural properties of certain classes of graphs upon which max-cut is defined. More precisely, we exploit the graph minor theorem due to Robertson and Seymour which allows for the constructive characterisation of minor-closed families of graphs and we use such characterisations (a.k.a. decompositions) for deriving complete polyhedral descriptions of certain families of cut polytopes.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Not at all

11/09/2018, 13:30, Room - Welcome 3 Code: OR60A3395

A Decomposition Algorithm for the Robust Lot-Sizing Problem with Remanufacturing

Miss Öykü Naz Attila *(University of Strathclyde)*

In this study, we propose a decomposition algorithm for the robust lot sizing problem with the option of remanufacturing. We assume that demands and returns are uncertain and belong to predetermined uncertainty sets, defined as budgeted polytopes (Bertsimas and Sim, 2004). The algorithm involves a min-max approach where two subproblems, namely the Decision Maker's Problem (DMP) and the Adversarial Problem (AP) are solved iteratively until a robust optimal solution is found (Bienstock and Özbay, 2008). The DMP seeks for a production plan that minimizes the total operational cost for a subset of demand and return scenarios. Subsequently, the AP returns a new scenario that worsens the total inventory and backlogging cost, which is then added to the DMP in the next iteration. The uncertainty sets are searched for worse solutions in this fashion, until none of the remaining scenarios are able to increase the inventory costs for the given production plan.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 14:00, Room - Welcome 3 Code: OR60A3551

Experiments with a General Benders' Decomposition Framework in SCIP

Dr Stephen Maher *(Lancaster University Management School)*

Benders' decomposition is a popular mathematical programming technique for solving large-scale optimisation problems. Unfortunately, since Benders' decomposition is viewed as a problem specific algorithm, it use typically requires bespoke implementations. While there are many state-of-the-art mixed integer programming solvers, there has been little attention paid to the development of general implementations of decomposition methods. The constraint integer programming solver SCIP has been extended to include a general Benders' decomposition framework in order to exploit the tighter integration with a mathematical programming solver and achieve algorithmic performance improvements. Further, with the use

of GCG the general framework has been used to evaluate the effectiveness of applying Benders' decomposition to the general mixed integer programs. The results demonstrate the benefits from implementing a general Benders' decomposition framework within a state-of-the-art mathematical programming solver.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:30, Room - Welcome 3 Code: OR60A3380

Cutting Planes and Column Generation with the Primal-Dual Interior Point Method

Prof Jacek Gondzio *(University of Edinburgh)*

We discuss the advantages of using interior point methods (IPMs) to solve the non-differentiable optimization problems that arise in the context of cutting plane and/or column generation applications. Along the way, we correct some false views that are widely held in the combinatorial optimization community. In particular, we argue that IPMs deliver a natural stabilization when restricted master problems are solved, which leads to fast convergence, in terms of the number of master iterations needed to localize the solution. Several new features of the approach, such as the use of primal-dual regularization and efficient IPM warm starts, will be discussed. Finally, some computational results will be reported, obtained with the Primal-Dual Column Generation Method (PDCGM) software:
http://www.maths.ed.ac.uk/~gondzio/software/pdcgm.html. This is a joint work with Pablo Gonzalez-Brevis and Pedro Munari.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:00, Room - Welcome 4 Code: OR60A3683

Algorithms for the Bilevel Knapsack Problem

Dr Ashwin Arulselvan *(Ashwin Arulselvan)* and Prof Alec Morton *(University of Strathclyde)*

We have a bilevel knapsack problem in which, at the outer level, a leader decides on how much cost subsidy could be provided to a set of projects of his interest. At the inner level, the follower solves another knapsack problem with some of the projects having subsidised costs. Both players have their own budgets and profit functions. We analyse several special cases, for which we provide efficient algorithms. We also provide an exact algorithm for the general case, for which we show convergence. The problem finds applications in health economics, where a donor is interested in allocating funds to developing countries for health-related projects.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 09:00, Room - Welcome 3 Code: OR60A3356

A First-Order Method for Binary Quadratic Programs

Mr Nirmalya Kumar Mohanty and Dr Rupaj Kumar Nayak *(International Institute of Information Technology)*

Many important optimisation problems arising in practical applications can be formulated as Binary Quadratic Programs (BQPs). In general, BQPs are NP-hard in the strong sense, but a variety of effective exact and heuristic algorithms are available. Recently we came across an interesting application of BQP: an image restoration problem, in which the goal is to re-create an image that has been corrupted by noise. This problem leads to very large-scale BQP instances. To tackle them, we propose a heuristic approach based on semidefinite programming (SDP). Since existing second-order interior-point methods for SDP are too slow for our application, we also devise and test a new first-order method.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:30, Room - Welcome 3 Code: OR60A3487

Anomalous Behaviour of Dual-Based Heuristics

Mr M. Hasan Mansoor, Dr Trivikram Dokka and Prof Adam N. Letchford *(Lancaster University)*

Some popular heuristics for combinatorial optimisation are "dual-based", in the sense that they first solve some kind of dual problem, and then attempt to exploit information from the dual solution(s) when constructing primal solutions. We show that dual-based heuristics can exhibit highly counter-intuitive behaviour. In particular, greedy heuristics for solving the dual, which consistently yield dual solutions of poor quality, can consistently yield primal solutions of high quality; and, conversely, high-quality (even optimal) dual solutions can consistently yield primal solutions of poor quality. Furthermore, for any given dual heuristic, there is often no correlation between the quality of the input dual solution and the quality of the output primal solution. We use the simple plant location and set covering problems as examples.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 09:30, Room - Welcome 4 Code: OR60A3572

An Integer Programming Approach to the Student-Project Allocation Problem with Preferences over Projects

Miss Sofiat Olaosebikan, Dr David Manlove and Mr Duncan Milne *(University of Glasgow)*

The Student-Project Allocation problem with preferences over Projects (SPA-P) involves sets of students, projects and lecturers, where the students and lecturers each have preferences over the projects. In this context, we typically seek a stable matching of students to projects (and lecturers). However, these stable matchings can have different sizes, and the problem of finding a maximum stable matching (MAX-SPA-P) is NP-hard. There are two known approximation algorithms for MAX-SPA-P, with performance guarantees of 2 and 3/2. In this paper, we describe an Integer Programming (IP) model to enable MAX-SPA-P to be solved optimally. Following this, we present results arising from an empirical analysis that investigates how the solution produced by the approximation algorithms compares to the optimal solution obtained from the IP model, with respect to the size of the stable matchings constructed, on instances that are both randomly-generated and derived from real datasets. Our main finding is that the 3/2 -approximation algorithm finds stable matchings that are very close to having maximum cardinality.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 10:00, Room - Welcome 4 Code: OR60A3632

Mathematical Models for Stable Marriage Problems with Ties

Dr Maxence Delorme, Dr Sergio Garcia, Dr Jacek Gondzio and Dr Joerg Kalcsics *(University of Edinburgh)*, Dr David Manlove and Dr William Pettersson *(University of Glasgow)*

In the stable marriage problem, we are given two disjoint sets of agents, traditionally called "men" and "women", together with a set of (ranked) preference lists where each agent has ranked the members of the other set in order of preference. A solution of the problem has the particularity that no couple forms a blocking pair, i.e. prefers to be matched together more than to the mates to which they are currently assigned. When the list of preferences is strictly ordered, the problem can be solved in polynomial time by using the Gale-Shapley algorithm. However, in real world cases, we often have the presence of ties in the preference lists, and the problem of finding a maximum stable matching becomes NP-hard. In this talk, we are interested in two real-world matching problems: first, we study a classical stable marriage problem with ties, where the aim is to assign children to families in a children's charity. Then, we study a stable marriage problem with ties and capacities (also called the Hospital/Residents Problem with Ties). For both problems, we review the integer linear programming (ILP) formulations that have been proposed in the literature and we show their limits when the number of agents grow. We then introduce two new ILP models that use alternative constraints to ensure stability and measure their efficiency with respect to the classical models on both real world and randomly generated instances.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 10:00, Room - Welcome 3 Code: OR60A3680

Semidefinite Programming Relaxations of the Clique Partitioning Problem

Miss Anh Vu and Prof Adam Letchford *(Lancaster University)*

The Clique Partitioning Problem (CPP) is a much-studied (and strongly NP-hard) combinatorial optimisation problem, with many applications. One can construct a semidefinite programming relaxation of the CPP using standard techniques. We present four ways to strengthen that relaxation, two of which are non-standard. One is based on the addition of a small number of carefully chosen "aggregated" cutting planes, and the other exploits a lower bound on the optimal profit, obtained by a primal heuristic. Computational experiments are provided, on several families of instances.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

12/09/2018, 12:00, Room - Welcome 3 Code: OR60A3606

KEYNOTE: On Tractable Cases in Combinatorial Optimization

Dr Vladimir Deineko *(University of Warwick)*

This presentation will consist of two parts. The first part is an introduction to the exciting world of polynomially solvable cases of NP-hard problems (this is how we interpret here the term “tractable cases”). Three well-known NP-hard combinatorial optimization (CO) problems will be discussed: the quadratic assignment problem, the travelling salesman problem and the bipartite travelling salesman problem. Some cases in which these problems can be solved in polynomial time will be described. The second part of the presentation will illustrate a usage of CO algorithms in real life applications. We will reflect on our experience of situations in which theoretically easy problems become "tractable" in real life applications.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

12/09/2018, 16:00, Room - Welcome 3 Code: OR60A3350

HiGHS: High-Performance Open-Source Software for Linear Optimization

Dr Julian Hall and Miss Ivet Galabova *(University of Edinburgh)*

This talk will present HiGHS, a growing open-source repository of high-performance software for linear optimization based on award-winning computational techniques for the dual simplex method. The talk will give an insight into the work which has led to the creation of HiGHS and then set out the features which allows it to be used in a wide range of applications. Plans to extend the class of problems which can be solved using HiGHS will be set out. HiGHS is free for academic use under the MIT license, and the terms of its commercial use will be defined.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:30, Room - Welcome 3 Code: OR60A3484

MINLP in SCIP and Stronger Separation of Bilinear Terms

Mr Felipe Serrano, Dr Ambros Gleixner and Mr Benjamin Mueller *(Konrad Zuse Institute)*

In this talk, we briefly introduce how SCIP solves mixed-integer nonlinear programs (MINLP) and show a technique for stronger separation of bilinear terms. The standard way of separating bilinear terms uses the convex envelope of the function xy over the given bounds of the variables. By projecting the linear constraints present in the problem onto the x,y-space, we can obtain a polytope strictly contained in the bounds. Using the convex envelope of xy over this polytope gives stronger cutting planes. We also show that computing an approximation of the projection can naturally be integrated with OBBT, a procedure that SCIP uses when solving MINLPs. Finally, computational results are presented.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:00, Room - Welcome 3 Code: OR60A3417

Homomorphisms and Generalisations Seen From Both Sides

Dr Stanislav Zivny *(University of Oxford)*

The topic of this talk is the computational complexity of the homomorphism problem between two relational structures, also known as the constraint satisfaction problem (CSP). We briefly

discuss the known classifications of CSPs parametrised by the source or target structures. We then discuss a classification of general-valued CSPs parametrised by the source structures. Based on joint work with Clement Carbonnel and Miguel Romero.

What is the nature of your talk? Very theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 09:30, Room - Welcome 3 Code: OR60A3472

Improved Worst-Case Guarantees for K-Means Clustering

Dr Justin Ward *(Queen Mary, University of London)*

In the k-means clustering problem we are given n input points in a Euclidean space and seek to find k "center" points in the space so that the sum of the squared distances of each input point to its nearest center is minimised. While there have been several new results for low-dimensional or well-clusterable instances, the best known approximation guarantee for the general problem has remained 9 since 2002. In this talk I will present a new algorithm that achieves a 6.36-approximation for this problem, as well as an improved 2.64 approximation for the Euclidean k-median problem. The algorithm is based on a new Lagrangian multiplier preserving primal dual approach. This talk is based on joint work with Sara Ahmadian, Ashkan Norouzi-Fard, and Ola Svensson.

What is the nature of your talk? Very theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 10:00, Room - Welcome 3 Code: OR60A3416

A Constant-Factor Approximation Algorithm for the Asymmetric Traveling Salesman Problem

Dr Laszlo Vegh *(London School of Economics and Political Science)*, Dr Ola Svensson and Mr Jakub Tarnawski *(École Polytechnique Fédérale de Lausanne)*

We give a constant-factor approximation algorithm for the asymmetric traveling salesman problem. Our approximation guarantee is analyzed with respect to the standard LP relaxation, and thus our result confirms the conjectured constant integrality gap of that relaxation. Our techniques build upon the constant-factor approximation algorithm for the special case of node-weighted metrics. Specifically, we give a generic reduction to structured instances that resemble but are more general than those arising from node-weighted metrics. For those instances, we then solve Local-Connectivity ATSP, a problem known to be equivalent (in terms of constant-factor approximation) to the asymmetric traveling salesman problem. This is joint work with Ola Svensson and Jakub Tarnawski.

What is the nature of your talk? Very theoretical
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 11:00, Room - Welcome 3 Code: OR60A3282

Algorithms for Junior Doctor Allocation

Dr David Manlove *(University of Glasgow)*

Between 1999-2012, NHS Education for Scotland ran a matching scheme (the Scottish Foundation Allocation Scheme or SFAS) for allocating junior doctors to 2-year foundation posts

at Scottish hospitals, based on the preferences of doctors over hospitals and vice versa. The underlying computational problem is called the Hospitals / Residents problem. A solution is a stable matching, which is an allocation of doctors to hospitals such that no doctor and hospital, not already assigned to one another, would prefer to be assigned to each other than to remain with their assignees. In the classical setting, where all preference lists are strictly ordered, there is a linear time algorithm for finding a stable matching in a given instance of HR. However in practice, preference lists may include ties (giving the Hospitals / Residents problem with Ties or HRT) - in this case stable matchings may have different sizes and the problem of finding a maximum cardinality stable matching is NP-hard. Also in real applications, couples may apply jointly so as to be assigned to geographically close hospitals. This gives rise to the Hospitals / Residents problem with Couples (HRC). An HRC instance may not admit a stable matching, and the problem of finding a stable matching or reporting that none exists is NP-hard. We describe integer programming techniques that we have used to find maximum cardinality stable matchings in instances of HRT, and to find a stable matching or report that none exists, given an instance of HRC. We show results arising from implementations of our IP models as applied to real datasets corresponding to previous runs of SFAS. This is joint work with Augustine Kwanashie and Iain McBride.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 11:30, Room - Welcome 3 Code: OR60A3477

Pareto-Optimal Allocations and Their Application in Logistics

Dr Pavlos Eirinakis *(University of Piraeus)* and Dr Ioannis Mourtos *(Athens University of Economics and Business)*

Pareto-optimal matchings appear in settings where multiple agents have preferences over multiple (indivisible goods). Such matchings have recently received considerable attention and the so-called Serial Dictatorship (SD) has been the core notion in all algorithms obtaining them. We present a more general setting, in which this approach becomes applicable, where goods have certain availability and agents are willing to receive only a specific quantity of these goods, while also having strict preferences over a subset of the goods available. We discuss how SD must be modified in this setting and we establish some interesting properties, e.g. that there are Pareto-optimal solutions not found by SD. Furthermore, we discuss alternative mechanisms and present some computational results. Last, we present the application of our approach in a real-life problem related to collaborative logistics.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 12:00, Room - Welcome 3 Code: OR60A3552

Integer Programming Approaches to Multi-Dimensional Vector Assignment Problems

Dr Trivikram Dokka *(Lancaster University)*

We present new compact integer programming formulations for binary multi-dimensional vector assignment problems and illustrate the strength of these formulations through computational experiments. We also propose a math-heuristic, based on the classical

assignment formulation, which gives very close to optimal (almost optimal) solutions for large and difficult instances.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 14:00, Room - Welcome 3 Code: OR60A3345

Lifted Cover Inequalities for 0-1 Linear Programs: A New Lifting Procedure

Miss Georgia Souli and Prof Adam Letchford *(Lancaster University)*

Integer programming software has improved substantially in recent years, to the point where many important practical problems can now be solved to proven optimality (or near-optimality) in reasonable computing times. One of the key ingredients to this success is the use of strong valid linear inequalities, also known as cutting planes. In the 1970s, Balas and Wolsey derived a family of inequalities, called “lifted cover inequalities” or LCIs, for problems with binary variables. The LCIs proved to be so useful as cutting planes, that they are now incorporated into all of the leading integer programming solvers. In this talk, we take an old procedure, due to Balas, and show that it can be substantially improved, so that it yields stronger and more general LCIs, with no significant increase in running time. Some computational results are also presented. (This is joint work with Adam N. Letchford.)

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 14:30, Room - Welcome 3 Code: OR60A3336

New Cutting Planes for Fixed-Charge Problems

Prof Adam Letchford and Miss Georgia Souli *(Lancaster University)*

This talk is a companion to the talk by Georgia Souli. As mentioned in the abstract for that talk, cutting planes are a crucial component in modern software packages for integer programming. In the 1980s, Padberg and Wolsey derived a family of cutting planes, called “flow cover inequalities” or FCIs, for mixed-integer linear programs with so-called "fixed charges". The FCIs have received much attention since then, and have been strengthened and generalised in various ways. In this talk, we present a completely new family of valid inequalities, which we call “rotated knapsack inequalities”, for the same class of problems. Some preliminary computational results are also presented. (This is joint work with Georgia Souli.)

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

Community OR



Organisers: Eliseo Vilalta-Perdomo, Martha Vahl and Rebecca Herron

11/09/2018, 11:00, Room - Minor Hall Code: OR60A3676

KEYNOTE: Facts, Reason and Prolepsis: Risk Communication Versus Risk Counseling

Dr Jan Gerrit Schuurman *(Max Planck Institute for Human Development Berlin)*

Behaviour qualifies as agency in so far as it exhibits distinctly a response to reasons. Often, the sources of normatively for a decision based on reasons is available at the end of a process—which can be years and even decades. This is a problem for decision that particularly involve actions that find their justification in probabilistic information and statistics. Representations formats that attempt to make agents "see the facts clearly" often and end up being ignored by agents who are facing true dilemmas, actual problems and real life decisions. But can we make agents see reasons that are available conditional on the agents actions and involve an unknown period of time? I will present a visual argument that we can. The argument will hinge on prolepsis: representation of a thing as existing before it actually does or did so, as in he was a dead man when he entered. The argument will involve three steps: (1) A reading of a renaissance painting by Hans Holbein (2) A formal argument regarding the distinction between internal and external reasons and (3) A discussion of a solution based on steps 1 and 2. The argument is substantiated by means of a mammography case study.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 12:00, Room - Minor Hall Code: OR60A3603

A Soft Systems Approach to Understanding the Business Perspective on Responsible Engagement with Third Sector Organisations and Sustainable Community Development in Scotland

Miss Elena Pershina, Dr Kenny Crossan and Dr Miles Weaver *(Edinburgh Napier University)*

The purpose of this research project is to present an application of Community OR (COR), using Soft Systems Methodology (SSM) to understand the business perspective on sustainable community engagement of businesses. The work is built on findings of Weaver, Crossan, Tan and Paxton (2018) and seeks to gain further insights into the business perspective of the "Connect Model". The research is based on the assumption that there is a lack of connectivity and alignment between and within public, for-profit, and the third sector organisations in Scotland. The study adapts the community OR methodology to build understanding of how resources can be released into the community and what products, processes and relationships can bring real transformation. The data from 28 interviews collected during the Responsible Business Forum in 2016 from a variety of businesses was analysed to develop the "business

connect" model which addresses the need to 'invest in social capital' and align social resources to sustain community development in Scotland. The applied systems thinking approach helps to understand the nuances of business perspectives in the changing landscape of responsible business in Scotland and emphases the need for an 'open system' that addresses the 'whole problem' area.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 13:30, Room - Minor Hall Code: OR60A3522

Community Operational Research: A Survey of the Discipline

Prof Michael Johnson and Mr George Chichirau *(University of Massachusetts Boston)*, Prof Gerald Midgley *(Hull University Business School)* and Mr Jason Wright *(University of Massachusetts Boston)*

Community operational research (COR) is an extension of multiple OR/MS traditions to support participatory research, localized impact and social change. It applies critical thinking, evidence-based policy analysis, community participation and decision modeling to local interventions. It emphasizes the needs, voices and values of disadvantaged and marginalized populations. It rests on a foundation of meaningful engagement with communities. This presentation summarizes a multi-year effort to assemble cutting-edge research in COR in a special issue of European Journal of Operational Research available August 2018. We review principles for community OR, describe the breadth and diversity of the field through the experience of editing and contributing to the EJOR special issue, and explore some areas of COR of particular interest, including diversity, equity & inclusion; and community data analytics & smart cities.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 14:00, Room - Minor Hall Code: OR60A3613

The Community in Community OR

Ms Martha Vahl

OR developed during WWII to solve practical problems – but nowadays most practitioners seem to restrict themselves to dealing with economic and business problems. There is no reason not to broaden the field of application, however. One area worthy of inclusion is that of communities: collectives of people that play important roles in society but lack clear boundaries, clear objectives, clear organisational structures and often clear problems and hence aren't easy to support analytically. Earlier attempts to broaden the field such as Third Sector OR have had to create clarity by imposing external constraints, e.g. by having stakeholders define boundaries. This limits the scientific value of these attempts. In this presentation I explore an alternative that helps to avoid the introduction of external constraints. I focus on the interactive strategies of those involved and on experiences that are not in line with their community roles and hence are considered surprising. A social innovation example is provided to illustrate the approach.
What is the nature of your talk? A Mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 14:30, Room - Minor Hall Code: OR60A3570

Developing Your 'North Star' to Clarify Purpose

Dr Miles Weaver, Dr Kenny Crossan and Dr Hock Tan *(Edinburgh Napier University)*

There is widespread acceptance that business "can do well, by doing good" leading to the rise in organisations defining themselves as 'purpose-driven'. In the context of Scotland, there appears to be a fertile environment for growth in this area, with examples of the Scottish Government Economic Strategy (March, 2015) focused on 'inclusive capitalism' and emerging initiatives such as the adoption of the Sustainable Development Goals in policy-making, engagement activities with businesses including the Scottish Business Pledge and the Scotland CAN-B programme (launched in May, 2018). This mantra presents a WIN-WIN situation, emphasising business growth and a fairer and more inclusive Scotland but such a position cannot always be realised. There is inherent complexity, issues and challenges, different perspectives and competing priorities at play when clarifying 'purpose'. One issue that came out of Rich Picture workshops with representatives from the Scottish Government highlighted the desire to follow a 'North Star'. Later discussions with critical friends and further analysis of over 20 Rich Pictures from workshops that represented different sectors showed that there simply cannot be one "North Star" – business must clarify their own. This study argues that OR, particularly recent developments in COR can play a significant role in helping organisations to build a meaningful engagement with communities when values can be aligned. Many of these ideas and techniques are incorporated in Weaver, Crossan, Tan and Paxton (2018) 'shared spaced' concept. This includes the need for strong facilitation skills to structure the issues and challenges an organisation wishes to address, in making value and boundary judgements (i.e. the groundwork before a meaningful engagement can be pursued between matched parties), the co-creation of solutions and evaluating impact. Practical applications and further thoughts on embedding the process in practice are also outlined.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 09:00, Room - Bowland Hall S Code: OR60A3544

Community Knowledge Networks - The Self-Organisation and Articulation of Social Issues in Rural Lincolnshire

Dr Rebecca Herron, Dr Eliseo Vilalta Perdomo and Ms Zoraida Mendiwelso Bendek *(University of Lincoln)*

Traditional OR has been interested in supporting decision-making, problem-solving and improving operations in a wide variety of contexts. Communities provide an intriguing domain of focus as they as often loosely-configured groups of people, organising their own activities and linked to one another in a complex (although sometimes sparse) web of interactions, commitments, interests and resources. Discovering how researchers can support such communities is one of the general aims of Community OR. Many different forms of supporting actions can be identified in the OR, Systems and Knowledge Management Literature. In this example researchers from CORU (The Community OR Unit) have been working for a number of years with community members in the South Holland district of South Lincolnshire (UK). Part of this work has involved supporting and co-facilitating a community knowledge network that meets twice yearly to identify, discuss and reflect on the most pressing social issues in this rural community. The network has provided a self-organised approach to articulating issues of concern to and by local stakeholders. This paper reflects on both the practical aspects and the

theoretical underpinnings (from Complexity Theory, Systems Modelling and Knowledge Management) that the author has drawn upon to guide and inform our actions and reflections.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 09:30, Room - Bowland Hall S Code: OR60A3323

Introducing Systems Thinking Concepts, Power Issues and Biases in the Theory and Practice of Program Evaluation

Miss Maria Alejandra Torres-Cuello and Mr Luis Arturo Pinzon-Salcedo *(Los Andes University)*

In this paper we explore how systems thinking concepts are introduced in a program evaluation approach which has at its methodological core the engagement of stakeholders throughout its different stages. In illustrating such introduction we will present a theoretical development as well as its practical application in a real life situation in which different members of a program community are involved in planning and implementing a social program evaluation, as well as in generating recommendations for its improvement on certain issues. We also show how methodological pluralism becomes a central element of the evaluation methodological development by presenting how different methods, whether they are qualitative or quantitative, are used to serve different purposes, an issue which is useful for the operational research practice. Along with the introduction of systems thinking concepts in a program evaluation approach, power issues and cognitive biases are explored as well. The introduction of both of these concepts is significant given that how we decided to address power differs from the traditional conceptions by which it is addressed. In order to do so, we decided to approach it by means of Michel Foucault's ideas with respect to power, knowledge, and truth. On the other hand, the paper also discusses the role of judgmental biases in program evaluation, and discusses how to prevent them. As far as we know this is the first time in which cognitive biases are addressed systemically at both program evaluation theory and practice. Finally, we address how exploring and introducing the aforementioned ideas benefits the theory and practice of evaluation as well as that of operational research.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 10:00, Room - Bowland Hall S Code: OR60A3307

OR Approaches for Unbounded Problems with Undefined Resources

Dr Eliseo Vilalta-Perdomo *(University of Lincoln)*, Dr César García-Díaz *(Universidad de los Andes (Colombia))*, Prof Martin Hingley and Mrs Rosario Michel-Villarreal *(University of Lincoln)*

Different OR approaches are explored to discuss how individuals may increase their expertise and overrun community barriers for development. These approaches will be discussed from a perspective of unbounded problems with undefined resources. Traditional descriptions for such kind of problems will be presented (i.e. Arrow's impossibility theorem, Hardin's Commons problem, Axelrod's Prisoners' dilemma) and real projects will be expressed through such challenges, to discuss limitations for hard OR approaches. An exploration on Kahneman's ideas will be used as a framework, for a proposal on potential languages, able to structure and support individual performance and collective sustainability.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 13:30, Room - Faraday 2 Code: OR60A3699

Community OR SIG AGM Meeting

Ms Martha Vahl

The annual general meeting of the special interest group for Community OR

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

Cutting and Packing

Organisers: Xiang Song and Julia Bennell

13/09/2018, 13:30, Room - Welcome 4 Code: OR60A3528

Heuristics for the Score-Constrained Strip-Packing Problem

Miss Asyl Liyakat Hawa *(Cardiff University)*

In this research we consider a problem that arises in the production of boxes, where flat cardboard items must be scored to aid the folding process. Consider a set of rectangular items of fixed height and varying widths, where each item possesses two vertical score lines marked in predetermined places. The score widths of an item are the distances between each score line and the nearest edge of the item. A pair of knives mounted onto a bar cut along the score lines of two adjacent items simultaneously, allowing the items to be folded with ease. By design, the distance between the knives must exceed a fixed minimum, and as such have a "minimum scoring distance". The aim is to find an alignment of the items on a strip such that the sum of adjacent score widths exceeds the minimum scoring distance, in order for the knives to score the items correctly. In practice strips of material are provided in fixed widths, thus given large problem instances multiple strips may be required. Therefore, the Score-Constrained Strip-Packing Problem (SCSPP) involves finding the minimum number of strips required to pack all items such that the scoring distance constraint is fulfilled. In the special case where the minimum scoring distance is zero the SCSPP is equivalent to the NP-hard one-dimensional bin packing problem, hence the SCSPP is also NP-hard. We will present an exact polynomial-time algorithm for finding a feasible alignment of items on a strip, which models the problem graphically and attempts to construct a specific type of Hamiltonian path. Then, we will explain how this algorithm can be integrated with a heuristic to find solutions for the SCSPP, and compare this with two simpler heuristics. Finally, we will show how the combined heuristic is more effective at finding solutions for harder instances.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 14:00, Room - Welcome 4 Code: OR60A3616

A Heuristic for the Skiving and Cutting Stock Problem in Paper and Plastic Film Industries

Miss Xiang Song *(University of Portsmouth)*, Dr Yan Chen *(South China University of Technology)*, Prof Yaodong Cui *(Guangxi University)* and Prof Djamila Ouelhadj *(University of Portsmouth)*

This paper investigates the skiving and cutting stock problem (SCSP) encountered in the paper and plastic film industries, in which a set of non-standard reels generated from previous cutting processes are used to produce finished rolls through the skiving and cutting process. First,

reels are skived together length-wise to form a reel pyramid (a polygon) and then, the reel-pyramid is cut into finished rolls of small widths. Depending on if a reel can be divided length-wise into sub-reels to form the reel-pyramid, the problem can be classified into divisible SCSP (DSCSP) and indivisible SCSP (ISCSP). In this paper, two integer programming (IP) models are proposed for DSCSP and ISCSP respectively. A sequential value correction procedure combined with the two IP models (SVCTIP) is developed to solve the two SCSPs. The effectiveness of the SVCTIP is demonstrated though extensive computational tests.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

Data Mining

Organiser: Dolores Romero Morales

13/09/2018, 13:30, Room - County LT Code: OR60A3430

How to Fit an Equation to Data Symmetrically

Dr Christopher Tofallis *(University of Hertfordshire)*

We present a simple method for estimating a single relationship between multiple variables, which are all treated symmetrically i.e. there is no distinction between dependent and independent variables. Remarkably, the weights or coefficients are easily obtained from exact formulae. The approach extends the geometric mean functional relationship to multiple dimensions. It is especially useful when dealing with data measured in different units as it is naturally scale invariant (unlike orthogonal regression). Different equivalent expressions are provided for the coefficients, which can be calculated using standard spreadsheet functions. Unlike other approaches to fitting symmetric relationships, computation of eigenvectors or eigenvalues is not required. This ease of calculation will hopefully allow more widespread application of symmetric fitting to obtain relationships.

What is the nature of your talk? Practical

Does your talk require prior knowledge of the subject area? A little

Is your talk accessible and relevant to practitioners? Very

13/09/2018, 14:00, Room - County LT Code: OR60A3651

From Unicorns to Racehorses - Taking Predictive Analytics with Machine Learning From Myth to Business Reality

Ms Gillian Groom *(Minitab Ltd)*

The changes in technology enabling us to collect and process large volumes of data, are not only allowing us, but also requiring us to use a wider variety of machine learning algorithms to gain insights and make data driven decisions. Machine learning is the "new" hot topic, linked with big data, the Internet of things and Industry 4.0 and open source programming tools such as R and Python. If you believe the publicity you will need to recruit "data scientists" in your organisation to effectively use Machine Learning to solve business problems and exploit opportunities. However, I believe that OR practitioners are ideally suited to deliver real business results in this space. In order to position ourselves as being the right fit, I want to review some of the common myths that need to be dispelled. Thus assist business users in their understanding what Machine Learning can and cannot deliver and why OR practitioners are some of the "racehorses" that will enable business to cross the winning line of business improvement using these algorithms.

What is the nature of your talk? Practical

Does your talk require prior knowledge of the subject area? A little

Is your talk accessible and relevant to practitioners? Highly

DEA and Productivity

Organiser: Jill Johnes

11/09/2018, 11:00, Room - Bowland Hall S Code: OR60A3423

Output Attributes and the Relationship between Competition and Price Dispersion: Evidence from the US Airline Market

Mr Charles Howell and Dr Emili Grifell Tatjé *(Autonomous University of Barcelona)*

There is a high degree of dispersion in fare prices in the US airline market. When competition on an airline route changes we would expect there to be a change in the level of dispersion. Various theoretical and empirical studies find this to be true, but their findings differ widely on the direction of change. Utilizing a novel method of cost decomposition, we identify the degree of differentiation in an airline route and find that the response of price dispersion to changes in competition is conditioned by the level of differentiation. We empirically test this on a set of quarterly panel data from 2002 through 2016, our findings contribute towards explaining the contradictions in previous research and extending knowledge on the effect of completion on price dispersion.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 11:30, Room - Bowland Hall S Code: OR60A3481

A Cross-European Efficiency Assessment of Offshore Wind Farms: A DEA Approach

Miss Negar Akbari, Prof Dylan Jones and Dr Richard Trelor *(University of Portsmouth)*

Offshore wind energy is recognized as an important source of renewable energy and has experienced a rapid growth in recent years especially in north-western European countries. In this paper the efficiency of 70 offshore wind farms across five north-western European countries is being assessed using the Data Envelopment Analysis Method. The number of turbines, cost, social impact and area of the wind farms are selected as the inputs and the connectivity to population centres and the produced electricity are the outputs. The result shows that the median efficiency of all offshore wind farms considered in this study is 94.6% and the relative median efficiency of offshore wind farms located in the UK is lower than that of Germany and Denmark, but not statistically different from that of Belgium and Netherlands while the median for the two groups of Germany-Denmark and Belgium-Netherlands is also not significantly different. This study offers a practical and holistic performance assessment to the offshore wind stakeholders and policy makers via including economic, environmental, technical and social inputs and outputs in the analysis.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 12:00, Room - Bowland Hall S Code: OR60A3424

Company Productivity and the Efficiency of Supply Chains: A Network Data Envelopment Analysis

Prof Geraint Johnes and Prof Martin Spring *(Lancaster University)*

The importance of company networks in analysing productivity has come to the forefront of attention in the UK context, given both challenges to the smooth functioning of supply chains arising from Brexit and evidence that the country's poor productivity performance is due to a long tail of lagging firms. Yet the research literatures on productivity and efficiency, on the one hand, and supply chains, on the other, have only very limited overlap. In this paper, we show that supply chains can be modelled as a network data envelopment analysis of the type developed by Färe (1991) and extended by Tone and Tsutsui (2009). We use empirical data on supply chains provided by Willems (2008) to illustrate how this method can shed light on the efficiency of different nodes within the network, hence highlighting variations in performance across the supply chain. We comment on the potential for this method to throw light on the role played by supply chains more widely in explaining productivity performance across the economy.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 13:30, Room - Bowland Hall S Code: OR60A3390

Spatial Productivity Analysis of Chinese Urban Commercial Banks

Mr Bingquan Zhao *(Loughborough University)*

Urban commercial banks are currently third largest banking groups in China which have been rapidly developing in last five years. However, there is limited research on the productivity of these urban commercial banks. This paper contributes to the productivity analysis of this area. This paper measures spatial total factor productivity of 64 urban commercial banks during 2013-2016 operating in 26 regions. We introduce a spatial index of total factor productivity using spatial autoregressive production function. We decompose the spatial TFP index into efficiency change and return to scale change. We also report productivity results on spatial direct (feedback) and spatial indirect (spatial spillovers) components. We found that there is a positive spatial dependence in banking production. On average, productivity of Chinese urban commercial banks has 42.6% growth from 2013 to 2016. Return to scale change is main driver of the productivity improvement while the efficiency change has remained unchanged. The results provide additional evidence to the fast development of urban commercial banks. We also found that regions with multiple urban banks have higher productivity growth and return to scale change compared to the regions which have a single urban bank in operation. This may imply that competitive market environment encourages banking productivity. In addition, the multiple bank regions (eastern regions) are more economically advanced than single bank regions (western regions) which are captured by the spatial dependence.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:00, Room - Bowland Hall S Code: OR60A3349

The Measuring of the Productivity in the Faculties of Public Universities from Romania Using Malmquist Productivity Index

Mrs Gabriela Vica Uglea and Mr Stelian Brad *(Technical University of Cluj Napoca)*

Efficiency of public universities is important for getting performance at institutional level. DEA is a tool for measuring efficiency and productivity of decision making units. This research illustrates the application of non-parametric DEA models in dynamic (time dependent) situations to evaluate the productivity growth of eleven Faculties of Technical University of Cluj-Napoca in Romania. The performance evaluation of public universities from Romania using data collected from the reports released by the President of the Technical University of Cluj-Napoca throughout five academic years has been considered in this study. The productivity changes of the faculties over time have been analysed using the Malmquist index technique, which is usually decomposed into a boundary catch-up effect, i.e. the efficiency changes over time in each faculty, and boundary shift of the best practice frontier over time typically due to changes in technology. The input and output variables used in this study are those contributing to performance and efficiency in higher education. The input variables taken into consideration are the number of academic staff and the number of non-academic staff, whereas the ratio between the number of students and the number of teaching staff and the amount of research projects attracted by each faculty represent the output variables taken into account in the current study. We used the output orientated DEA-Malmquist index in estimating the productivity growth from the overall data of the eleven faculties of the Cluj-Napoca University. The results show that the productivity index of each faculty over five years has significantly changed. This analysis also shows that the efficiency boundary varies during the studied period.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 14:30, Room - Bowland Hall S Code: OR60A3421

A Network Data Envelopment Analysis of the Teaching Excellence Framework Evaluation of Teaching in Universities in England

Prof Jill Johnes *(University of Huddersfield)* and Dr Boon Lee *(QUT Business School)*

The Teaching Excellence Framework (TEF) is an assessment of undergraduate teaching quality across higher education institutions (HEIs) in England, Wales and Scotland. The TEF was introduced by the UK government in order to help prospective students make an informed choice about their university, and also to feed into the government's decision regarding the level of tuition fees that HEIs can charge, although following the publication of the TEF results, the government announced a freeze on tuition fees. Results for those HEIs opting into the assessment (this was voluntary) were published in June 2017, and HEIs were awarded gold, silver or bronze based on key data and an environment statement. The purpose of this paper is twofold. First, to apply a two-node network data envelopment analysis (DEA) to the TEF database to establish the efficiency of teaching of universities England. In the first node, universities are seen to use their staff to student ratio and their expenditure to student ratio to produce four outputs namely the proportion of graduates and three student responses based on the National Student Survey. In the second node, the first node output (proportion of graduates) is treated as an input along with the non-academic staff to student ratio, and these produce graduate employment and highly skilled graduate employment outputs. This network

DEA approach will allow insights into where precisely inefficient universities are particularly weak (node 1 or node 2). Second, the factors underlying the efficiency results of node1 are investigated using a fractional regression model. This paper provides an early analysis of the TEF exercise and the data underpinning it, and as such will have clear policy implications concerning both the efficacy of the TEF and the efficiency of universities' teaching activities.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

Defence and Security

Organisers: David Lowe, Ann Steptoe (not pictured) and James Bleach

11/09/2018, 11:00, Room - Bowland SR20 Code: OR60A3617

KEYNOTE: OR in Defence and Security - Past and Present

Dr Paul Syms *(Dstl)*

Whether it has been branded 'operational research' or not, there is a very long history, starting with Archimedes and King Hieron II of Syracuse, of military leaders inviting independent and objective advice on important matters of defence and security. This paper discusses the criteria defining military operational research, then traces its history from ancient times to the present. Some episodes, including the Prussian Kriegsspliels and the advice on convoying merchant shipping in two world wars, are well documented. Others are less well known, but deserve to be included in the story for their impact or their innovation. The years since World War Two have seen a waxing and waning of different OR methods and applications, with wargaming in the ascendant today, while historical analysis (at least in the USA) has fallen out of favour. So, what of the future? That is for the rest of the Defence and Security Stream.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 12:00, Room - Bowland SR20 Code: OR60A3670

Improving RAF Weapons Employment: Falklands Conflict and First Gulf War

Mr Philip Jones *(Dstl)*

The author will provide a personal perspective on work to improve air weapons employment during the Falkland Islands conflict and the first Gulf War. It will highlight the impact of the work and that the use of OR to support military operations did not cease at the end of World War II. It will highlight how modelling was used to inform operational plans and how recommendations derived from pan-disciplinary analysis of laser guided bomb employment at the end of the first Gulf War led to significant improvements in success rates in subsequent operations. It will also highlight the lessons learnt from the work. This is the first time this material has been presented in the public domain.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 13:30, Room - Bowland SR20 Code: OR60A3669

A Historical Review of Using Scenarios to Inform Cross-Government Science and Technology Investment for Countering Terrorism

Mr David Lowe *(Dstl)*

In 2008 the Office of Security and Counter Terrorism tasked Dstl to support cross-government decision making with regard to the investment of science and technology funds. Ten years on, this presentation will look back on the scenario-based analysis that was undertaken by the Dstl team, working with stakeholders across government, to align research investment against the UK Government's strategy to Prevent, Pursue, Protect and Prepare.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - Bowland SR20 Code: OR60A3655

Security Screening

Mr Ian Griffiths and Mr Marc Escandell *(decisionLab)*, Dr Christopher Holt *(Dstl)* and Ms Rachel Purkess *(CORDA)*

We have carried out an exploratory investigation into security screening at a facility. The primary purpose was to determine whether an agent-based modelling approach could support quantitative assessment and provide insights into screening systems. We have developed a prototype simulation model to support this investigation. We will present the approach to the modelling, which includes realistic movement through the facility and their activities, as well as the screening measures. It also includes performance metrics that allow us to assess the effectiveness, in terms of numbers of people screened, and cost, in terms of level of disruption caused. We will present the results of a pilot study that demonstrates the model's capability, which considered a base case (no screening) and six screening scenarios. These show the effectiveness of each of the screening scenarios in our example study case, as well as their impact on the level of disruption. Although only a proof-of-concept study, it has produced some interesting insights into the screening measures, which we will discuss, as well as presenting our conclusions on the applicability of the model and its future application.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 14:30, Room - Bowland SR20 Code: OR60A3672

Eliciting the Requirements of Border Force's Internal Data Strategy

Mr Mark Ashforth *(Dstl)*

UK Border Force is developing a comprehensive Data Strategy to facilitate its management and operation in an increasingly data-driven environment. The Defence Science and Technology Laboratory (Dstl) was tasked to support part of the initiative by eliciting requirements for management information across the Border Force in order to improve efficiency and enable informed trades between competing demands for investment. A programme of semi-structured interviews was devised to elicit the information requirements at all levels of management and across all UK regions and port types. The interviews were built around a consistent set of questions as to the responsibilities of each role, what information is required and for what purpose. The responses to these questions were then analysed and

grouped into a visual framework of mutually consistent categories that support a “golden thread” from the Border Force Strategic Objectives through information requirements, the data required to feed them and, ultimately, to recommendations on how the data should be collected. This will feed into work already ongoing within Border Force to redesign data feeds to enable a much more consistent and reliable input to performance analysis. The output of the work describes a comprehensive and consistent approach to management information that has hitherto not existed at Border Force. Support to the implementation of these recommendations is expected to form the next piece of Dstl work for the Border Force.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:00, Room - Bowland SR20 Code: OR60A3677

Structuring Scenario-Based Experimentation for Counter-UAS Assessments

Prof Patrick Driscoll *(US Military Academy)*

In contrast to statistical data collection experiments, limited replication opportunities afforded by scenario-based experimentation require a different approach for evidence collection that blends objective and subjective methods. This talk introduces one such approach for assessing counter-Unmanned Aerial Systems (CUAS) that uses subject matter experts to complement limited data collection, thereby motivating Bayesian updates for parameter estimation.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 09:30, Room - Bowland SR20 Code: OR60A3612

How Innovation in OR Could Be Harnessed to Address Current and Emerging Defence and Security Challenges

Dr Deborah Fish *(Dstl)*

The Defence Science and Technology Laboratory maintains a wide range of decision support tools, ranging from simple spreadsheets to complex models of combat, developed over decades. This talk will provide an overview of our thoughts on how innovation could be used to deliver a step change in the impact or efficiency with which we can generate evidence to inform decisions. Foci include the use of deep reinforcement learning to control military units in combat models, a shift from developing models from scratch to maximum use of commercially available tools, and a drive to develop models of novel and non-traditional effects, such as cyber and information warfare.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Bowland SR20 Code: OR60A3663

Piercing the Fog: Understanding Threats through Systematic Mapping

Mr Jordan Di Placito *(Dstl)*

This method uses multidisciplinary analysts and subject matter experts input to combine their knowledge, experience and skills to piece together the pathways that threat can take. The pathways then plot the routes of a potential threat from the initial inception through to the exploitation of the event. The resulting methodology combines a range of disciplinary inputs, including sociology, psychology, mathematical modelling, physical testing, red teaming and war gaming to bound, map and visualise the 'routes to threat' that exist, as well as identify how to begin to counter them. The range of approaches are all controlled and combined using a central 'spine' which ensures parity across a range of disparate fields, whilst also enabling the creation and maintenance of an accessible and robust evidence base to support decisions made using this product. Combining the research and expertise into this framework allows the technical approach to be followed in this area, however this must be aligned with suitable visualisations and tailored products for various audiences to interact with the product in a meaningful way. This effort has had visualisation and requirement specialists involved from the outset to identify suitable ways for audiences across the world to interact with the work. Significant effort has gone into aligning specific user requirements with the data, not to shape the collection of data, but to bound and classify the analysis and presentation of data. The data in turn allows salient and timely information to be easily highlighted to decision makers. This work has taken a range of existing techniques and disciplines, and identified a coherent methodology for not only bringing them together into a central repository but also for identifying the relevant aspects, in order to provide the right information in the right way at the right time.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 12:30, Room - Bowland SR20 Code: OR60A3435

Thief of Time: Using Dynamic Distribution of Time Resources as an Equivalent to Variety in Changing the Locus of Power and Control via Variety Distribution in Complex Socio-Technical-Political Situations

Dr Terence Love *(Design Out Crime and CPTED Centre)*

This paper describes the role of the dynamics of the distribution of time as a resource in controlling the locus of power and control in highly complex systems following the Variety Axioms of Love. The paper describes how changing the distribution of time resource by hostile or otherwise actors can be used to modify the availability of variety and thus shape the movement of the locus of control in complex socio-technical-political situations. The paper concludes with an example from the realm of international corruption and bribery.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

Disaster Management

Organiser: Paola Scaparra

12/09/2018, 09:00, Room - Bowland LT Code: OR60A3466

Towards Optimizing Natural Disaster Response Plan and Coordination of Inter-Governmental Organization in South-East Asia

Prof Juliana Sutanto and **Dr Marc Goerigk** *(Lancaster University)*, **Ms Puspa Sandhyaduhita** *(Universitas Indonesia)* and **Prof Konstantinos Zografos** *(Lancaster University)*

A frequent issue with mathematical models for disaster management is that they may not accurately reflect the requirements of the decision maker, and so may end up unused. In this talk we describe the key process of eliciting user requirements in detail. The inter-governmental organization under study is a non-profit organization that plans for and coordinates natural disaster responses across member states in South East Asia. When it detects early warning in a member state, this organization will prepare a disaster response plan and coordinate volunteers from across the member states. This talk has two parts. In the first part, we give insights into the practical requirements we elicited. To better understand current processes in planning and coordination, we created use case diagrams, use case descriptions, and service blueprint diagrams that map its current processes with the corresponding information systems and data assets. We identified two organizational structures, i.e. a functional-based structure in nominal situation and a role-based structure in emergency situation. In a role-based structure, different individuals may fill-in the same role depending on the individuals' availability at the time of disaster. Through the blueprint diagram, we also identified gaps in decision making and in the creation of emergency response planning forms that rely primarily on tacit knowledge. In other words, different individuals assuming the same roles in emergency situations may make different decisions and create different emergency response plans. In the second part, we identify the types of models and algorithms that will be suitable for the decision maker, based on different types of problems.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:30, Room - Bowland LT Code: OR60A3442

Optimal Investment Strategies to Minimize Flood Impact on Road Infrastructure in Hanoi Capital City, Vietnam

Dr Trung Hieu Tran *(University of Nottingham)*, **Mr Graham Adutt**, **Dr Maria Paola Scaparra** and **Ms Phuong Dang** *(University of Kent)*, **Dr Thinh Quang Dang** *(Institute of Meteorology, Hydrology and Climate Change)*, **Mr Cong Chinh Ngo** *(Asian Management and Development Institute)*, **Dr Van Hiep Nguyen** *(Vietnam Academy of Science and Technology)* and **Dr Hoai Chung Pham** *(Transport Development and Strategy Institute)*

In recent years, the frequency and intensity of flood events in Vietnam has increased dramatically due to climate change, fast urbanization and aging drainage systems. These events have a clear adverse impact on the country's ability to achieve sustainable economic, environmental and social development. In this paper, we propose a multi-period optimisation model for strategic, long-term planning of mitigation actions, which minimizes the impact of floods on urban road networks over different flood scenarios. Specifically, we propose a mixed-integer non-linear programming model that identifies the optimal mix of structural (e.g. drainage network, reservoirs, floodwalls, etc.) and non-structural (e.g. land-use planning, public awareness of environmental protection, etc.) mitigation measures over a 20-25 year planning horizon. The model considers road infrastructure's direct and indirect flood losses that are represented by a flood-depth damage function and a congestion function, respectively. Due to the non-linearity of the functions, we develop a linearization technique to solve the non-linear problem efficiently. The experimental results, carried out on a case study of Hanoi capital city, Vietnam, demonstrate the efficiency and effectiveness of our linearized model for solving practical applications. This work is a part of the GCRF_OSIRIS project, funded by the British Academy Cities and Infrastructure programme, and uses real data and inputs provided by the project Vietnamese partners, including the Vietnam Transport Development and Strategy Institute, the Asian Management and Development Institute, the national Institute of Meteorology, Hydrology and Climate Change and the VAST Institute of Geophysics. Project website: https://research.kent.ac.uk/gcrf-osiris/. Twitter: @GCRF_OSIRIS

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 10:00, Room - Bowland LT Code: OR60A3485

Identifying Optimal Defence Plans to Minimise the Impact of Flooding on a Road Network

Dr Stefano Starita *(Thammasat University)* and **Dr Maria Paola Scaparra** *(University of Kent)*

Nowadays, floods pose a serious threat to global society. The number of people living in at-risk areas is rising. This is further exacerbated by climate change and has a more dramatic impact on developing countries. This work focuses on the protection of a road network infrastructure against flooding. A mathematical optimization model is introduced to find optimal flood defence strategies, given a limited protection budget. Multiple disruption scenarios of different magnitudes are incorporated in the formulation. This work departs from the usual facility-level protection assumption (i.e. protection decision on a single arc or node of the transportation network). We assume that the decision maker chooses from a set of available protection plans which can cover single or multiple facilities, simultaneously. This is a more generic yet realistic representation of the problem, where protection strategies usually range from small and cheap (sand bags along the road) to large and expensive (dams, canal diversion etc.), with the latter having an impact on wide areas of the transportation network. To efficiently solve the

challenging optimization model, a customized GRASP algorithm is introduced. The algorithm is tested on a set of artificial networks of different sizes. Finally, a case-study based on the road network of Hertfordshire (UK) is introduced to provide some analysis and insights. Results of this analysis indicate that protecting against rare and large floods is not cost-effective, whereas optimal strategies should target small yet frequent events.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:00, Room - Bowland LT Code: OR60A3508

Improving Supply Systems Reliability against Natural and Man-Made Disasters: Risk-Neutral vs Risk-Averse Approaches

Dr Maria Paola Scaparra *(University of Kent)* and Dr Stefano Starita *(Thammasat University)*

In the wake of the 21st century's terrorist attacks and numerous natural disasters, a variety of optimisation models have been proposed by OR researchers to identify cost-efficient ways of increasing the reliability of service and supply systems. These models usually aim at allocating limited protection resources among systems facilities so as to optimise some measure of performance in case of disruption (e.g. distribution costs, demand coverage etc.). In this paper, we discuss and compare two different classes of models, which are typically used to protect systems against natural and man-made disasters, respectively: risk-neutral models and risk-averse models. In the first class of models, facilities are assumed to fail at random with some probability and the objectives typically deal with expected costs or performances. The models in the second category identify location strategies for coping with worst-case facility disruption and are usually modelled through bilevel defender-attacker models. We propose a new risk-neutral model to determine an effective distribution of protective resources among facilities in p-median systems so as to reduce the probability of failure to which facilities are exposed in case of external disruptions. The failure probability of protected assets depends on the level of protection investments and the ultimate goal is to minimize the expected facility-customer transportation costs to provide goods and services. We then compare the optimal protection strategies generated by this model with the ones obtained by applying a risk-averse bilevel approach. We test both approaches on a real case study based on the Toronto general hospital network and discuss differences and similarities in investment strategies for different budget levels. The analysis also highlights that, regardless of the model used and the risk attitude of the decision maker, small changes in levels of protection can be effective at improving a system's ability to cope with disasters.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:30, Room - Bowland LT Code: OR60A3533

An Optimisation-Simulation System for Stock Pre-Positioning and Relief Distribution in Disaster Management

Dr Pavel Albores *(University of Aston)* and Dr Oscar Rodriguez-Espindola *(Aston Business School)*

The supply of food and supplementary items is an essential part to reduce suffering in disaster operations. This activity is particularly challenging immediately after the disaster strikes, when

delays can have a significant effect in the victims. Several governments globally are recurring to policies such as stock prepositioning to allow immediate deployment of products after the disaster. Nevertheless, research has concluded that it can be an expensive policy. Moreover, poor planning of the location and number of products prepositioned can render the policy ineffective. For instance, Mexico has used this policy for several years with poor results. To tackle this challenge, this research integrates optimisation and simulation to provide a system to analyse the location of warehousing facilities and prepositioning of stock at a national level. The objective of the optimisation model is to maximise the number of items that can reach all the potential demand areas at different levels of coverage. As part of the model, resources and facilities from different organisations can be included to improve collaboration, improve coverage and reduce duplication of efforts. The policy provided by the optimisation model is used as input in a discrete-event simulation model programmed into Simul8 to analyse its performance under different circumstances. The system was tested using data obtained from Mexican disaster authorities to analyse its capabilities. The results show the value of the use the system as support for investment in facility location and stock prepositioning in the country.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 11:30, Room - Bowland LT Code: OR60A3499

Integrating Shelter Location and Evacuation Routing Operations: A Trade-Off between User and System Perspectives

Miss Annunziata Esposito Amideo and Dr Maria Paola Scaparra *(University of Kent)*, Prof Antonio Sforza and Dr Claudio Sterle *(University of Naples Federico II)*

Disaster-related issues are usually handled according to the Disaster Operations Management (DOM). DOM is composed of two pre-disaster phases (i.e. mitigation and preparedness) and two post-disaster phases (i.e. response and recovery). Shelter location and evacuation routing are crucial tasks pertaining to the DOM response phase. The shelter location problem aims at identifying the best refuge sites (i.e. shelters) where people either move towards or are directed to when a disaster occurs. The evacuation routing problem aims at designing the optimal routes so that people can leave disaster-affected areas to reach either shelters or other alternative safe destinations as quickly as possible. Optimization researchers have tackled the two separate problems quite extensively over the years. However, their combination has been investigated only recently with some relevant aspects still largely overlooked (e.g. different evacuation modes, evacuees' behaviour, disaster propagation, egalitarian policies). In this work, we present a new model to support decision-making within the evacuation planning context. The model considers shelter location, car-based (i.e. self-) and bus-based (i.e. supported-) evacuation decisions. An interesting feature of our model is that it allows decision planners to identify a trade-off between self-evacuation and supported evacuation oriented solutions, by changing a parameter which represents the route length that self-evacuees are willing to travel. The overall result is an ensemble of evacuation planning policies which vary for different equity level between self- and supported-evacuees. These aspects are embedded in a scenario-based mixed integer program which is solved via a branch-and-cut algorithm and tested on a realistic case study. Results show the practical applicability of the model and its potential to inform evacuation decisions during a disaster.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 13:30, Room - Bowland LT Code: OR60A3561

KEYNOTE: Refugee Resettlement via Machine Learning and Integer Optimization

Prof Alexander Teytelboym *(University of Oxford)*, Ms Narges Ahani *(WPI)*, Prof Tommy Andersson *(Lund University)* and Prof Andrew Trapp *(WPI)*

Around 100,000 refugees are resettled to dozens of countries from conflict zones every year. While there is growing evidence that the initial placement of refugee families profoundly affects their lifetime outcomes, there have been few attempts to optimize resettlement destinations within host countries. We describe how machine learning and integer optimization can be used to empower resettlement agencies to drastically improve refugee employment outcomes. We describe possible future work on multi-objective optimization, the dynamics of allocation, and the inclusion of refugee preferences.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

Energy Applications

Organisers: Dylan Jones and Graham Wall

11/09/2018, 11:00, Room - Private 1 Code: OR60A3319

How smart is your thermostat? And how intelligent does your heating system need to be?

Dr Roger Main

There are now many types of 'smart' devices for controlling central heating, allowing those with smartphones to micro-manage their heating systems. Some devices can also learn about users' habits and preferences, and some also take additional information from outside sources on the internet. For the last few years, I have been designing and building my own control system for underfloor heating. This type of heating has its own challenges, particularly because of the time-lag between switching the heating on or off and the effect on the room. From the early – and very basic – simulations, through the prototypes, and towards the final (albeit not yet completely finished) system, I look at some of the important aspects of such a system and ask whether micro-management is necessary (or desirable) and what information is useful (rather than simply being available).

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 11:30, Room - Private 1 Code: OR60A3358

A Mathematical Model for the Optimal Operation of Microgrid: A Case of Economic and Environmental Quatification

Mr Omefe Patrick Omavuezi and Prof Patrick Luk *(Cranfield University)*

The transition of existing energy grid towards a sustainability requires effectively harnessing and managing available distributed energy resources like wind, solar PV and energy storage to balance the mismatch between demand and supply using enabling technologies like microgrids. In line with the UK national target, Cranfield University's carbon management plan aimed at reducing both cost and carbon emissions by 50% by the year 2020 while meeting the electricity and heat demand. In order to meet this targets it is imperative to develop an energy management system to optimise the operation of the complex energy mix. The host site is the Cranfield Campus energy grid network which includes a two 2MW ow temperature hot water (LTHW) boilers, one 3MW steam/CHP boiler, one 1.4MWe CHP and a 950KW biomass boiler. A mixed integer linear programming model that integrates a 1MW solar plant and electrical energy storage is presented in order to determine the economic and environmental benefits aimed at minimising the daily operational cost and CO2 emissions. A decision-making energy management model integrated with an optimisation algorithm to deal with the intermittent nature of solar PV is presented in this paper as well as other constraints like cloud cover,

variability in demand profile and the planned decommissioning of CHP units were considered to improve the quality decision making in the proposed model formulated and implemented IBM ILOG CPLEX software. The effect of this inclusion was analysed and a reduction in both operations cost and CO2 emissions are reported. The results showed a significant decrease in the proposed microgrid compared to the existing energy infrastructure.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 12:00, Room - Private 1 Code: OR60A3330

Energy Cost Minimisation of Microgrid Integrated with Distributed Energy Resources Using a Novel Load Dissection Configuration

Mr Omefe Patrick Omavuezi and Prof Patrick Luk *(Cranfield University)*

This paper presents a systematic approach to minimise the overall cost of operating Cranfield University microgrid as well as reduce CO2 emissions. The proposed load dissection configuration (LDC) is primarily based on operating a thermal storage systems as an independent energy device within the context of a microgrid. The thermal storage system is designed to meet hot water demand which is 15% of the over energy demand. It consists of solar thermal collectors to heat water, hot water tank for storing the hot water, solar PV and battery storage to power immersion heater in order to meet the desired hot water temperature. The proposed thermal storage system serves as both a generation and storage device and operates as a single system in conjunction with other distributed energy resources in the proposed Cranfield University microgrid. A mathematical model was developed to accommodate the thermal storage system in the optimisation problem with the primary aim of minimising energy cost and C02 emissions. In conventional systems, hot water demand is met using electricity generated by the existing energy grid which is subjected to transmission losses, cost of gas purchase and tariff rates under a fossil fuel based generation units. The equivalent energy savings, economic and environmental benefits associated with the proposed LDC are investigated. The results demonstrate the significant value when the proposed microgrid is operated using the LDC while meeting hot water demand considering the demand profile of hot water

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 13:30, Room - Private 1 Code: OR60A3386

Roadmapping a Nuclear Future

Mr Les Collier, Mr John-Patrick Richardson and Mr Paul Jennings *(National Nuclear Laboratory)*

In the nuclear industry there is considerable complexity, long timescales, significant uncertainty, and costs running for decades totalling in excess of £100 billion - all of which means that it is vital that long-term scenario planning is undertaken. There are major challenges to address, alongside a range of opportunities, which all need to be considered when planning what might happen in the future. This leads to the need for a Strategic Roadmap. A Strategic Roadmap is a time-based plan that defines and shows where a business is, where it wants to go, and how it plans to get there. A Strategic Roadmap should communicate the Why, What and How:

• WHAT - Clearly articulate and illustrate the vision and strategy;
• WHY - Link back to their highest level instigator;
• HOW - Align internal stakeholders;
• HOW - Communicate to external stakeholders;
• HOW - Help identify gaps and/or inconsistencies in achieving strategic aims;
• HOW - Remove duplicated effort across the business; and
• WHY - Demonstrate benefit.
The skills of an OR analyst include understanding complexity, dealing with uncertainty and fostering collaboration – all of which are required to develop a roadmap. This presentation covers roadmaps developed with the support of the NNL Decision Science team, involving: developing roadmaps of the Sellafield Limited (SL) Technical Baseline; coordination of the use of Unmanned Aerial Vehicles (UAVs) / drones within the nuclear industry; and working with the Department for Business, Energy and Industrial Strategy (BEIS) developing a technology roadmap for nuclear fission. The talk will cover the benefits of roadmapping, techniques used to develop these roadmaps, and explain the SL technical baseline in more detail, with examples showing how roadmapping can be used to prioritise work and investigate alternative futures, with particular focus on the use of Robotic and Artificial Intelligence (RAI) technologies within nuclear decommissioning.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - Private 1 Code: OR60A3392

Usage of Operational Research Methodologies in the Southern UK and Northern French Tidal Stream Energy Sector

Dr Graham Wall and Dr Dylan Jones *(University of Portsmouth)*

This seminar arises from the authors' experiences on past and proposed future EU Inter-regional projects on marine renewable energy. First, marine renewable energy is overviewed and the comparative advantages and disadvantages of tidal stream energy are discussed. Secondly, the potential for the usage of Operational Research techniques to overcome some of the challenges currently facing the tidal stream energy sector is highlighted. Thirdly, the authors recent work in mapping and prioritising the impediments to the commercial scale production of tidal stream energy in the Southern UK and Northern France in highlighted. An Analytical Hierarchy Process based process for prioritisation of the resulting multiple criteria and resolution actions is described and its results are given. Suggestions for future usage of Operational Research techniques in the marine renewable energy, and specifically tidal stream energy sectors are given.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:30, Room - Private 1 Code: OR60A3611

KEYNOTE: Performance Modelling, Impact Assessment and Decision Analysis of Multi-Vector Decentralised Energy Systems

Prof Jian-Bo Yang, Mrs Ting Wu and Prof Dong-Ling Xu *(University of Manchester)*

Fossil fuels like coal, oil and gas utilized by large-centralized power plants are limited and inadequately distributed in the world. The consumption of conventional energy sources has a high impact on global warming in the form of CO2 emission. There has been growing recognition that future energy strategy should be to develop more renewable energy, while transferring a centralized energy system to a decentralized energy (DE) system. Given the novelty of DE systems, their performances and potential impact on world economy have not yet been studied systematically. There are challenges to renewable energy generation, distribution and consumption, which involve technical, economic, cultural and financial aspects. It is necessary to systemically model, analyse and assess the cost-effectiveness and the societal and environmental impact of various DE solutions which are based on different types of renewable energy. This requires the systematic and consistent handling of multiple factors of both a quantitative and qualitative nature under uncertainty, which in essence is a multiple criteria decision analysis problem but needs to make use of both numerical data and expert knowledge. In this presentation, multi-criteria performance and impact analysis for DE systems will be discussed. We will show the preliminary investigation into a case where individual DE systems are constructed for each area of one county and five cities in a region, which are connected to the national energy network. Every individual DE system is a hybrid system that includes various types of energy including solar, wind and storage units. The regional energy network covering the five areas is a complex hybrid system that includes energy generation, energy transmission and trading. We will discuss the preliminary findings from the case study, which we believe can benefit various stakeholders, including policy makers, energy suppliers and consumers, energy network owners, and DE investors in local communities.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

Forecasting

Organisers: Robert Fildes and Ivan Svetunkov

11/09/2018, 11:00, Room - Welcome 2 Code: OR60A3558

Forecasting with Judgment: An Overview

Dr Fotios Petropoulos *(University of Bath)*

Judgment is an integral part of the forecasting process. Multiple studies have examined the efficacy of the human input and intervention regarding the production of the point or interval forecasts as well as adjusting statistically derived predictions. More recently, two studies examined the role of judgment in terms of selecting from a set of statistical models, suggesting that human selection is on par if not better than the algorithmic one while humans are less prone in choosing the worst model. This presentation will provide an overview of recent developments in judgmental forecasting, empirically showcasing best (and worst) practices. Also, we will discuss stages of the forecasting process where judgment is regularly applied, but the effects remain unexplored.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 12:00, Room - Welcome 2 Code: OR60A3529

Brain Imaging and Forecasting: Insights from Judgmental Model Selection

Dr Xun Wang *(Cardiff Business School)*, Dr Weiwei Han *(Beijing University of Posts and Telecommunications)*, Dr Fotios Petropoulos *(University of Bath)* and Prof Jing Wang *(Beihang University)*

In this article, we shed light on the differences between two judgmental forecasting approaches for model selection: forecast selection and pattern identification, with regards to their forecasting performance and underlying cognitive processes. A laboratory experiment using real-life time series as stimuli were designed to record subjects' selections together with their brain activity by means of electroencephalography (EEG). We find that the cognitive load, measured by the amplitude of parietal P300, can be effectively used as a neurological indicator of the cognitive and forecasting performance of subjects. As a result, judgmental forecasting based on pattern identification outperforms forecast selection on both accuracy and speed. Time series with low trendiness, medium noisiness and negative trend suffer from low forecasting accuracy due to high cognitive load induced.

What is the nature of your talk? Very theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 13:30, Room - Welcome 2 Code: OR60A3591

Interpreting Algorithmic and Qualitative Information When Making Judgmental Forecast Adjustments

Mrs Anna Sroginis, Prof Robert Fildes and Dr Nikolaos Kourentzes *(Lancaster University)*

Despite the continuous improvements in statistical forecasting, human judgment remains essential in business forecasting and demand planning. Typically, forecasters do not solely rely on statistical forecasts, which are obtained from various Forecasting Support Systems (FSS); they also adjust forecasts according to their knowledge, experience and information that is not available to the statistical models. However, we do not have adequate understanding of the adjustment mechanisms, particularly how people use additional information (e.g. special events, promotions, strikes, holidays etc.) and under which conditions this is beneficial. To investigate this, we conduct experiments that simulate a typical supply chain forecasting process that additionally provides qualitative and model-based information about past and future promotional periods for retail products. Using laboratory experiments, we find that when making adjustments people tend to focus on several anchors: the last promotional uplift, current statistical forecast and contextual statements for the forecasting period. At the same time, participants ignore the past base-line promotional uplifts and domain knowledge about the past promotions. They also ignore statistical models that incorporate promotional effects, hence showing lack of trust in algorithms. These results highlight the need for more fundamental understanding of processes behind human adjustments and the reasons for them in order to guide forecasters in their tasks and to increase forecast accuracy.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 13:30, Room - Welcome 4 Code: OR60A3376

Forecasting Airport Transfer Passenger Flow Using Real-Time Data and Machine Learning

Mrs Xiaojia Guo and Prof Bert De Reyck *(University College London)* and Prof Yael Grushka-Cockayne *(University of Virginia)*

Passengers missing their connection at an airport can have a major impact on passenger satisfaction and airline delays. Accurate forecasts of the flow of passengers and their journey times through an airport can help optimize the experience of connecting passengers, improve resource deployment, and support air space punctuality. In collaboration with the Airport Operation Centre at London Heathrow Airport, we utilize real-time data to develop a predictive system based on a regression tree and Copula-based simulations. The system generates three outputs: (1) mean and quantiles of passengers' journey times through the airport; (2) expected number of late passengers for each outbound flight; (3) mean and quantiles of the transfer passenger arrivals at the immigration and security areas. These real-time predictions can be used to inform target off-block time adjustments and determine resourcing levels at security and immigration. Our predictive system has been implemented at Heathrow airport, one of the busiest airports in the world handling more than 75 million passengers per year, with more than a quarter of all passengers making a flight transfer.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - Welcome 2 Code: OR60A3550

The Mangle in Practice; the Ideal Lens for Studying Forecasting in Practice?

Dr Christina Phillips *(University of Leeds)*

Forecasting is a blend of data, algorithms, human and computational systems, making it a rich socio-technical system in which perceptions can affect forecast use as much as error measures. This can make it difficult to study unless one looks at only one or two of these aspects rather than the whole system. The Mangle of Practice provided a way to study improvement in just such a system holistically, when it was used alongside action research in a recently published study. We build on that study to ask if a 'Mangle in Practice', developed as part of a methodological framework to study Human Centric Analytics in sociotechnical systems, could provide us with a way to study the multifaceted interactions within forecasting and planning systems. Used in this way the mangle can provide recoverable information from multiple points along the supply chain in which the forecast is used, to develop insights which further our understanding of forecasting in practice. These insights can prompt discovery and development which will be inherently practical and can provide insights regarding ways to manage the use of forecasts in practice. We believe that the Mangle in Practice has the potential to provide us with a bridge between academic forecasting (and analytics) development and its use in practice.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 14:00, Room - Welcome 4 Code: OR60A3635

A Time Series Method to Forecast Container Cargo in Port Terminals

Dr Rafael Bernardo Carmona Benitez *(Universidad Anáhuac Investigaciones y Estudios Superiores S.C.)*, Dr Maria Rosa Nieto Delfin *(Universidad Anáhuac México)* and Dr Jose N. Martinez *(California State University Dominguez Hills)*

Economic growth has a direct impact on cargo at port terminals. To encourage growth, investment decisions on infrastructure are required. These decisions are normally based on cargo forecast. Hence, forecast is important to assess viability of investments especially because it requires huge amount of money that required a long pay-back period. Cargo forecasts can be obtained by applying time series models or development of econometric models. In this paper, a dynamic forecasting method to estimate and forecast cargo is developed. We propose to divide cargo time series into three components: trend, variability and distribution over time. The proposed method combines ARIMA method to estimate trend, Generalized Auto-Regressive Conditional Heteroskedasticity (GARCH) to estimate variability and the distribution of cargo is estimated using Bootstrap methods. This combination of methods, to our knowledge, has never been used to forecast cargo at port terminals. These time series methods are applied mainly in finance to forecast time series volatility, since cargo at port terminals is highly volatile, the main contribution of this paper is to apply and validate the combination ARIMA-GARCH-Bootstrap to forecast cargo at port terminals and compare it with three of the most applied models to forecast time series. The ARIMA-GARCH-Bootstrap method is applied to forecast cargo through the Ports of Los Angeles and Long Beach using monthly data from 2008 to 2016. Database is divided into Import cargo and Export cargo and then subdivided in four type cargo: Bulk cargo, Container cargo, Refeer (refrigerated container) cargo and RO-RO (roll-on, roll-off) cargo. Then, the ARIMA-GARCH-Bootstrap method is

calibrated for eight cargo time series. The Diebold-Mariano Test and the SPA test are applied to conclude and validate that the proposed method is better than others.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:30, Room - Welcome 4 Code: OR60A3662

Nowcasting Electoral Behaviour with Social Media Content

Mrs Lucia Rivadeneira, Dr Manuel Lopez-Ibañez and Prof Jian-Bo Yang *(University of Manchester)*

Capturing the perceptions that social media (SM) users form about market competitors as they occur is increasingly important to shape sound marketing campaigns with real power to opportunely intervene on consumers' decisions. This study proposes a framework to iteratively predict the reproduction of tweets based on a set of observable characteristics, aimed at maximising the use of Twitter as a marketing campaign tool. Taking the presidential race of Ecuador 2017 as case study, a voting behaviour model was developed to examine how different features embedded in personal tweets of the two favourite candidates (type of tweet, emotion, URL, hashtag, and timeline) functioned as predictors of their tweets impact in terms of retweet-counts. Identifying the best-fit model that would achieve the lowest error involved testing several statistical classification techniques, including logistic regression, naïve bayes, decision tree, support vector machine, and evidential reasoning. In the end, evidential reasoning was the approach with the lowest misclassification error with nearly 0.24 and 0.30 for the two contenders. Findings would ideally enable improved approaches to managing social media campaigns for both corporate and political purposes.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:30, Room - Welcome 2 Code: OR60A3460

Reactions to Demand Magnitude and Variability in Order Decisions: Behavioural Implications

Dr Mustafa Sinan Gonul and Prof Dilek Onkal *(Northumbria University)*, Dr Celile Itir Gogus *(Bilkent University)* and Dr Ayse Kocabiyikoglu *(Sabancı University)*

In recent years, considerable research attention has been drawn to the behavioural newsvendor problem, which constitutes one of the fundamental problems of inventory management with significant practical consequences. One of the persistent findings in this literature is the pull-to-centre effect, which can be summarized as the tendency of the decision makers to set their order decisions between the mean demand and the normative order quantity. In the current study, we attempt to explore how decision makers will react to demand uncertainty, particularly to changes in demand magnitude and demand variability and investigate the corresponding pull-to-centre effect. We also try to identify the possible cognitive biases, such as overconfidence, that may prevail in this decision process. Findings are discussed and guidance for future research will be given.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 09:00, Room - Welcome 2 Code: OR60A3370

An Overview of Retail Forecasting

Prof Robert Fildes *(Lancaster University)* and Prof Shaohui Ma *(Nanjing Audit University)*

The retail industry in developed countries forms a major component of economic activity. It is rapidly changing, in part through developments in on-line retailers. Based on a literature review and survey evidence this introduction will review the limited research on different aspects of retail forecasting, in particular the different problems that must be faced: these include the volume of category, brand and SKU-level sales at distribution centre and store as well as volume of store sales by location. Promotional events and on-line behaviour are important influences affecting demand. Such different types of problem have seen surprisingly little research focussed on operational problems retailers face. This presentation aims to identify the gaps, present the evidence on effectiveness and act as a stimulant to researching these important problems where small improvements in accuracy can have major financial benefits.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:30, Room - Welcome 2 Code: OR60A3410

Distributional Regression for Demand Forecasting in e-Grocery - A Case Study

Mr Matthias Ulrich, Prof Hermann Jahnke and Prof Roland Langrock *(University of Bielefeld)*, Dr Robert Pesch and Dr Robin Senge *(inovex GmbH)*

In traditional brick-and-mortar retailing, information on customer demand typically results from point-of-sale data. These data are censored, and hence biased, due to stock-outs affecting the individual purchase. In contrast, e-retailing allows for the observation of customer preferences before stock-out information becomes known to the buyer and, therefore, yields uncensored demand data. Moreover, in e-grocery the customer selects a future delivery time slot so that future demand is partly known to the retailer at the replenishment decision time. Considering data from a German e-grocery retailer, in this case study we discuss demand forecasting in e-grocery, making use of the corresponding new types of data that are not available in traditional retailing. Since underage and overage costs are usually asymmetric, we seek a suitable model for the entire demand distribution, rather than point forecasts only, to minimize the costs. Thus, we propose the application of Generalized Additive Models for Location, Scale and Shape (GAMLSS), which allow a flexible selection of distributions for the demand, and also a flexible modeling of covariate effects on any of the distributional parameters. As benchmark models we consider linear regression, random forests, quantile regression and quantile regression forests. The models are evaluated by comparing their out-of-sample forecasting error for varying levels of asymmetry in the costs.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 10:00, Room - Welcome 2 Code: OR60A3566

A Review of the Latest Techniques for Call Centre Forecasting and their Implications for the Call Centre Manager

Dr Devon Barrow *(Coventry University)*

Call centres worldwide employ millions and serve billions of customers as a first point of contact. Forecasting of time-dependent arrival rate is required for setting staffing requirements in the short to medium term, and for capacity planning in the long-term. For both analytical and simulation call centre models, the arrival volume is typically modelled as a nonhomogeneous Poisson arrival process with time-varying arrival rate, and so a forecast of the arrival rate is required. The complex nature of the call arrival data however brings with it particular forecasting challenges including the existence of multiple seasons, the impact of special days, and the potential high frequency of the data (from 5 minutes), resulting in large amounts of data. In this talk we review the various ways in which this forecasting challenge can be addressed, and the implications for call centre management. This includes whether to produce forecasts at high frequency where forecasts may be optimal for staffing, but may not be ideal for long lead-times and capacity planning. Alternatively, one may adopt the standard approach, which involves forecasting weekly demand while accounting for any seasonal variations, and subsequently breaking this volume forecasts into 15, 30 or 60 minute time buckets using appropriate proportions that mainly capture the intra-week and intra-day seasonality. One benefit of this approach is that it ensures reconciled forecasts across all levels, and therefore aligned decision making but it may not be optimal in terms of forecasting at the shorter intervals which are needed for scheduling. As a consequence, recent approaches involving temporal aggregation have become very attractive. In this talk I consider the hierarchy of decisions made in call centre management, and the corresponding hierarchy of forecasts and associated forecasting methods available.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Welcome 2 Code: OR60A3576

KEYNOTE: Strategic Predictors, Calibration Tests and Scoring Functions for Probabilistic Forecasts

Prof James Taylor *(University of Oxford)*

Probabilistic forecasts are needed to support decision making in many applications. The forecast accuracy of different predictors can be compared using scoring functions, and insight can be provided by calibration tests. These tests evaluate the consistency of the prediction with the observations, and are used by some as the sole approach to evaluation. It is important that calibration tests cannot be gamed by predictors that, although clearly inadequate, have been strategically designed to pass the test. Drawing on previous results for quantile prediction, we show how strategic predictors exist for previously proposed calibration tests for quantile-bounded intervals, expectiles, event probability forecasts, and also for the widely-used test for distributional forecasts based on the probability integral transform. To address this, we introduce and extend existing regression-based calibration tests, which cannot be gamed. We make further contributions related to expectiles. Motivated by the attractive properties of expectiles, we introduce the idea of expectile-based interval forecasts. We provide interpretation for these intervals, and present a scoring function and calibration test. We also

introduce, for distributional forecasts, a new scoring function based on expectiles. We use financial and environmental data to illustrate several of our new proposals.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:30, Room - Welcome 2 Code: OR60A3521

Movie Demand Forecasting Using Delphi Method

Miss Kit Mun Mak, Dr Wei Chong Choo and Prof Annuar Md Nassir *(Universiti Putra Malaysia)*

An accurate forecast of box-office demand in this industry is a valuable tool in planning and decision making, such as scheduling, screen number, and share between distributor and exhibitor. The uniqueness and short life cycle of each movie have made forecasting demand very difficult and tricky. As mentioned by Jack Valenti, nobody knows anything and ultimately, the audiences decide the fate of the movie. Thus, to deal with this great uncertainty in movie demand, some authors suggested using judgment in forecasting. However, forecasting movie demand using judgemental method has received limited attention in the literature. This study predicts the movie demand using Delphi method and compared with individual estimates. Participants included 7 postgraduates. There are 11 movies released in 2017 were selected. 6 of them will be assigned randomly to Delphi group and the remaining one will be individual estimates for each movie. The results differed at individual movie level. In week 1 predictions, Delphi group outperformed individual estimates for six movies and as accurate as individual estimates for a movie. In week 2 predictions, individual estimates outperformed Delphi group by six movies.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:00, Room - Welcome 2 Code: OR60A3429

Forecasting with Pre-Release Search Traffic Profiles

Mr Oliver Schaer, Prof Robert Fildes and Dr Nikolaos Kourentzes *(Lancaster University)*

Pre-release forecasting is a vital task for organisations to adjust advertising strategies and operational decisions. Past studies have demonstrated the predictive value of pre-release buzz for forecasting the adoption of new products. Previous approaches that rely, for example, on functional principal components, or similar approaches, do not investigate specifically for potential similarities of pre-release buzz and product success. We propose to construct profiles of pre-release buzz patterns and associate them with product success. The resulting model allows forecasting the success of a new product by observing its relatively easy to measure pre-release buzz. This approach will not only provide marketers with useful information about their own products but will also allow to gain insights about the competition, as pre-release buzz is publicly available, for example via online discussions and searches. We test our approach on video games sales where we aim to investigate how using pre-release search traffic clusters from Google Trends differs compared to profiles of (i) product features clusters and (ii) life-cycle sales. Finally, we assess the predictive horizon of the approach, as to demonstrate when such signals become available.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 17:30, Room - Welcome 2 Code: OR60A3346

Deep Neural Networks for Forecasting Model Selection - An Image Recognition Approach to Classify Time Series Patterns from Graphs

Mr Sasan Barak and Dr Sven F Crone *(Lancaster University)*

Deep Learning has achieved breakthrough accuracy in classification tasks of image, speech and general pattern recognition. As a result, the underlying algorithms of deep neural networks (DNN) have seen a resurgence of interest across disciplines, including time series forecasting. However, these applications of DNNs as forecasting algorithms see them applied similar to conventional neural network algorithms, using autoregressive input vectors, and thus far removed from their original domains of classifying image data. However, in forecasting model selection such applications of image recognition exist. Traditionally, expert based forecasting model specification utilises time series graphs, seasonal (year-on-year) plots, autocorrelation functions and spectral analysis charts in order to identify the existence and type of seasonality, trend, outliers and structural breaks, serving as model selection filters to narrow down the choice of potentially useful models. While visual data exploration allows accurate forecasting model selection, it does not facilitate large-scale automation of model selection over many individual time series. In this paper, we propose a novel use of deep learning in time series image recognition for model selection. We train deep neural networks on an image of a time series for a multi-class classification of its patterns of level, trend, seasonality, and trend-seasonality, and thus select between Exponential Smoothing (ETS) base learners. We assess the efficacy of the two DNN architectures most widely used in image recognitions, Convolutional (CNN) and Long-Short-Teem-memory (LSTM) neural networks on a synthetic dataset of 40,000 time series created with different patterns and noise distributions. Results are compared to benchmarks of statistical tests for seasonality and trend, aggregate model selection, and wrapper based model selection using information criteria and forecast errors. Our results show the capability of DNNs to identify time series patterns directly from graphs, and improve accuracy on statistical tests and wrappers whilst being more efficient in computing resources.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 09:00, Room - Welcome 2 Code: OR60A3399

Forecasting Using Exponential Smoothing: The Past, the Present, the Future

Dr Ivan Svetunkov and Prof Nikolaos Kourentzes *(Lancaster University)*

Exponential smoothing has been known in both theoretical and practical forecasting for more than 60 years. It has evolved substantially from a simple exponential smoothing method, aiming at dealing with level data to a state-space framework, covering various time series characteristics. In this presentation we discuss the key milestones in the development of exponential smoothing, show the connections between the exponential smoothing and the other forecasting models and, finally, propose a more general framework that can potentially encompass all the existing forecasting models, called "Generic Univariate Model".

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 09:00, Room - Welcome 4 Code: OR60A3391

Out-of-Sample Equity Premium Prediction: A Complete Subset Quantile Regression Approach

Dr Ekaterini Panopoulou *(University of Kent)*

This paper extends the complete subset linear regression framework to a quantile regression setting. We employ complete subset combinations of quantile forecasts in order to construct robust and accurate equity premium predictions. Our recursive algorithm that selects, in real time, the best complete subset for each predictive regression quantile succeeds in identifying the best subset in a time- and quantile-varying manner. We show that our approach delivers statistically and economically significant out-of-sample forecasts relative to both the historical average benchmark and the complete subset mean regression approach.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:30, Room - Welcome 2 Code: OR60A3377

Quantile Forecasts of Life Cycles Using Exponential Smoothing

Mrs Xiaojia Guo *(University College London)*

We introduce an exponential smoothing model that a manager can use to forecast the demand of a new product or service. The model has five features that make it suitable for accurately forecasting life cycles at scale. First, the model can capture the wide range of skewed diffusions commonly found in practice. Second, its parameters are exponentially smoothed; thus, the model can react to local changes in the environment. Third, the model relies on multiplicative errors, instead of the additive errors primarily used in existing models. Fourth, the model includes prior distributions on its parameters. These prior distributions become regularization terms in the model and allow the manager to make accurate forecasts before the peak of a life cycle, which is notoriously difficult. The model's multiplicative errors, along with its skewed shape and time-varying, regularized parameters, can make its quantile forecasts more accurate than existing diffusion models. Fifth, the model's estimation procedure is based on an efficient optimization routine, which can be used to forecast life cycles at scale. In an empirical study of more than one hundred time series of search volume, we demonstrate that our model outperforms leading diffusion models in out-of-sample forecasting. Our model's point forecasts and other quantile forecasts are more accurate at short-, medium-, and longer- term forecasting horizons. Accurate quantile forecasts at different horizons are critical to many operational decisions, such as capacity and inventory management.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:30, Room - Welcome 4 Code: OR60A3437

Network Characteristics and Project Duration Forecasting: A Comparative Assessment of Earned Schedule (ES) and Earned Duration Management (EDM)

Prof Homayoun Khamooshi *(The George Washington University)*

There have been very few studies comparing the reliability and accuracy of forecasting project duration using EDM based models. Most of these studies did not consider the network characteristics and the size of the data used were relatively small. This research incorporates network characteristics and uses more than twelve hundred projects to develop the results for the hypothesis. The study compares the performance of EDM against Earned Schedule at multiple stages of the project. The findings suggest that EDM generally outperforms all the other techniques and the network characteristics have minimum to no bearing on accuracy of forecast.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 10:00, Room - Welcome 2 Code: OR60A3285

Demand Forecasting Using Complex-Valued Autoregressive Models

Prof Sergei Svetunkov *(National Research University "Higher School of Economics")* and Dr Ivan Svetunkov *(Lancaster University)*

There are many pairs of products that are either interchangeable or complementary. In the process of forecasting of the demand on those products, it is important to take those features into account. While it is possible to use vector autoregressive models (VAR) in this case, they are cumbersome and contain too many parameters, which in cases of real data may lead to overfitting. In this presentation we propose a complex-valued autoregressive model (CAR), which can be considered as a parsimonious version of VAR. We demonstrate how to estimate this model, discuss the properties of the complex-valued autocorrelation function and propose the order selection mechanism. Finally, we demonstrate the performance of the CAR on an example of real data, comparing it with VAR model.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:00, Room - Welcome 2 Code: OR60A3673

A 60 Year Retrospective on Intermittent Demand Inventory Forecasting

Prof John Boylan *(Lancaster University)* and Prof Aris Syntetos *(Cardiff University)*

Sixty years ago, exponential smoothing methods were in their infancy. In early commercial implementations, all Stock Keeping Units were treated in the same way regardless of whether they were fast-moving or slow-moving. However, this failed to take into account the special nature of 'intermittent' demand items with periods of zero demand. Early research was focussed on the distributional properties of intermittent demand. . Forecasting of mean demand advanced through the work of John Croston, which was later refined by other researchers to take into account bias corrections. Further developments have improved the demand forecasts required to decide whether an item should be discontinued, thereby reducing the risk of obsolescence. A parallel development has been the introduction of re-sampling methods, which do not require any particular distributional assumptions. These methods have

been included in commercial software and are particularly appropriate for with lumpy demand patterns. Alternative non-parametric methods, based on blocks of past data have also been proposed and recent research has made some headway in understanding their properties. A more rigorous statistical model basis for intermittent demand forecasting has taken some time coming. In the Box-Jenkins framework, a natural extension was to Integer Auto-Regressive Moving Average (INARMA) models. Very recent research has found that it is possible to position Croston's method within a statistical model, which includes hidden trends and seasonalities. Empirical evidence on its application to retail demand forecasting will be reviewed. The presentation will include a review of the open research questions in this field, and any progress towards answering these questions. Opportunities for software enhancements will also be highlighted, in an attempt to bridge the gap between theory and practice in this important area of application. These will be embedded within an intermittent demand forecasting framework taken from the authors' recently completed book on this subject.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 11:30, Room - Welcome 2 Code: OR60A3368

Forecasting and Inventory Control for Compound Poisson Demand Using Periodic Demand Data

Prof Ruud Teunter *(Groningen University)*, Dr Mohamed Zied BABAI *(Kedge Business School)* and Dr Aris Syntetos *(Cardiff University)*

Although compound Poisson demand is a popular choice for inventory control, there exists hardly any guidance on obtaining its parameters from real demand data. The forecasting literature focuses on predicting period or lead time demand, which does not yield consistent estimates for the parameters of a continuous-time compound Poisson distribution. In particular, we show that substituting Croston forecasts for the demand parameters leads to dramatically too high inventory levels, although this is common in forecasting and inventory control software. Standard statistical estimation methods offer an alternative, but they are less intuitive and can have severe biases in finite samples (method-of-moments) or are not available in closed form (maximum likelihood). We propose a new, intuitive, consistent, closed-form method-of-moments estimator and show that it dominates in terms of estimation accuracy and achieved service level.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 12:00, Room - Welcome 2 Code: OR60A3397

Forecast Nervousness in Supply Chains: Should We Use Consumer Demand or Retailer Orders?

Dr Qinyun Li and Prof Stephen Disney *(Cardiff University)*

Retailers observe and satisfy consumer demand. They replenish their in-store inventory by placing orders onto manufacturers. They usually place firm orders to the manufacturer in the morning to be dispatched later that day. They also provide future predicted daily orders over the coming weeks; these are future order forecasts. We have recently delivered a measure of the accuracy of these order forecast streams that we call nervousness (Li and Disney, 2017).

The nervousness measure places a weight on the variances of the n-period forecast errors to combine them into a single metric. The geometrically decreasing weight assigns more importance to short-term forecast errors (presumably they are more costly) than forecast errors in the distant future (likely they are easier to cope with). The natural question to ask is should the manufacturer use the retailer's future order forecasts based on the end consumer demand? Or should the manufacturer ignore the retailer's future order forecasts and create his forecast stream based on the retailer's actual order history? We answer by considering a two-echelon order-up-to policy based supply chain. Both the retailer and the manufacturer use exponential smoothing to forecast. We investigate the case of general lead-times with a z-transform analysis. For i.i.d. demand we find exact closed-form expressions for the nervousness experienced by the manufacturer. We also obtain closed-form order and inventory variances at both echelons, both with and without information sharing. We also investigate how the nature of demand pattern influences these characteristics via a frequency response analysis.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 13:30, Room - Welcome 2 Code: OR60A3597

Model Uncertainty in Hierarchical Forecasting

Dr Nikolaos Kourentzes *(Lancaster University)*

Hierarchical forecasting is widely used in practice, as it ensures that forecasts are consistent across different planning levels. For example, a company may need forecasts at stock keeping unit per store level for inventory decisions, at product level for production and procurement decisions, at brand level for marketing decisions and so on. All these forecasts must be consistent to ensure aligned decisions and the smooth operations of the organisation. Hierarchical forecasting may be cross-sectional, addressing cases like the previous example, or temporal ensuring consistency across planning horizons. For many years, hierarchical forecasting was based on ad-hoc approaches such as top-down, i.e. forecast at the top level of a hierarchy and disaggregate to all required levels, or bottom-up, i.e. predict at the lowest level and aggregate the forecasts as needed. Nowadays, the model based optimal combination approach provides a more flexible and accurate hierarchical forecasting framework. This operates by requiring a forecast at every node of a hierarchy and combining them linearly to construct consistent forecasts. The combination is optimal in the sense of minimising any reconciliation errors; that is any disagreements between forecasts at the various nodes of the hierarchy. However, this approach does not consider the certainty the analyst has on each forecast and underlying model for each node. Intuitively, one would expect that it is reasonable to weight more forecasts that one feels confident about over forecasts that are less certain. We propose such a weighting framework, drawing on the extensive model selection literature; that is aware of the predictive confidence we place on statistical models. We examine two variants, one that is computationally efficient, but has strict modelling requirements, and one that trades computational efficiency for minimal assumptions. We demonstrate the power of the methodologies in multiple cases for cross-sectional and temporal hierarchies.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 14:00, Room - Welcome 2 Code: OR60A3517

Weighted Energy Score

Dr Xiaochun Meng *(Sussex University)* and Prof James Taylor *(Saïd Business School, University of Oxford)*

Multivariate probabilistic forecasting is particularly intriguing and challenging due to its inherently complex nature and computational difficulty. For some applications, such as financial market risk assessment, a specific region is often of more importance than the whole distribution. To emphasise the region of interest for multivariate distributions, we propose the weighted energy score by generalising the existing energy score via threshold and quantile weight functions. The proposed weighted energy score is proper and provides useful insight into the evaluation of multivariate probabilistic forecasts. We use financial data to provide empirical support for the proposed weighted energy score.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 14:30, Room - Welcome 2 Code: OR60A3488

On the Untunability of Forecasting Algorithms

Dr Steven Prestwich *(University College Cork)*

Forecasting algorithms based on exponential smoothing have smoothing factors, and it is often recommended that these be tuned to minimise an error measure on observed data. We show that forecasting algorithms such as simple exponential smoothing and Croston's method cannot always be optimally tuned to time series using any of several error measures. We argue that proposed fixes such as artificially adjusting the initial forecast are arbitrary and yield meaningless results. Instead we propose a data augmentation approach: adding non-stationary time series to the training data, and minimising a weighted error. The choice of such series is a form of judgemental forecasting that requires experts to explicitly state their assumptions on unseen future data.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

Health Systems

Organiser: Adrian Yeow Yong Kwang

11/09/2018, 11:00, Room - Welcome 4 Code: OR60A3682

Devising Logical Rules in Healthcare Operations Management

Dr Fahim Ahmed *(University of Strathclyde)*, Mrs Gillian Anderson and Dr Robert Van der Meer *(Strathclyde Business School)*

There are several OR techniques used within healthcare operations management. They range from basic soft OR methods to a more formal analysis of an operational problem. However, there is a need to provide more structured and precise framework for the healthcare professionals to understand the operational dynamics of the system right from the beginning. In most cases, they are able to capture the details about various aspects through discussion, modelling, brainstorming and find ways to record them in the operations management process. However, the specific information about the logical operational rules are not easily identifiable at the initial stages, mainly because there are not many techniques that can capture these details. In this talk, we present results of a short study conducted at a user group event attended by 25 healthcare professionals that reveals interesting points about their understanding and structuring of these logical rules. A framework to visually structure these rules at problem defining phase will be presented. This is based on finite state machine diagrams adapted from computer science. The approach will be presented with a short case study in healthcare context.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 11:30, Room - Welcome 4 Code: OR60A3383

Analysis of Modifiable Risk Factors of Non-Communicable Chronic Diseases in the Brazilian Population

Miss Simone Lima, Ms Caroline Mota and Miss Danielle Santos *(Universidade Federal de Pernambuco)*

Factors related to a long and healthy life are important areas of research for public health management which are associated with people's behaviour, education, socio-economic situation, aging, and genetic issues. Health challenges include the treatment of non-communicable chronic diseases (NCDs) such as cancer, cardiovascular diseases, diabetes, and chronic respiratory diseases that affect the lives of many people around the world. This study aims to analyse modifiable risk factors for NCDs including smoking, unhealthy diet,

physical inactivity, and harmful use of alcohol. This analysis can support decision-making on public health. The data used in this research was derived from the Brazilian national health survey - PNS 2013.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 12:00, Room - Welcome 4 Code: OR60A3465

A considered comparison of the deaths from breast and prostate cancers – with an extension to other causes of death

Mr Malcolm Fenby

In February 2018 (in the UK), it was widely reported that "Prostate cancer deaths overtake those from breast cancer". Whilst this is true, looking at deaths by age reveals a different story: that for those aged under 85, deaths from breast cancer exceed those from prostate cancer (and for those aged under 65, deaths from breast cancer are 5.5 times those from prostate cancer). This presentation will introduce a metric 'Lost Life Expectancy' – which measures the gap between age at death and life expectancy. It is suggested that is this (one of many) useful metrics for such comparisons – thus it is extended to all causes of death. This presentation is an extension of article that was published in the April 2018 edition of Inside OR.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:00, Room - Welcome 4 Code: OR60A3325

Augmenting Antibiotics Prescription Decision Support System with Case-Based Inputs via Prescriptive Algorithmic Model

Dr Adrian Yeow *(Singapore University of Social Sciences)* and Prof Kim Huat Goh *(Nanyang Technological University)*

Clinicians have often overridden existing antibiotics prescription guidelines prompted by the EMR system. Some of the reasons behind their actions are: time-lag in system (when requesting for additional information on particular guidelines), the extra steps required, the clinicians' own prior experience. Our research is an ongoing study that looks at how a new prescriptive algorithm improve the existing rule-based decision support system to influence compliance behavior among clinicians. Our goal is to understand how the improved accuracy and ability of the algorithmic model leads to changes in compliance behaviors.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 11:30, Room - Welcome 4 Code: OR60A3688

A Hybrid Systems Approach Using Real-Time Data and Computer Simulation: A Research Framework and its Implementation in the Context of Urgent and Emergency Care

Ms Alison Harper and Prof Navonil Mustafee *(University of Exeter)*

Conventional simulations rely on historic data and are generally used for medium to long-term decision making. With the advent of technologies associated with business intelligence and

data sciences, it is now possible to process and store an increasing volume and variety of data, including high-velocity and real-time data. With open architectures and standards for data sharing, this data is increasingly available for data-driven applications which may run, for example, prediction algorithms or visualisations. This study aims to investigate how real-time simulation can support short-term decision-making in urgent and emergency care. A hybrid systems modelling approach is proposed, which is the combined application of real time-data feeds, forecasting and simulation. The hybrid approach is encapsulated in a research framework, which proposes a step-by-step approach to inform the development of a real-time simulation. The framework is implemented through a case study that focuses on the urgent care network in Torbay and South Devon; it relies on the NHSquicker platform for real-time data feed. The potential impact of the real-time model will be evaluated in terms of its contribution to distributed situation awareness using staff interviews. Distributed SA is system knowledge held in both the human and technical components of a system which supports short-term decision-making.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 12:00, Room - Welcome 4 Code: OR60A3701

Assessing Heterogenous Relationship among Trade Unions in Nigerian Health Sector Using Soft System Methodology

Mr Francis Andem *(University of Uyo)*

Nigeria's heath sector has many trade unions. The sector despite its vital position in the social well-being of the citizens, is confronted with heterogeneous relationship and behaviour among unions in its system. The complex nature of these relationships creates turbulence in Nigerian health system. This paper sought to use the Soft System Methodology (SSM) in assessing the heterogeneous relationship among unions in the health sector. Factors such as lack of clear role definition, standardization of processes, inter union conflicts, perceived disfavour among unions and poor government policies showed significant effect on unions' heterogeneous relationship. I concluded that there systemic turbulence and failure of policy framework in Nigeria health sector. I recommend that a system thinking approach to a guide for government, union and stakeholders in the Nigerian health sector.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 13:30, Room - Private 2 Code: OR60A3687

Health Systems Editors' Meeting

Prof Paul Harper *(Cardiff University)*

This is a closed session - only for editors-in-chief and area editors of Health Systems, and T&F staff.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? Subject experts only
Is your talk accessible and relevant to practitioners? Not at all

Healthcare Applications

Organiser: Dave Worthington

11/09/2018, 11:00, Room - Welcome 1 Code: OR60A3503

Will Data Science Enable a New Era of Healthcare OR Simulation?

Dr James Crosbie, Dr David Halsall and Dr Jonathan Pearson *(NHS England)*

Challenge: The affordability of healthcare presents a challenge to all developed nations as demand continues to rise faster than GDP growth. The NHS has drawn on simulation modelling in the past to investigate how performance and cost efficiency can be improved. High impact simulation studies have tended to focus on a particular problem area or a limited geographic location. Large scale healthcare simulations tend to be restricted by the lack of operational data and pathways which change with behavioural aspects of patients and staff. Past: A short review of simulations which have had a high impact on NHS policy making in the past will be presented. Some of the characteristics of simulation modelling projects which have limited impact will also be made. Some rules of thumb of what makes a successful simulation project will be presented. Future: In common with other healthcare systems, the NHS has a strong desire to harness the power of information to provide better and more cost effective care. Comparing healthcare to other industries who have transformed their services around the digital economy is not always helpful because of the complexity of the patient journeys. Notwithstanding this limitation the NHS is set to capitalise on data sets under its control and move towards a population health management approach to prevention and treatment of patients in geographical areas. By tapping into new integrated data sets the simulation modeller may be able to provide insights into a much wider range of system configuration questions. We will pose the question if data availability is no longer the limitation for the simulation modeller what tools and techniques will be needed in the future to make high impact with our analysis?

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 11:30, Room - Welcome 1 Code: OR60A3540

Exploring Broadening Implementation of My Research in the NHS

Dr Marion Penn and Prof Chris Potts *(University of Southampton)* and Dr Xiaozhou Zhao *(University of Hertfordshire)*

The lack of implementation or follow through of OR applications in healthcare has been receiving increasing attention in recent years. The work done within the OR in Healthcare community has great potential to impact the effectiveness and efficiency of our healthcare system. However, the literature often fails to discuss implementation or only shows evidence

of implementation in the hospital with which the research was conducted. Various potential reasons for this have been cited including lack of knowledge of the methods used, lack of software availability, lack of staff awareness and lack of time available. This talk will report on a project following up on my PhD study, to make the research readily available and allow NHS clinicians and managers to explore what difference they could make and therefore persuade them to make changes. The original research used discrete event simulation, implemented through Simul8, to explore the impact of different scheduling algorithms on the ability to schedule operations within due dates. This has been adapted to create an Excel tool into which simple data on a case mix of patients can be entered and then at the click of a button the potential impact of different scheduling algorithms explored.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 12:00, Room - Welcome 1 Code: OR60A3489

Understanding the Dynamics of Referral-To-Treatment (RTT) Pathways in Great Britain

Dr Richard Wood *(NHS Bristol, North Somerset and South Gloucs CCG)*

In the NHS there are three main constitutional targets relating to A+E, Cancer, and elective treatment for which waiting time performance is measured. The measure for elective waits is known as referral-to-treatment and the target in England is that at any time 92% of patients are waiting no more than 18 weeks for the start of their treatment from GP referral. The dynamics of this pathway are unfortunately not well understood in the health service and activity planning assumptions and not always aligned with performance planning assumptions despite a clear and intuitive link between the two. In this work a model is constructed which links together the key variables at play – referrals, capacity, activity, performance, and waiting list size. The model, implemented as a discrete time simulation of a priority-based queuing system, tracks patient arrivals onto the pathway through GP referrals and their subsequent wait until their RTT "clock-stop", i.e. the activity required to stop the clock and terminate the pathway. Varying the handles of the pathway – referrals and capacity – in line with "what if" scenarios can be used to show the effect on the dependent variables of activity, performance, and waiting list size. These response variables are important measures demanded by health system regulators and are often the subject of media interest given the 15.7m pathways of 2017/18 and an average performance of just 89%. Some real-life examples of use of this model will be presented alongside a simple analogy of the model mechanics which has been useful in explaining the dynamical concepts to clinicians and managers.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 13:30, Room - Welcome 1 Code: OR60A3583

Combining Data Mining and Simulation in Healthcare Modelling

Dr Honora Smith, Dr Kasia Bijak and Dr Christine Currie *(University of Southampton)*, Dr Navid Izady *(Cass Business School)*, Miss Christina Saville and Miss Dandan Shi *(University of Southampton)*

Two case studies are described that combine data mining with simulation modelling in different ways to find efficiencies in hospital services. The first is set in a breast diagnosis clinic

in a London hospital serving a local district; general practitioners refer patients to this clinic. Firstly, a study was carried out into whether the information on referral forms was sufficiently accurate and complete enough to be used in planning initial diagnostic tests in the clinic. Two scorecards, one simple and one more complex, were developed to predict a patient's risk of abnormal breast diagnostic results. It is usual to base the decision of where to set the cut-off score between low- and high-risk patients on a scorecard's predictive performance. In contrast, we show how a discrete event simulation (DES) can be used to optimise the cut-off in terms of operational performance. In consultation with clinic staff, the performance measure used is the daily average proportion of patients' time that adds value, called the clinic efficiency. The impact of introducing risk-based pathways is estimated through simulation: potential improvements are demonstrated. The second study investigates efficiency of admission policies of patients into an adult intensive care unit in a major tertiary hospital serving a large area of the West of England. Logistic regression models were built to predict patients' mortality for different admission groups (planned, unplanned, late or re-admitted). We describe a DES model to investigate the impact of the late admission group and strategies for improving efficiency by bringing patients into the ICU earlier. Mortality prediction models are incorporated into the DES. It is shown that the ICU can accommodate more unplanned patients than it can currently, if the late admission group can be reduced.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:00, Room - Welcome 1 Code: OR60A3586

Machine Learning for Behavioral Healthcare Analytics: Addressing Waiting Time Perceptions in Emergency Care

Dr Daniel Gartner *(Cardiff University)* and Dr Rema Padman *(Carnegie Mellon University)*

Recent research has highlighted the need to improve patient satisfaction by reducing waiting times in hospitals. This study examines under- and overestimation of waiting times in an emergency department (ED). Early and accurate determination of patients' estimates and, consequently, perceived waiting times can potentially increase patient satisfaction. Using data from more than 250 patients, we test the applicability of machine learning methods to predict under- and overestimation of waiting times in two ED areas. Our attribute ranking and selection methods reveal that actual waiting time, clinical attributes, and the service environment are among the top ranked and selected attributes. The classification methods reveal that the precision to classify a patient to the true outcome of overestimating waiting times reaches almost 70% in the first waiting area. If a patient waits in a treatment room, the second waiting area under study, this precision level reaches almost 78%. In a second stage of this study, we develop a discrete-event simulation (DES) model that represents the emergency department. We link the waiting area-dependent attribute selection and classification approaches with the DES model. In an experimental study, we evaluate the impact of different staffing patterns on actual waiting times as well as under- and overestimating behaviour in the two areas. Our results can be employed to control waiting time perceptions and, potentially, increase patient satisfaction in hospitals.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:30, Room - Welcome 1 Code: OR60A3650

Assessing and Improving Trauma Outcomes Prediction

Miss Fatima Almaghrabi, Prof Dong-Ling Xu and Prof Jian-Bo Yang *(University of Manchester)*

Trauma is a major public health issue and a major cause of mortality and disability worldwide. In England and Wales, for example, there were 17,201 injury-related deaths, in 2010. For every death following an injury there are approximately 10 people survive, potentially with serious permanent disabilities. Trauma outcome prediction models are useful in identifying the extent of patient injuries and prioritising immediate life threats. This research aims to identify the most accurate tools for building a prediction model and to increase model accuracy to enhance the care services provided to trauma patients. Thus, the research attempts to identify which algorithms have the highest classification accuracy in predicting trauma outcome. The results of some machine learning (ML) algorithms, such as decision tree, logistic regression, random forest and neural network results were compared to the evidential reasoning rule. After that, different machine learning classifiers have been combined using the evidential reasoning rule for ensemble learning to enhance model prediction.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 09:00, Room - Welcome 1 Code: OR60A3599

Multidisciplinary Approach to Reduce Overcrowding in Hospital Emergency Departments

Dr Luca Grieco, Dr Sonya Crowe, Prof Naomi Fulop, Prof Martin Utley, Dr Cecilia Vindrola-Padros and Dr Victoria Wood *(University College London)*, Ms Harriet Walton and Dr Samer Elkhodair *(University College London Hospitals NHS Foundation Trust)*

Emergency department (ED) overcrowding is common and impacts on patient safety, quality of care, staff morale and cost. The underlying causes of overcrowding can vary between hospitals and policy guidance generally lacks the contextual information needed to filter suggested interventions according to the particular challenges of any given hospital. We aimed to assess the relative extent to which different external factors were hindering ED performance in a UK hospital and identify suitable interventions given the hospital's context-specific problems and capacity for change. In a qualitative strand, we interviewed and shadowed staff at a UK hospital to identify key processes, flows of patients and external factors that were hindering ED performance. This informed the development and analysis of a queueing network model that related external factors to different measures of ED performance. We then identified and characterised interventions aimed at reducing overcrowding from existing literature, and assessed their impact (using the model findings) and feasibility (using the qualitative findings) for the hospital under study. Performance against the "4-hour target" (≤95% of patients leaving ED within 4-hours) is primarily driven by delays in accessing hospital beds, and physical congestion in the ED is also influenced by the volume of low acuity patients. Therefore, interventions targeting output factors will likely have most impact, although their feasibility may be hindered by organisational resistance to change and the availability of social and community care. Interventions targeting input factors (which typically reduce the volume of low acuity patients) may reduce physical congestion but are unlikely to improve 4-hour performance. Influenced by our work, the hospital is prioritising action on speeding up admission processes and freeing up beds earlier in the discharge process. Our approach could be usefully applied to other hospitals to identify the solution(s) most likely to work for them.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:30, Room - Welcome 1 Code: OR60A3600

Enhancing Cooperation between Emergency Departments and Out-of-Hours Cooperatives of General Practitioners

Dr Henk van Stel *(UMC Utrecht)*, Mr Egbert Roos and Dr Martin Smits *(Tilburg University)*

BACKGROUND: Cooperation between emergency departments (ED) of hospitals and out-of-hours cooperatives of general practitioners (GP-OOH) for delivering urgent healthcare is highly debated. Low-urgent patients should ideally be treated by a GP. Although there are several cooperation initiatives throughout the Netherlands, there is a lack of evidence about outcomes. Traditional research designs are incapable of dealing with the complexity and context related to cooperation of organizations. STUDY GOAL: To develop a decision support tool ('management cockpit') to provide healthcare professionals and management insight in the effects of cooperation on performance of the local emergency care system. METHOD: System Dynamics Modeling was used to build a realistic simulation model of complex organizational processes and cooperation and to use this model to simulate decisions about process changes and cooperation. Model building from causal maps was based on interviews with managers and professionals, on scientific literature and on anonymized data from an ED and a GP-OOH in a city in the center of the Netherlands. Data included actual occupancy with healthcare professionals over one year, all visits to an ED and a GP-OOH over one year, with information about urgency, time and diagnosis. These data were converted to a standard week pattern. Cost estimate were attached to each activity, resource or material in the model. Main performance indicators were waiting times, total costs and occupancy. RESULTS: Different organizational models of cooperation resulted in changes in total costs of -1% to -5%, with an increase of costs for the GP-OOH of 6 to 9% and increased workload, and a decrease in ED-costs of 8 to 15%. The increase in GP-workload and decrease in revenue at the ED were not acceptable to stakeholders. CONCLUSION: Modelling gives insight in performance of different models of cooperation in emergency care. Advanced models should include the whole hospital system.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 10:00, Room - Welcome 1 Code: OR60A3495

Redesigning 'Step Up' and Hospital 'Front Door' Services to Meet the Needs of Older Patients in the Hywel Dda University Health Board

Miss Sara Heledd Thomas *(Office for National Statistics)*

With the population of those over 65 years old living within the area served by the Hywel Dda University Health Board (HDdUHB) projected to increase by almost a third by 2035 and bed occupancy levels at its major hospitals already over the threshold considered to be safe, alternative pathways need consideration. This issue is often exacerbated by many elderly, frail patients de-conditioning during their stay at the hospital and the delays experienced when waiting for transfers of care to the home. During summer 2017, I carried out an investigation into the potential impact of introducing new services for frail, elderly patients on the hospital bed occupancy and A&E waiting times at Glangwili General Hospital in Carmarthen. In this

presentation, I will discuss how I went about creating a Simul8 model of the A&E department, as well as highlighting the ways in which the model was made fit for purpose and appropriate for testing the interventions proposed by the service managers. In particular, I will discuss the assumptions the model makes and the conclusions drawn from testing the model with new pathways introduced.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Welcome 1 Code: OR60A3281

KEYNOTE: Algorithms for Paired and Altruistic Kidney Donation in the UK

Dr David Manlove *(University of Glasgow)*

A patient who requires a kidney transplant, and who has a willing but incompatible donor, may be able to 'swap' his or her donor with that of another patient in a similar situation. The UK Living Kidney Sharing Schemes (UKLKSS), run by NHS Blood and Transplant, aim to find optimal sets of 'kidney exchanges' involving incompatible donor-patient pairs and altruistic (non-directed) donors in the UK. In this talk we describe the algorithms that we have designed and implemented in order to construct optimal sets of exchanges for quarterly matching runs of the UKLKSS since July 2008. We also provide an overview of outcomes, showing the numbers of transplants that have been identified and that have proceeded from these runs. This is joint work with Péter Biró, John Dickerson, Gregg O'Malley, William Pettersson, Ben Plaut, Tuomas Sandholm and James Trimble. For more information about this work, see the short introductory article in volume 2018, issue 1 of Impact (https://doi.org/10.1080/2058802X.2018.1435455). A more mathematical description of the Operational Research techniques that are used to solve to solve the kidney exchange problem in the UK are described in a short article in volume 475 of the London Mathematical Society Newsletter (see https://www.lms.ac.uk/sites/lms.ac.uk/files/files/NLMS_475.pdf, pages 19-24). A full technical description is contained in the following article published in ACM Journal of Experimental Algorithmics (http://dx.doi.org/10.1145/2670129).

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 16:00, Room - Welcome 1 Code: OR60A3542

Optimisation-Based Decision Support for Facility Layout Planning When Building or Rebuilding Hospitals

Dr Anders N. Gullhav, Prof Henrik Andersson, Miss Vilde N. Kvillum, Prof Bjørn Nygreen and Miss Anne Marit R. Vigerust *(Norwegian University of Science and Technology)*

When building or rebuilding a hospital, a decision of great importance is to design its internal layout. We consider a facility layout problem for hospitals, where a diverse set of hospital functions, such as operating rooms, bed wards, medical imaging labs, and emergency rooms, has to be assigned unique locations. A layout that reduces the amount of transportation of patients, personnel and materials is desirable in terms of operational effectiveness. The demand for transportation between functions is expressed through a relatedness value, and hence, one seeks a layout with minimum total distance between pairs of functions weighted by the pairs' relatedness. We formulate this problem as a mixed-integer program (MIP) that

aims to help hospital planners when designing internal hospital layouts. Due to its objective function, the problem has similarities with the quadratic assignment problem, and thus, the problem is very hard to solve for real-world cases. Therefore, we propose a heuristic iterative solution approach that solves relaxed versions of the MIP model. To our knowledge, our approach is novel within the literature. We present results from artificial and real-world instances, which show the applicability of our approach.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:30, Room - Welcome 1 Code: OR60A3588

Restructuring Inpatient Wards at a Public Hospital

Dr Sebastian Rachuba *(University of Wuppertal)*, Dr Elvan Gokalp and Dr Nalan Gulpinar *(University of Warwick)*

Structures and sizes of inpatient wards at public hospitals have grown historically and only few changes are made to the allocation of beds to wards and departments. Restructuring of existing allocations is thought to be promising with regards to a more efficient bed utilisation, especially with seasonal demand. However, resulting changes cause disruption and would affect daily working practice. We present a mixed-integer optimisation model to support ward restructuring at a public hospital. The optimisation model assigns beds to wards and departments and considers individualised ward structures, staffing requirements, and different room sizes. We apply the model in a case study using real world data in order to demonstrate the effects of restructuring. We analyse the trade-offs between restructuring effort, the resulting costs and the quality of new structures. Finally, we discuss operational and managerial implications of our research.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:00, Room - Welcome 1 Code: OR60A3512

A GRASP-Based Decision Support System for the Home Health Care Routing and Scheduling Problem

Mr Carlos Lamas-Fernandez and Dr Thomas Monks *(University of Southampton)*

The Home Health Care Routing and Scheduling Problem (HHCRSP) consists in assigning routes and schedules to nurses that deliver health care services to patients at their homes. A varied range of hard and soft constraints such as time windows, synchronisation of nurses, skill mix or patient and nurse preferences make this problem particularly difficult to solve by hand, and this is a challenge faced by many community nursing teams on a daily basis. In this work we present an open-source decision support system (DSS) that aims to help solving this problem in a practical way. Our DSS is based on a Greedy Randomised Adaptive Search Procedure (GRASP) that solves a multi-objective HHCRSP, providing a range of high quality solutions in a short time and according to different criteria. The DSS is also linked with open source maps and an interactive reporting system that allows to visualise the solution of the HHCRSP problem in an intuitive way, which can help planners both save time and achieve more efficient plans for their everyday operations. Our preliminary results working with three home health care teams in the south of England suggest that this is a promising approach given its

flexibility to include practical constraints and its speed. Furthermore, we expect that its availability and independence of commercial solvers will help reaching more teams in the future.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:00, Room - Welcome 1 Code: OR60A3515

Infinite-Server Queues for 'Predictive Modelling 'in Health Care

Dr David Worthington *(Lancaster University)*, Dr Dan Suen *(STORi)* and Prof Martin Utley *(CORU)*

Despite the apparently unrealistic assumption of infinite resources, infinite-server queueing models have played a central role in the development of queueing theory and its applications. Healthcare modelling applications have been a major beneficiary of these models. Many healthcare examples have concentrated on capacity planning for services where: either queues rarely occur and so the infinite-server assumption provides an easy way to approximate system behaviour; or the distribution of 'offered load' or 'unfettered demand' can be compared with possible resourcing levels to provide indicative performance levels as a basis for decision making. These applications can be for single-node or multimode systems, for time-homogeneous or time-inhomogeneous arrivals, and where resources can be fixed or time-dependent. Healthcare modellers often have to choose between two differing theoretical approaches found in the literature, modelling in continuous time and in discrete time. This talk therefore first provides a brief and accessible consolidation of the two approaches. It then goes on to provide a brief discussion of recent and future healthcare applications, with some discussion of the established concept of 'offered load' and newer concept of 'predictive modelling'.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:30, Room - Welcome 1 Code: OR60A3501

A Modelling Approach to Support Decisions around the Use of Patient Activation in the Management of Patients with Multiple Chronic Conditions

Dr Evrim Gunes, Dr Odysseas Kanavetas and Dr Lerzan Ormeci *(Koc University)* and Dr Christos Vasilakis *(University of Bath)*

We develop a Markov Decision Process framework to manage care for individual patients with multiple chronic conditions through a complex care hub. Complex care provision influences the evolution of Patient Activation Measure (PAM), an indicator for healthy behavior, which affects the evolution of health state of patients. We define a general model where the transition probabilities and the rewards are time dependent parameters. Then, we explore optimal and heuristic policies which maximise the welfare for static parameters. Through numerical experiments we explore the performance of alternative policies that focus on managing more complex patients or improving activation of all patients.
What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 10:00, Room - Welcome 1 Code: OR60A3536

Modelling Disease Progression and Treatment Pathways for Depression

Mrs Sarie Brice, Dr Daniel Gartner and Prof Paul Harper *(Cardiff University)* and Dr Doris Behrens *(Aneurin Bevan University Health Board)*

Depression is a mental health condition that affects more than 300 million people world-wide. The condition and the system of care are complex involving different severity stages and providers of care, respectively. In this paper, we model the system of care and its patients by breaking down the condition into mild, moderate, and severe stages. These three categories differ from each other by the number and severity of symptoms presented. Our model captures the clinical progression of patients between the stages, which depends on several factors including whether patients are seeking treatment. We also capture in the model those patients who do not seek medical help. In terms of services, we model the complexity of patient pathways mainly across primary and secondary care services. Our chosen methodology comprises of two linked simulation paradigms: an agent-based model (ABM) describes and models the clinical progression of depression and takes into account the different stages and transitions between them; a system dynamics (SD) model is then linked with the ABM and is used to capture and model treatment pathways. Drawing from the literature, we populate our model with parameters such as prevalence rate, uptake of treatment rate, likelihood of progressing to a different stage etc. Our hybrid simulation framework is being used to dynamically model a large population and capture resulting resource needs from those presenting with different stages of depressions. Furthermore, we will use the framework to measure the cost-benefit of various intervention strategies, such as earlier diagnosis and appropriate treatment of those with depression, and modelling the subsequent changes to resource consumption, costs and quality of life through preventing progression to more severe clinical stages.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:00, Room - Welcome 1 Code: OR60A3568

Primary Care Homes: A Case Study for the Evaluating of Small Scale Primary Care Interventions and a Role for OR

Mr Christopher Sherlaw-Johnson *(Nuffield Trust)*

The Primary Care Home programme has been developed to support small scale initiatives for improving the quality, efficiency and coordination of primary and community care. The Nuffield Trust was funded to evaluate this programme at 15 test sites over a period of six months. Examples of local initiatives included a social prescribing service, enabling more joined up care for frail older people and special community clinics catering for particular conditions. Because of the short timescale and the fact that each initiative was in its early stages, we focussed on guiding their decisions for implementation and on enabling them to be suitably equipped for ongoing future evaluation. This presentation will describe our approach, the issues that arose concerning data and its analysis and methods for addressing them. Healthcare interventions at this scale are common, but activity in the wider environment, the population size, resources and time available make them difficult to evaluate. There is clear scope for operational research methods, but they are not widely used.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:30, Room - Welcome 1 Code: OR60A3579

An Integrated Decision Analytics Framework for Lung Volume Reduction Surgery Treatment of Emphysema

Dr Shengfan Zhang *(University of Arkansas)*

Emphysema is a slowly progressive disease of the airways that is characterized by a gradual loss of lung function. It is a major cause of death and disability in the United States. Lung volume reduction surgery (LVRS), which reduces the lung size, will open the airways and allow easier breathing. Despite of the advantages of LVRS in specific patients, it has mortality and morbidity risks and costs more than other treatments which makes it crucial to determine the subgroup of patients that can benefit the most from LVRS and assign them to surgery at the best time. Existing studies on emphysema only deal with one-time clinical decision, i.e. whether to perform an LVRS, or to take medication or other regular medical treatments. The goals of this research are to (1) identify key contributory clinical variables that significantly differentiate long term outcomes for emphysema patients, using data analytics methods; and (2) evaluate the cost-effectiveness of such patient stratification, and quantify the benefits and risks associated with different treatment timing by patient groups, using Markov decision modeling. In this study, we used data from the National Emphysema Treatment Trial (NETT), one of the largest clinical trials funded by the U.S. National Institute of Health, which investigates the effects of LVRS on clinical outcomes as a palliative treatment for severe emphysema.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 12:00, Room - Welcome 1 Code: OR60A3607

Healthcare Behavioural OR

Prof Paul Harper *(Cardiff University)*

Behavioural Operational Research (BOR) is defined as the study of behavioural aspects related to the use of OR methods in modelling, problem solving and decision support. BOR may broadly be considered within three categories: behaviour in models (methods), behaviour with models (actors) and behaviour beyond models (praxis). Examples of behavioural considerations within healthcare applications include patient and staff behaviours relating to services and patient access to them, patients' understanding of public health campaigns, physicians' understanding of the benefits and risks of recommendations, and the effects of social networks on transmission, propagation, and reaction to disease. In this talk I will present some motivating examples including some recent research exploring the nature of the relationship between service times and workload in order to assess and quantify any workforce (server) behaviours within an Emergency Department. I will also briefly report on the key findings from a comprehensive literature review on the implementation of behavioural aspects in the application of OR in healthcare (co-authored with Martin Kunc and Konstantinos Katsikopoulos).
What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 13:30, Room - Welcome 1 Code: OR60A3440

Building Systems and Research Capacity (and a Future University) in Remote, Rural Uganda

Mr Andrew Dobson *(Bwindi Community Hospital, Uganda)*

The speaker has been working as a pro-bono analyst with a medium sized not-for-profit health service provider in remote, rural Uganda, for more than half the time in the last 6 years. The work has evolved over the period from a wide variety of shorter ad-hoc analytical consultancy-type exercises, eg on fundraising strategies, efficiency, performance analysis, and business planning, to a longer-term programme of work, centred around building systems and (local) analysis and research capacity, and aimed at supporting the organisation with its associated nursing school to achieve its vision of becoming a specialist provider of health care services, a centre of research and a university by 2025. This talk will focus on current work, which in the last 12 months has involved inter-related strands on:- 1) Further extending and integrating electronic information systems across the hospital, 2) Developing research capacity through training and supporting a group of key managers to complete, and seek to publish in peer reviewed journals, 5 formalised operational research studies, 3) Supporting the introduction of a significant new mobile phone-based technological innovation to better connect the community in 101 remote rural villages with the health services. 4) Business planning for the nursing school to become a university. The talk will run through these briefly, and go into more detail on the content and findings of the 5 formal operational research studies, as current illustrations of what the organisation seeks to pioneer further in future, with the support of its systems. These include 2 studies looking at the impact of 2 of the organisation's key community health interventions on under 5 child mortality.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 14:00, Room - Welcome 1 Code: OR60A3334

Operational Research Analysts, Social Scientists, Engineers and Clinicians an Interdisciplinary Programme to Improve Fetal Heartrate Monitoring and Maternity Safety

Dr Guillaume Lamé, Dr Jenni Burt, Prof Mary Dixon-Woods, Dr Elisa G. Liberati, Dr Rebecca K. Simmons and Dr James Ward *(University of Cambridge)*, Dr Cathy Winter *(University of Bristol)* and Prof Tim Draycott *(Southmead Hospital)*

Poor practice in electronic fetal heartrate monitoring during labour is a major contributor to avoidable harm in maternity care. Cardiotocography (CTG) is intended to allow caregivers to continuously monitor the baby's heartrate to identify pathologies and take appropriate action, but is vulnerable to problems in interpretation and response. Reports over more than 25 years, mostly based on incident reviews and litigation claims, have advocated training as a means of improving care. More recently, digital decision-support for CTGs has also been recommended. However, adverse events continue to occur, resulting in anguish and burden for families and health systems. We suggest that new insights are needed to understand the problem. Until now, very little work has been undertaken to understand "work as done" versus "work as imagined" in relation to electronic fetal monitoring. We present an interdisciplinary multi-method research programme to observe, describe and analyse how maternity staff practise and react to CTGs. A distinctive feature of the programme is that it will combine an ethnographic study of electronic fetal monitoring practice with an online skills assessment, risk modelling workshops, analysis of legal claims, and the design and crowd-sourced preliminary evaluation of an intervention to address the identified safety issues. Operational research (OR)

tools, principles and methods will be deployed in most steps (to inform ethnographic observations, to structure workshops, to model risks, to design an intervention), but will be fully integrated with social sciences, clinical expertise and safety science. The expected products of the study will be (1) a framework of risks and failure modes in the process of electronic fetal monitoring; (2) a proposed intervention to address these risks; (3) a protocol to evaluate this intervention in a trial. This study will also contribute to a better understanding of interdisciplinary collaborations between OR and social sciences within a clinical context.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 14:30, Room - Welcome 1 Code: OR60A3470

Social Network Formation and Dynamics: The Case of Obesity

Mr Mark Tuson, Dr Daniel Gartner and Prof Paul Harper *(Cardiff University)*

Evidence from social network analysis suggests that an individual's immediate social network can significantly affect the probability of that individual becoming overweight or obese. Our research uses five avenues of enquiry to investigate this paradigm: First, exploring the nature of the interaction between social networks and obesity. Second, identifying how this interaction varies for different sub-groups of the population. Third, assessing which intervention strategies would be effective in modifying this interaction. Fourth, we would like to identify which sub-groups might have the most impact on resources in the future. Finally, quantifying the future impact of current childhood obesity issues on the adult population. To tackle the problem, we use a hybrid simulation modelling approach: An agent-based model of social networks is used to model individual stochastic behaviour and at the same time deliver a topologically stable network consistent with real world social networks. Embedded within each of the agents is a Systems Dynamics model simulating individual decision-making behaviour using input from the network and constructs from the Theory of Planned Behaviour, and the subsequent impact of that decision-making on calorie intake and that individuals body mass. The simulation is calibrated using a vectorised implementation of a gradient descent function, modified to allow for the stochastic nature of the simulation output. Our results demonstrate that the approach can be used by local health service networks strategically to set policy, specifically prioritisation and resource allocation for obesity. Tactically it provides a means for a more detailed review of resource allocation within the area, and a mechanism for testing and 'tuning' the social elements of existing or proposed implementations. The presentation includes initial forecasts using data from a local health authority, and a description/discussion of the implementation methodology, trialling and validating sub-models with AnyLogic, and then combining and programming them in Java.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

Healthcare Applications - Posters




Organisers: Paul Harper, Sally Brailsford, Cynthia LeRouge and Nelson King

12/09/2018, 12:00, Room - Welcome 4 Code: OR60A3700

Building Capability in Mathematical Modelling and Analytics within a Healthcare Organisation

Dr John Boulton, **Dr Izabela Spernaes** and **Dr Doris Behrens** *(ABUHB)*, **Dr Daniel Gartner** and **Dr Tracey England** *(ABUHB & Cardiff University)*, **Prof Paul Harper** and **Dr Vincent Knight** *(Cardiff University)*

Aneurin Bevan University Health Board runs a 12-month programme to break down barriers associated with adopting mathematical modelling and analytical techniques within healthcare. It is aimed at a small cohort of participants and helps develop capability to undertake data analytics and healthcare operations management tasks in practice using Excel. Course participants have the opportunity to work on case studies and develop solutions for problems in their service area. The programme is front loaded with classroom sessions (for example: forecasting and geographical analytics) with assessed coursework after each session. After their completion, participants are required to carry out a practical project which aligns with the health board's current list of priorities.

To date, two cohorts have been taken through the programme. Both cohorts have been evaluated using a Kirkpatrick Framework (level 1 and 2) and the results of the course evaluation and the subsequent impact of the projects will be presented.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Welcome 4 Code: OR60A3697

Implementing OR in Healthcare: The Impact of OR in the NIHR CLAHRC Wessex

Dr Marion Penn, **Dr Thomas Monks**, **Dr Brad Keogh** and **Dr Rudabeh Meskarian** *(University of Southampton)*

The operational research team within the NIHR CLAHRC Wessex has a focus on implementation of OR in healthcare settings. This poster will introduce a range of recent projects demonstrating the potential for impact on change within various healthcare settings. Location modelling, with the ability to explore variations on the optimal solution, has been implemented for reallocation of sexual health clinics across Hampshire. Simulation modelling was used to support the design of community hospital wards, saving the local health economy an estimated £3.5m per annum. Neonatal patient flows between units across Wessex have been modelled, allowing exploration of the potential impact of changes in any unit on the network as a whole. Various aspects of hospital emergency patient care have been explored: including whether Emergency Department consultants should work overnight, data

visualisation of patient flows though acute hospitals & forecasting of emergency patient demand for resource management.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 12:00, Room - Welcome 4 Code: OR60A3696

Service Delivery Models for C-Reactive Protein Point of Care Testing

Mr Carlos Lamas Fernández, Dr Thomas Monks and Prof Michael Moore *(University of Southampton)* and Dr Gail Hayward *(University of Oxford)*

Acute uncomplicated lower respiratory tract infection (LRTI) is the one of the commonest acute illness managed in primary care. Often, and sometimes unnecessarily, it is treated with antibiotics. There is evidence that antibiotic prescribing in LRTI may be reduced by appropriate use of point of care (PoC) tests. One candidate for these tests C-reactive protein (CRP).
In this work we estimate the costs and consequences of a number of different approaches of implementing a CRP PoC testing network in three different locations in the UK. These approaches include locating PoC tests in GP practices, pharmacies or both.
We propose a facility location model that designs the network and the service delivery with the objectives of minimising the cost and the extra travel burden for patients. This model provides the basis for analysing the costs and consequences of each implementation approach.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 12:00, Room - Welcome 4 Code: OR60A3630

Modelling to Support the Redesign of the Welsh Blood Service Supply Chain System

Miss Emily Williams, Prof Paul Harper and Dr Daniel Gartner *(Cardiff University)* and Ms Cath O'Brien *(Welsh Blood Service)*

Human blood is a scarce resource and its role in healthcare is fundamental, with donated blood saving the lives of many on a daily basis. However, the availability of such an invaluable resource is ultimately attributable to the many voluntary donors. Thus, the efficiency and timelines of the collection of blood from donors is crucial to the effectiveness of the blood supply chain. Working in partnership with the Welsh Blood Service, our aim is to improve the efficiency of the collection of blood and reduce wastage in the system. Through observation, preliminary data analysis, and simulation, we have identified that the scheduling of staff and appointments at donation clinics considerably influences the success of a clinic. Presently, the majority of clinics operated by the Welsh Blood Service are mobile and take place in over 500 different locations, with staff shifts varying greatly. From our review of existing literature on Operational Research methods for the collection of blood from donors, there is a significant lack of research into the scheduling of staff for blood donation clinics, and matching location planning to supply. With the use of methods such as simulation and mathematical programming, we aim to optimise both the assignment of staff to clinics, and the scheduling of appointments based on the donor panel of the clinic location. This will enable clinics to run more efficiently and effectively, thus increasing productivity and donor satisfaction.

What is the nature of your talk? A Mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Somewhat

12/09/2018, 12:00, Room - Welcome 4 Code: OR60A3625

Smart Simulation and Modelling of Complex Cancer Systems

Miss Emma Aspland, Dr Daniel Gartner and Prof Paul Harper *(Cardiff University)*, Dr Phil Webb and Prof Peter Barrett-Lee *(Velindre Cancer Centre)*

Lung cancer is in the top ten causes of death, the most common cause of cancer death in men, and second most common in women, worldwide. Cancer mortality can be reduced with early treatment and detection, and suggests that this is where the need for improvement lies. Hospital information systems are increasingly used as part of decision support tools for planning on the strategic, tactical, and operational decision levels. Clinical pathways are an effective and efficient way to standardise the progression of treatment, which in effect can reduce the pressure and problems surrounding subject areas that decision makers have to address. This research, in partnership with Velindre Cancer Centre, the largest specialist cancer centre in Wales, has the overall goal to improve patient care and outcomes by reducing time to diagnosis and treatment times for those with lung cancer. Our review of the current literature has highlighted that a view of the complete pathway, from entering to leaving the system, should incorporate patient, staff and admin activities along the way. The way in which these three types of activities are considered will produce the unique aspect of this work. Data mining and machine learning techniques will be used to discover the clinical pathways, along with observations and consultation with those who interact with the pathways day to day. The pathway will then be simulated and allow for some scenario analysis. We aim to bridge the gap between data mechanics and operational research, to produce a state-of-the-art decision support tool to allow Velindre Cancer Centre to align capacity to best match demand in an effective and efficient manner.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Welcome 4 Code: OR60A3614

Ciw: An Open Source Discrete Event Simulation Library

Mr Geraint Palmer, Dr Vincent Knight, Prof Paul Harper and Miss Asyl Hawa *(Cardiff University)*

Ciw enables reproducible simulation models by upholding three pinnacles of reproducible simulation modelling: Readability, Modularity, and Extendibility. Ciw and the Python ecosystem also allow simulation models to follow best practices in computational research, for example moving away from a GUI, automated testing, version control, and documentation. This work compares Ciw to several alternative discrete event simulation frameworks in terms of reproducibility, best practices, and performance. These include SimPy, AnyLogic, spreadsheet modelling, and custom Python and C++ scripts. The strengths of the library are illustrated in terms of best practice and reproducibility for computational research. Examples of the use of Ciw for healthcare applications will be highlighted.

What is the nature of your talk? A Mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Welcome 4 Code: OR60A3409

A General Model to Compute Activity-Based Waste Disposal Costs for Health Care Products

Dr Peter Vanberkel and Ms Saeideh Moayed *(Dalhousie University)*

Hospitals are large producers of solid waste, of which some is benign, some is extremely hazardous, and much is in between. The cost of segregating and disposing of products in these waste streams is high, and studies have shown there is considerable potential to reduce these costs while simultaneously decreasing environmental impact. In this article we develop an activity-based costing method that assigns waste disposal costs proportionally to each product. By providing disposal cost information at this level of aggregation it is possible to directly influence purchasing decisions, identify priority products for focused interventions, and determine the ratio of a product's purchasing cost to disposal cost. The method is tested on products with different purchasing costs, disposal costs, physical characteristics, and disposal processes.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Welcome 4 Code: OR60A3396

Supporting Provider Communication on Labor and Delivery Floor Using Mobile Technology

Dr Bengisu Tulu, Mr Anthony Perullo, Mr Christopher Hammer, Mr Andrew Gelinas, Mr Scott Friedlander and Mr Robert Curtis *(Worcester Polytechnic Institute)* and Dr Amir Mehdizadeh *(University of Massachusetts Medical School)*

Active labour is a fast-paced, rapidly changing and can often require quick decisions with only minutes to make them. With several people responsible for a patient, there is increased risk of vital information being lost through sign out processes, or a delay of transfer of this information between these different providers. Using Ionic open source framework and rapid application development methodology, we developed a mobile app that allows obstetric providers to keep log of their patients, instantaneously notify their fellow providers and allow them to quickly learn about a new patient. We conducted a joint application design session with 19 obstetric providers to develop paper prototypes of the system that would best support the communication needs on the maternity ward. Using this data, we built multiple iterations of the prototype and conducted a usability study with 21 obstetrician participants using the final prototype. The results of our usability study indicate that obstetricians found the app easy to use and they felt confident and comfortable using the app. They also indicated that they would like to use the app. Feedback from all participants in our focus groups showed a universal positive response to our prototype. When asked to compare current methods used for logging and sharing information with this prototype, there was a near unanimous preference for the prototype. One of the most common questions asked was when a live version would be available for use. Given the demand for this app, we believe further development would be worthwhile. This solution also has the potential for creating a database of information for further research on increasing the efficacy and safety of active labour.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

Information Systems

Organisers: Crispin Coombs and Oliver Kayas

11/09/2018, 11:00, Room - Private 2 Code: OR60A3556

KEYNOTE: Enterprise Cognitive Computing - Crystal Ball or Mirror?

Prof Monideepa Tarafdar *(Lancaster University)*

The application of cognitive computing to enterprise business processes poses a number of social, technical and ethical challenges. Even as enterprise cognitive computing is poised to take off, understanding these is essential if organizations are to get value from their investments in artificial intelligence. I will highlight some of these challenges and explore how organizations can deal with them.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 12:00, Room - Private 2 Code: OR60A3453

Predictive Recommendations in Electronic Negotiations

Mr Muhammed Fatih Kaya and Prof Mareike Schoop *(University of Hohenheim)*

Recommender Systems have successfully been applied to business processes in various commercial environments for many years. They generate important added value and provide suggestions in order to support their users (from managers to end customers) during their decision making processes. In today's world, business partners negotiate often electronically with each other and try to arrive at a common agreement during business negotiations. To support such electronic negotiation processes, negotiation support systems (NSSs) offer support in decision making and communication. They provide alternative contract solutions, assist the negotiators in their decisions and aim to enhance the whole electronic negotiation process in order to facilitate a successful negotiation. The integration of an additional system component in NSSs, which is of predictive character, might improve the stability of the negotiation process and the assistance for decision makers. This goal requires a model-based approach. To this end, our research goal is to develop a predictive learning model capable of (1) detecting systematic patterns based on the exchanged electronic negotiation data and of (2) generating future-oriented recommendations regarding the behaviour of the negotiator. With the help of such recommendations, negotiators can prevent the failure of the negotiation and have the opportunity to adapt their behaviour or rather negotiation strategy accordingly with regard to a positive course of negotiation. To reach this overall goal, methodological challenges have to be overcome ranging from data preparation and model building to the generation of recommendations in the final step which will be discussed in the context of our research.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:00, Room - Private 2 Code: OR60A3592

The Role of Big Data Analytics in Accelerating Innovation: A Study from the Telecom Industry

Miss Amani AL-Jaafreh, Dr Amjad Fayoumi and Prof Juliana Sutanto *(Lancaster University)*

An increase in technological, and analytical tools capabilities is enabling organizations to collect and analyse massive amounts of data from multiple sources to discover hidden patterns and provide deep insights about user behaviours, and market trends that can benefit organizations. Organizations could leverage these insights to accelerate innovation and value creation. We found that it is very important to explore what data to capture, codify, and store it; how it should be analysed and interpreted; as well as how insights can be transformed into value. Our review shows a clear scarcity of research on this topic. The study aims to use qualitative methods of both interviews and documents review in three telecom companies in Jordan to understanding how to collect, store, and analyse customer data to accelerate innovation and value creation.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:30, Room - Private 2 Code: OR60A3666

Using Analytics Tools to Investigate the Impact of a Digital Learning Platform on European Schools

Dr Masoud Fakhimi, Prof Lampros Stergioulas and Dr Munir Abbasi *(University of Surrey)*

The use of emerging innovative Digital Learning Platforms (DLP) in education are dramatically influencing teaching and learning paradigms in many different countries around the world. With the rapid growth of educational tools, applications, services, and platforms, the methodology of measuring and reporting their impact on education is becoming crucial and more challenging for all stakeholders. Moreover, the large scale and number of user activities in DLPs significantly increases the volume of available data that a DLP can use in order to provide statistical information and analysis related to impact assessment. The presented research work developed a generic framework to measure the impact of DLPs and the use of related technologies and tools on educational institutes. We also present the application of a social statistics tool that offers a wide view of the social activities taking place in a DLP and monitors the overall status of its portal. The proposed system collects the information from the several databases in the portal using Extract, Transform and Load (ETL) tools. Finally, the paper presents the application of this analytics framework to measure the impact of the Open Discovery Space platform on 2000 primary and secondary schools across 23 EU countries. This paper further explores the impact of such DLPs on existing curricula and their potential for modernising the educational system.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:00, Room - Private 2 Code: OR60A3372

Re-Designing Mindfully Enterprise Systems Modules in Higher Education

Dr Masoud Fakhimi *(University of Surrey)*, Ms Athina Ioannou *(Brunel University London)* and Dr Konstantina Spanaki *(Loughborough University)*

The study aims to uncover the nature of the contemplative practices in business higher education by highlighting their necessity in the design of IT courses and conceptual distinctiveness from the existing learning and teaching practices. The focus is to explore how the use of mindfulness background and context can be applied in the development and design of IT courses (in specific 'Enterprise Systems' modules in three UK Universities). The approach proposed here could disrupt and reshape the business IT education and subsequently enhance the experience of business school graduates. An innovative contemplative approach to IT education is borrowed for this approach from mindfulness psychology and relative stress and anxiety studies to facilitate the innovative module redesign. Explicitly, we draw on the conceptualisation of the mindfulness literature to develop our argument that the use of contemplative practices in the design of IT-related courses in Higher Education can create value for the business school graduates. The study conceives that value can be realised in terms of enhancing the graduates' professional skills but also in the development of the overall personal well-being and resilience towards the use of IT in the workplace but also everyday life.

What is the nature of your talk? Very theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 11:30, Room - Private 2 Code: OR60A3476

Development of a Realistic Evaluation Parallel Case Study Framework Linking Logic Models and Semi Structured Interviews

Dr Andrew Boilson, Dr Justin Connolly, Prof Regina Connolly, Dr Paul Davis and Prof Anthony Staines *(Dublin City University)* and Dr Dale Weston *(Public Health England)*

Background: The multi-national MIDAS (Meaningful Integration of Data Analytics & Services) project is developing a big data platform to facilitate utilization of a wide range of health & social care data. The platform will enable the integration of heterogeneous data sources, providing privacy-preserving analytics, forecasting tools & bespoke visualizations of actionable epidemiological data. Methods: An evaluation framework starting with a logic model & using the principles of realist evaluation has been developed working with users, & software developers. The tools used are a series of parallel case studies to address the requirements of stakeholder groups at critical time points during the project to ensure IT systems development is in line with user's requirements. The process includes longitudinal interviews with stakeholders, regular feedback to users & developers, & measurement of stakeholder's attitudes to the project using Q-methodology. Q-methodology explores distinct perspectives that exist within a group; semi-qualitative data are analysed using reduction methods to discern the existing patterns of thought. Stakeholders will rank Outputs, Outcomes, & Impact priorities of the study at three key time point's pre-implementation, post implementation & near completion of the project. Results: The first round of semi-structured interviews revealed general agreement between developers & end users expectations & requirements of the MIDAS platform. These findings related to respondents understanding of: MIDAS tools (pre implementation); the projects outputs; expected outcomes; anticipated impacts, alongside themes relevant to technology acceptance & use. The first round of the Q sort with stakeholders is underway. Conclusions: The process of engaging stakeholders will facilitate

better understanding of health IT use & acceptance as well as contributing to theory building efforts in relation to technology acceptance.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 12:00, Room - Private 2 Code: OR60A3689

A Unified Asset Health Model and Risk Forecasting Tool Using Advanced Machine Learning
Mr Ian Griffiths, **Ms Cristina Morariu**, **Mr Chris Smith-Clarke**, **Mr Gordon Squire** and **Dr Amrith Surendra** *(decisionLab)*

We developed a generalised and configurable condition forecasting capability to estimate future state and predict failures of physical components on-board platforms such as ships and aircraft. It aims to provide timely predictions, support risk-based planning and is flexible and practical. This has the potential to offer significant and efficiency savings in prognostic maintenance scheduling and engineering support. We have applied it to target use cases: defence aerospace, civil aerospace and naval marine. In defence, we have worked with subject matter experts in Rolls-Royce and the Royal Navy to understand the problem within each use case and the data, we then configured the solution and carried out hypotheses testing. For the two aerospace applications, we have delivered an executed model in each case, and these can be used to predict failures to support better proactive maintenance and prevent aircraft on the ground situations. For the naval application, we have deployed as a live tool on the Type 45 destroyer, piloted with HMS Defender. We will present our approach to our development and application, and the lessons we have learned. This work was funded by the Ministry of Defence's Defence & Security Accelerator, and we are indebted to a close collaboration with Rolls-Royce R2 Data Labs, the Royal Navy's Programme NELSON and support from the Defence Science and Technology Laboratory.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

Location

Organiser: Sergio Garcia Quiles

11/09/2018, 11:00, Room - LICA A27 Code: OR60A3439

The Multi-Period Design of Preventative Healthcare Networks

Dr Soheil Davari *(University of Hertfordshire)*

Preventive health care can be defined as a wide range of services to prevent or delay the deterioration of health and well-being. It covers people from all the age groups and encompasses a variety of services such as Hepatitis B screening, vaccination programmes, HIV counselling, and depression screening. One of the issues of designing a preventive healthcare system is the trade-off between the health benefits and the total costs. Hence, a careful analysis of the costs and benefits of preventive healthcare programs should be carried out before designing a system of preventive healthcare. In this research, we will address the problem of designing a preventative healthcare network and incrementally locating facilities over a set of periods (say years) with budget restrictions, congestion considerations, equity measures and considering the population dynamics over the years. We will provide a mixed-integer mathematical formulation for the problem aiming at maximisation of the service uptake and minimising the total cost. We will propose a heuristic solution to solve the problem and provide managerial insights.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 11:30, Room - LICA A27 Code: OR60A3475

A Multi-Period Model for Reorganising the Healthcare Service Network

Miss Zati Aqmar Zaharudin, Dr Andrew Brint and Dr Andrea Genovese *(University of Sheffield)*

Coping with budget reductions is an ongoing problem for many healthcare authorities. The ensuing retrenchment and restructuring reduces operational performance and often leads to a reduction in the number of operating facilities. If the service levels are essential rather than profit, then providers are often still obliged to serve as much demand as possible due to the nature of the service and contractual obligations. Reducing the number of facilities will increase the number of users at the remaining ones and create added congestion. Waiting times will increase, some demand could consider moving to another facility or, at a certain point, leave the system. Many facility locations and re-allocation models can be found in the literature, however very few discuss facility reorganisation considering the congestion issues stemming from budget reductions. In our research, we have developed a mathematical programming model that focusses on the possibility of having demand transfers across facilities with financial limitations in a congested environment. The model is implemented and tailored to a

healthcare system case study. The model can highlight risks arising from reorganisation processes, along with suitable interventions for mitigating such risks.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 12:00, Room - LICA A27 Code: OR60A3631

Governance of School System through Relocation Planning Using GIS Locations

Mr Abhishek Bhatnagar and Dr Nomesh B. Bolia *(Indian Institute of Technology, Delhi)*

The priorities of any school education policy are access, equity and quality. Of these, accessibility and quality are difficult to achieve simultaneously due to cost constraints. The schools should be located near the student habitations to offer good accessibility, especially in rural areas, owing to limited transportation facilities. Sarva Shiksha Abhiyan, a flagship programme of government of India, enables accessibility to schools by opening them in almost all habitations. Quality, however, remains a concern in low enrolment schools since many of them lack in teaching and infrastructural resources. Larger size schools that have good educational resources are economically more viable than smaller schools. The present study tries to address the trade-off between access and quality in schools by merging them. A mixed integer linear programming model (MILP) is formulated to obtain a set of schools that minimizes the number of students transferred and the corresponding distance of transfer based on the current enrolment. A school having an enrolment above a certain value would always remain open while others may close, provided a school exists within the access range. The consolidation model ensures at least one primary school at the lowest level, i.e. the panchayat level and at least one upper primary and secondary school at the next level, i.e. the mandal level. The model utilises the GIS location of schools to decide which schools among the existing ones to keep open and the number of students to be transferred from the schools closed to the open ones. The results indicate an improvement in teaching and infrastructural resource utilization and reduction in fixed costs due to closing of schools. The students have an average additional travel of a few 100 metres to the new school for better facilities. The results depend upon the demography and topological characteristics of the area.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 09:00, Room - LICA A27 Code: OR60A3444

Location Problems with Continuous Demand on a Polygon with Holes: Characterising Structural Properties of Geodesic Voronoi Diagrams

Mr Thomas Byrne and Dr Jörg Kalcsics *(University of Edinburgh)*

The problem of finding optimal locations for a set of service facilities is of strategic importance and has generated a large body of research literature. In most models customer demand is assumed to be discrete and aggregated to a relatively small number of points. However, in many urban applications the number of customers can be in the millions and representing every residence as a separate demand point is infeasible. Therefore it may be more accurate to represent demand as continuously distributed over some region. Moreover, the demand region and the region over which a facility can be located are often assumed to be convex polygons. However this is not realistic for real world applications. While a non-convex demand

region can be modelled as its convex hull with zero demand where appropriate, a non-convex feasibility region requires more work. Yet more problems occur when we introduce areas that cannot be traversed since we now must use geodesic distances. We consider the market share problem where the locations of p-1 facilities are fixed, and we seek to find the optimal location for an additional facility with the objective of maximising the total demand attracted by that facility; the function of which depends on the partition of the demand space into 'Voronoi cells'. In this talk we extend the structural properties of classic Voronoi diagrams to their geodesic counterparts and discuss how to determine the parametric representation of the objective function and how to solve the resulting non-linear optimisation problem.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 09:30, Room - LICA A27 Code: OR60A3547

An Efficient Heuristic Algorithm for the Alternative-Fuel Station Location Problem

Dr Thu Ba Nguyen *(University of Southampton)*, Dr Trung Hieu Tran *(University of Nottingham),* Dr Gabor Nagy and Dr Niaz Wassan *(University of Kent)*

We have developed an efficient heuristic algorithm for location of alternative-fuel stations. The algorithm is constructed based on solving the sequence of subproblems restricted on a set of promising station candidates, and fixing a number of the best promising station locations. The set of candidates is initially determined by solving a relaxation model, and then modified by exchanging some stations between the promising candidate set and the remaining station set. A number of the best station candidates in the promising candidate set can be fixed to improve computation time. In addition, a parallel computing strategy is integrated into solving simultaneously the set of subproblems to speed up computation time. Experimental results carried out on the benchmark instances show that our algorithm outperforms genetic algorithm and greedy algorithm. As compared with CPLEX solver, our algorithm can obtain all the optimal solutions on the tested instances with less computation time.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

12/09/2018, 10 00: Room - LICA A27 Code: OR60A3634

Computational comparison of mixed-integer programing models for reliable hub systems with fixed cost and multiple capacity levels

Dr Nader Azizi *(University of Edinburgh)*

In this research, we present two MIP formulations for the classical single allocation hub location problem considering hubs with multiple capacity levels that are subjected to random disruptions. The computational performance of the two proposed formulations are then compared using small instances from CAB dataset. We also address cases in which hub facilities are partially disrupted.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 09:00, Room - LICA A27 Code: OR60A3461

On Carriers Collaboration in Hub Location

Dr Antonino Sgalambro *(University of Sheffield)* and Prof Elena Fernández *(Universitat Politècnica de Catalunya - BcnTech)*

Hub location is nowadays one of the most studied areas within locational analysis, because of its wide range of practical applications, and due to the high economic impact of the decisions encompassed in these problems. In this work we consider hub location problems based on different classes of collaboration agreements among carriers. We assume multiple carriers operate on a shared network and are required to make optimal decisions on the location of their respective hubs and the routing of their demands through the network. Carriers collaboration models are compared by analysing in each case the potential savings obtained with respect to a purely competitive model. Mixed integer programming formulations are proposed and computationally tested. Numerical results from such a computational experience are presented and analysed, gathering useful managerial insights.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:30, Room - LICA A27 Code: OR60A3554

A Lagrangian Relaxation Method for Solving the P-Median Radius Formulation

Miss Minerva Martín del Campo and Dr Sergio García Quiles *(University of Edinburgh)*

The p-median problem is one of the most important problems in discrete location. It was originally defined by Hakimi in 1964 as a network problem and later formulated as an integer linear programming problem by ReVelle in 1970. The most recent exact method to solve the p-median problem is a radius formulation where the problem is formulated as a set covering problem. The algorithm proposed there starts with a partial formulation and develops a row generation technique to add more inequalities as needed. This strategy is embedded in a branch-and-bound algorithm and it is able to solve very large instances with several thousands of nodes. However, it does not work so well for problems with small values of p. In this work we have developed a heuristic method based on Lagrangian relaxation and branch-and-bound to obtain good solutions. The radius constraint is relaxed to form the Lagrangian dual problem and subgradient optimization was used to solve it. If the full set of radius constraints is relaxed, the dual problem can be solved quickly, however the bounds generated are weak. In order to obtain stronger bounds, we explore relaxing only a subset of the radius constraints. We look into how this affects the solution time and bounds for large instances with all types of values for p.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

Making an Impact

Organisers: Liz Archibald and John Ranyard

MAI Team members at OR60
Liz Archibald, *decisionLab*
Sophie Carr, *Bays Consulting*
Victoria Stephens, *Royal Bank of Scotland*
Ramune Sabaniene, *Sunday by Danske Bank*
John Ranyard, *Retired*
John Medhurst, *Larrainzar Consulting Solutions*
Ann Steptoe, *Dstl*

12/09/2018, 08:00, Room - County LT Code: OR60A3628
Networking with Impact (two sessions): Breakfast
Dr Sophie Carr *(Bays Consulting)*
We will invite you to start the day at 8am with breakfast and great conversations and create meaningful links. Those awkward introductions will be a thing of the past. You will start conversations before the conference via social media platforms. By signing up, you will get your tweet or post ready saying who you want to meet (and why!) alongside what your role is. We will give you the hashtags to start the conversations – then just tell us who is in your group for a picnic breakfast. Just make sure you are meeting up with new contacts as well as building on existing relationships!

Session 2 (Late afternoon): This involves RapidFire presentations to help you maximise the value of your networking opportunities. Do you have what it takes to explain your work in 20 slides in 20 seconds? You do? Great! Once you have seen the pitches and given yours – and noted who you wish to connect with, let's get networking in the fresh air. We will make sure you have every opportunity for group conversations to kick start future collaborations, so don't forget your business cards!

12/09/2018, 09:00, Room - County LT Code: OR60A3645
OR and Grand Challenges: Land, Lakes & Beyond
Chair: Dr Miles Weaver *(Edinburgh Napier University Business School)*
Panel: Liam McAleese *(Lake District National Park)* and Alistair Wright *(National Trust & tbc, Environment Agency)*
Addressing "grand challenges" is very much in the history and tradition of operational research (OR). From saving millions of lives and protecting Britain, ultimately helping to liberate Europe in wartime, to transforming our world today and for our future – people, planet and prosperity. The UN present 17 Sustainable Development goals and 169 targets to achieve by 2030, arrived

at by high-level political consensus and a movement to stimulate action. What role is there for OR to analyse these complex situations, to clarify values and objectives, bring about a meaningful engagement between different stakeholders, to ultimately make better decisions and take action? We have held this session now in Glasgow, Portsmouth and Loughborough – all with different challenges pitched by local decision-makers and we have concluded with potential actions. Many actions are still ongoing but confirm that the use of OR can lead to a real and positive impact. This year, with some of us taking inspiration from a cruise around Lake Windermere the evening before, we will discuss challenges that focus on 'life on land' (global goal 15) and related goals. We will hear from local prominent speakers who organisations make up in part the Lake District partnership, which has the aim to be an inspirational example of sustainable development in practice and we have some examples of using OR in practice. We will use problem structuring methods to analyse and understand the complexity of the challenges raised. Followed by outlining a plan of suggested action(s) to take ideas forward either as potential Pro Bono projects with third sector organisations at no cost, research funding bids, consultancy projects and/or student projects. Might your idea go forward!

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:00, Room - Market Pl Code: OR60A3621

OR and People: Get it Done Workshop by Creativedge

Mr Mark Godber *(Creativedge Training and Development)*

Have you ever felt a bit unmotivated? As if your productivity is slipping? This interactive 90 minute Creativedge session aims to help you "Get it Done"! The session will cover four key areas, and each attendee will have a clear set of actions to use straight away to make their work more productive and manageable. They are: assessing whether or not you are an achiever; teaching you how to self-motivate and get unstuck in those tricky moments; getting focused and overcoming blockages when you need to and working S.M.A.R.T.E.R, all the time.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:00, Room - Private 1 Code: OR60A3648

Waiting for MODot: What Should We Do If the Decision Maker Doesn't Come?

Dr Crispin Allard *(Atkins Ltd)*

The aim of this workshop is to explore how we as analysts engage with decision makers, looking at: different types of argument (data and evidence versus model and assumptions); presenting an argument to different types of decision maker; dealing with a decision maker indirectly via their representatives. We will use the characters and selected scenes from Samuel Beckett's play *Waiting for Godot* to help illustrate these points.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:00, Room - Private 2 Code: OR60A3646

Ocado Order Prediction Hackathon: A Practical Challenge Workshop Facilitated by Ocado & IBM

Mr Matthew Leadbetter *(Ocado Technology)*

This workshop will give a taster experience of a Data Hackathon. Participants will work in groups, supported by experienced technical guides, and will have the opportunity to gain hands-on practical experience of using data science approaches to tackle an issue. The challenge is to predict what a customer will order next on Ocado. Small groups will be provided with a real data set and will be supported to use tools within the IBM Data Science Experience. This is a collaborative environment incorporating Machine Learning, powerful visualisations and accessing open source technologies such as matplotlib, numpy and pandas. This session will be run as a full morning continuous workshop with breaks taken at convenient times.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 12:00, Room - County LT Code: OR60A3647

Agent Based Simulation in Action - A Hands-On Workshop Using Anylogic

Mr Marc Escandell *(decisionLab)*

This specially designed workshop will showcase some of the key components of agent-based simulation modelling in supporting decision making made in uncertain conditions. Our game will be located in the intriguing world of Crytocurrencies and make use of the Anylogic simulation package. Participants working in teams will use simulation to progressively improve their decision making over several rounds.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 12:00, Room - Market Pl Code: OR60A3385

Developing Your Career as an OR/Analytics Professional

Mr Gavin Blackett *(The OR Society)*, Ms Sophie Carr *(Bays Consulting)*, Mr Michael Mortenson *(University of Warwick)* and Dr John Ranyard

The OR Society now offers a myriad of professional qualifications, including Accreditation, Chartered Scientist and the newly launched Certified Analytics Professional (CAP). This session will help you decide which route is best for your career through an overview of the various routes and through sharing the experiences of people who have achieved them: why did they undertake this qualification? How tough was it? How has it helped their careers?

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Private 1 Code: OR60A3622

iAI - Introducing Artificial Intelligence, A Panel Session

Mr Angelico Fetta *(McLaren)*, Ms Deborah Fish *(Dstl)*, Mr John Hopes *(President of The OR Society)* and Dr Gilbert Owusu *(BT)*

"Whoever becomes the leader in Artificial Intelligence [AI] will become the ruler of the world" (Vladimir Putin). Is AI set to take over the world, or is it yet another bubble? What can AI and machine learning (ML) do for Operational Research and Analytics? Our panel of experts will answer your questions, help separate fact from fiction, and explain what AI and ML can do to improve the life of an OR/Analytics practitioner, both now and in the future.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 16:00, Room - Welcome 4 Code: OR60A3359

Behavioural OR and the Public Sector Scorecard

Mr Max Moullin *(Public Sector Scorecard Research Centre)*

The importance of Behavioural OR in addressing behavioural factors that could affect the effectiveness of OR models has been increasingly recognised – in particular the new OR Society special interest group on this topic. The Public Sector Scorecard explicitly incorporates behavioural factors both in the framework itself and in its interactive workshop-based approach involving staff, service users and other key stakeholders. For programmes requiring behaviour change such as reducing obesity, accidents or tax evasion, it will also show how the Theory of Planned Behaviour can be integrated into the Public Sector Scorecard to take into account the various factors needed to achieve change. In this interactive workshop participants will learn how to use the Public Sector Scorecard to help develop strategy, improve outcomes, and evaluate progress both for individual organisations and across organisational boundaries. It will include an interactive session showing how to develop a mini- strategy map for a particular outcome of interest to the group. A recent article* on the PSS in the OR Society publication IMPACT concluded: 'The Public Sector Scorecard has moved performance management from a top-down, blinkered, blame-game approach to a system founded on inclusiveness, cooperation and understanding'.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 16:00, Room - County LT Code: OR60A3640

Identifying and Using Strengths at Work

Ms Liz Archibald *(decisionLab)*

To get the most out of people, you must build on their strengths - does this sound like common sense? In practice, many organisations use tools and systems to support development which are based on the opposite premise. Rather than focus on strengths, many assessments are designed to find and plug "gaps". Strengths based approaches to development are an alternative way and have gained support over the last decade as potentially a more effective way of improving workplace performance. Participants in this workshop will be asked to complete an online assessment, which will produce an individualised report on your dominant

strengths. In the workshop, we will explore how this information can be used in practice, and how to harness this information to “find your edge” at work.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 16:00, Room - Market Pl Code: OR60A3641

A Gentle Introduction to Data Science

Mr Panagiotis Samartzis *(decisionLab)*

Data science, data visualisation and machine learning are widely used terms across industry. What are the challenges that data scientists face when they approach a problem? In this workshop we will tackle such a problem by breaking it down into steps and setting a number of questions that need answering. Then, using some simple yet powerful data visualisation and machine learning techniques we will enhance our understanding of the data as well as gain some insights that can assist decision making and drive growth. Join us in this workshop to take part in a concise yet quick and fun introduction to data science and some of its techniques through a hands-on mini-project. You will be able to understand basic data science concepts as well as see how employing such techniques in your data can add great value to your organisation.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:00, Room - Private 1 Code: OR60A3623

Python - It's Not Just a Snake

Miss Dominika Glowa *(Royal Bank of Scotland)*

The Python computer language is used in Analytics/Big Data with much success but until recently has rarely been used by OR groups. So what is it? How accessible is it? How long would it take you to learn? How close to other programming languages is it? Why should you choose to use Python and not other languages? If these questions keep you up at night, please come along to the session where Dominika will answer all these, and more! You’ll leave the session with some practical tips about where to start, when to use it, and what you should watch out for.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 16:00, Room - Private 2 Code: OR60A3642

How an Agile Framework Can Add Value to OR and Analytics Projects

Mr Lawrence Cook *(decisionLab)*

Agile processes are widely used in the software development community to provide a collaborative and transparent approach to project management. This workshop will explain the roles and processes of the scrum methodology, and help you to implement this framework into your organisation. We’ll provide practical experience, demonstrating the methods and tools used in industry. We’ll break epics into user stories, turn tasks into plans, and help you to stand

up. Take part in this interactive workshop for an insight into employing agile techniques to add value to Operational Research and Analytics projects

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 17:00, Room - County LT Code: OR60A3629

Modern Day Elevators - Network in 20 Seconds

Dr Sophie Carr *(Bays Consulting)*

The end of the day isn't time to relax: if you're investing time being out of the office then make the most of every opportunity and come along to showcase your work and interests in just 20 seconds. Here from everyone in the room, note down who you want to talk to and then connect with them whilst we get out into the fresh air on our netwalking session (the University of Lancaster Woodland Walk). We'll make sure you have every opportunity for group conversations to kick start future collaborations – don't forget your business cards.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

Metaheuristics

Organisers: Ender Ozcan and Andrew Parkes

11/09/2018, 11:00, Room - Bowland LT Code: OR60A3412

Scheduling Twin Robots in a Palletising Problem

Mr Oliver Thomasson, Dr Maria Battarra and Dr Gunes Erdogan *(University of Bath)* and Prof Gilbert Laporte *(HEC Montreal)*

In this talk we will introduce the Twin Robot Palletising Problem (TRPP), in which a selection of products must be transferred from the end of their production lines to pallets for shipping. The task of palletising is given to a pair of robots situated on a single rail, and the production endpoints and the shipping pallets are positioned alongside the rail on opposite sides. The goal is to minimise the time required to transfer all products while respecting a minimum safe distance between the robots. We will present our solution methods for the TRPP, including two mathematical formulations, an Iterated Local Search algorithm and a Hybrid Genetic Algorithm. A comparison of results from the metaheuristics will be provided, in addition to a comparison with a single robot version of the TRPP to demonstrate the benefits of a second robot on the rail.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 11:30, Room - Bowland LT Code: OR60A3436

Complexity Classes and Reductions for Heuristics

Dr Simon P Martin *(Schnellecke Digital Innovations)*, Dr Matthew Craven *(University of Plymouth)* and Dr John Woodward *(Queen Mary, University of London)*

We characterize a variety of NP-complete decision problems in terms of their constraints and attempt to classify them into two broad constraint classes, partition and allocation. We argue that the problems in each given class share the same (or refinements of) constraints from other problems in that class. We use polynomial time reductions to show this. Building on the work of Trevisan et al., and defining a reduction's complexity, we conclude that reductions from one problem type to another in the same constraint class will have lower complexity compared to reductions between the two classes. For example, we show that there is a reduction between Vertex Cover and Hamiltonian Circuit with a low polynomial time reduction algorithm. We claim they are in the same constraint class. We also show that 3-Colour and Subset Sum are both in a different class and have low polynomial time reductions between them. However, if we try to reduce from 3-Colour to Vertex Cover between classes we find the complexity, while still polynomial, is greatly increased. We ask the following question: can we use these reductions to modify known effective heuristics for one problem in a class to make them effective on

another problem in the same class? The presentation will be a mix of theoretical and practical results.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 12:00, Room - Bowland LT Code: OR60A3563

Sampling Strategies When Searching for Robust Solutions

Prof Juergen Branke, Mr Xin Fei and Dr Nalan Gulpinar *(Warwick Business School)*

Many real-world optimisation problems involve uncertainties, and in such situations it is often desirable to identify robust solutions that perform well over the possible future scenarios. In this paper, we focus on input uncertainty, such as in manufacturing, where the actual manufactured product may differ from the specified design but should still function well. In such cases, estimating a solution's expected fitness as part of an evolutionary algorithm is challenging, especially if the fitness function is expensive to evaluate, and its analytic form is unknown. One option is to average over a number of scenarios, but this is computationally expensive. The archive sample approximation method reduces the required number of fitness evaluations by re-using previous evaluations stored in an archive. The main challenge in the application of this method lies in determining the locations of additional samples drawn in each generation to enrich the information in the archive and reduce the estimation error. In this paper, we use the Wasserstein distance metric to approximate the possible benefit of a potential sample location on the estimation error, and propose new sampling strategies based on this metric. Contrary to previous studies, we consider a sample's contribution for the entire population, rather than inspecting each individual separately. This also allows us to dynamically adjust the number of samples to be collected in each generation. An empirical comparison with several previously proposed archive-based sample approximation methods demonstrates the superiority of our approaches.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 13:30, Room - Bowland LT Code: OR60A3684

Reinforcement Learning to Mix and Control Multiobjective Evolutionary Algorithms

Miss Wenwen Li *(University of Sheffield)*, Prof Robert John and Dr Ender Ozcan *(University of Nottingham)*

There is a growing number of studies on reusable high-level cross-domain search methodologies, such as selection hyper-heuristics managing low level (meta)heuristics and being applicable to different problem domains with minimal expert intervention. This study presents a novel reinforcement learning based selection hyper-heuristic for multiobjective optimisation. The proposed approach mixes and controls three well-known multiobjective evolutionary algorithms to exploit their individual strengths for an improved performance. Two variants of this selection hyper-heuristic, each utilising a different initialisation scheme are investigated across a range of benchmark functions as well as the real-world problem of vehicle crashworthiness. The empirical results and analyses demonstrate the effectiveness of the proposed selection hyper-heuristics for multiobjective optimisation.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:00, Room - Bowland LT Code: OR60A3691

Move Acceptance in Local Search Metaheuristics

Mr Warren Jackson, Prof Robert John and Dr Ender Ozcan *(University of Nottingham)*

Metaheuristics provide guidelines for solving computationally hard problems by defining high-level instructions for designing heuristic optimisation algorithms. They are used to find high-quality solutions to real-world problems in a reasonable time frame. Local search metaheuristics operate under a single-point based search framework with the goal of iteratively improving a solution in hand over time with respect to a single objective using certain solution perturbation strategies, known as move operators, and move acceptance methods starting from an initially generated solution. The cross-domain search problem is a high-level problem where multiple characteristically different problems are to be solved by a single search method and preferably with the least, or even without, expert intervention. In this talk, an overview of the cross-domain performance of existing move acceptance methods under a local search metaheuristic framework will be given. The results show that when re-tuned for each domain, Simulated Annealing (SA) has the best cross-domain performance, but only performs the best in 2 out of 45 instances, and SA is only amongst the best-performing methods for 5 out of the 9 domains. Additionally, a novel move acceptance method (AHTA) that has been designed with cross-domain search in mind will be introduced. The cross-domain performance of AHTA, which has been tuned once cross-domain, is compared to the benchmark move acceptance methods, which have been re-tuned for each domain. The empirical results show that the cross-domain performance of AHTA improves over the per-domain tuned benchmark algorithms.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Bowland LT Code: OR60A3661

KEYNOTE: Exact OR Metaheuristic Methods or a Bit of Both - The Rise of Matheuristics

Dr Jonathan Thompson *(Cardiff University)*

When faced with a combinatorial optimisation problem, one needs to decide whether to employ an exact or a metaheuristic solution method. The usual rationale concerns the complexity and size of the problem. If it is possible to produce an exact solution in the required amount of time, then an exact method should be used. Otherwise a (meta)heuristic method is employed. However this often means ignoring the exact model completely rather than using this information to improve the metaheuristic approach. Matheuristics covers a broad range of hybrid exact/heuristic approaches but this talk will focus in the main on how exact models can be incorporated into metaheuristics using examples including scheduling and routing problems.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

Multiple Criteria Decision Analysis (MCDA)

Organiser: Matthias Ehrgott

11/09/2018, 11:00, Room - County LT Code: OR60A3548

Multi-Objective Mixed Integer Programming: An Exact Objective Space Algorithm

Dr William Pettersson *(University of Glasgow)* and **Dr Melih Ozlen** *(RMIT University)*

This talk will describe one of the first objective space algorithms which can exactly find all supported and non-supported non-dominated solutions to a mixed-integer multi-objective linear program with an arbitrary number of objective functions. This algorithm is operates in three phases. First it builds up a super-set which contains the Pareto front. This super-set is then modified to not contain any intersecting polytopes. Once this is achieved, the algorithm efficiently calculates which portions of the super-set are not part of the Pareto front and removes them, leaving exactly the Pareto front.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 11:30, Room - County LT Code: OR60A3559

Solving Multi-Criteria Network Interdiction for Information Security

Dr Zhengliang Liu, **Dr Arman Khouzani** and **Prof Pasquale Malacaria** *(Queen Mary, University of London)*

In this study, we propose a methodology that efficiently solves a multi-criteria network interdiction problem for cyber-security. Cyber network has been topologically modelled by attack graph. Given an attack graph, and a set of available security counter-measures (controls) our method constructs a deployment strategy which minimises the security risk and the implementation costs of the strategy. The problem of interest in this study integrates two conflicting agents, the defender and the attacker, who are intertwined in their own decision-making and utility maximisation. On one hand to mitigate disastrous attack the defender deliberately selects and implements security controls from numerous available controls, each of which affects a certain subset of vulnerabilities in different ways. Furthermore, the cyber-security risk extenuation should be leveraged with the monetary expenditure as well as the negative operational side-effects of the counter-measures. On the other hand, the attacker's penetration procedure is predominantly influenced by the defence strategy. This hierarchical interaction implies bi-level nature of the problem. Hence, we propose a network interdiction model. This model not only captures the probabilistic and multifold effects of counter-measures, but also integrates the adversary agents' problems. Utilizing techniques such as dualisation and linearisation we convert the problem into a single level MILP optimisation,

which can be solved exactly. The efficiency of the method is revealed through the computational experiments.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 12:00, Room - County LT Code: OR60A3415

Semismooth Newton-Type Method for Bilevel Optimization: Theory and Extensive Experiments

Dr Alain Zemkoho *(University of Southampton)*

We consider the optimistic bilevel optimization problem involving twice continuously differentiable functions. Using the lower-level optimal value function, we reformulate the problem into a single-level optimization problem. To construct a tractable Newton method to solve the latter problem, we start by introducing a new stationarity concept that allows us to design a simple, yet powerful Newton scheme to solve the bilevel optimization problem. From numerical experiments conducted on 124 nonlinear bilevel optimization examples from the literature, our method is able to compute, just within a few seconds, the true/best known or better solutions for all the problems with an existing record on their results, i.e. for 114 out of the 124 problems. To the best of our knowledge, this is the first time in the literature where experiments on a method for nonlinear bilevel optimization are conducted at such a scale, and possibly with such a level of success. To achieve this success, appropriate choices had to be made for the exact penalization parameter, usually needed to mitigate the negative effects of the value function constraint. By so doing, we also provide a first benchmark study on the selection of this parameter. Furthermore, it is important to mention that second order sufficient conditions ensuring that the stationary points computed are at least locally optimal are also developed in this paper, that will be presented at the conference. (Ongoing joint work with Andreas Fischer and Shenglong Zhou)

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 13:30, Room - County LT Code: OR60A3474

Towards Explainable and Transparent MCDA Methods

Dr K.Nadia Papamichail *(The University of Manchester)* and Prof Theodor Stewart *(University of Cape Town)*

Making machine decisions explainable and transparent is an ongoing challenge. This work seeks to develop a framework for generating automated explanations for decision analytic tools. Natural language generation techniques have been applied to design a text planner and a sentence generator for orchestrating the dialogue between a decision aiding tool and a decision maker. We have developed explanations for augmenting the ability of an MCDA tool to explain its output and justify its recommendations. The content of the explanations depends on the stage of the decision analysis process. We have identified four stages of interactions between MCDA tools and their users. The natural language tool has been applied to a MAVT (Multi-attribute value theory) setting but can be extended to other MCDA approaches.
What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 14:00, Room - County LT Code: OR60A3326

Enhancing Knowledge Construction Processes within Multicriteria Decision Analysis: The Delphi-DC-MACBETH Collaborative Approach

Dr Monica Oliveira, Prof Carlos Bana e Costa and Dr Ana Vieira *(IST - Universidade de Lisboa)*

Multicriteria Decision Analysis (MCDA) is commonly used to help decision-makers and other stakeholders in complex evaluation contexts. Further to technical soundness and meaningfulness, for developing evaluation models for practical use it is critical to design adequate social processes to capture participants' values and perspectives, while promoting a shared understanding around key evaluation issues. Face-to-face workshops and decision conferencing (DC) processes, involving a relatively small number of participants, have been typically adopted for interactive model building and to promote model requisiteness. One such socio-technical approach is the MACBETH decision conferencing (DC-MACBETH) which uses the Measuring Attractiveness by a Categorical Based Evaluation TecHnique (MACBETH) to facilitate the elicitation of value judgements from a small group in a decision conferencing process. The DC-MACBETH approach has proven to be effective, but replicating this environment in participatory contexts that require to capture the views of a large, diverse and dispersed number of stakeholders, requires a different social setting. This paper tackles this challenge by enhancing the social component of the DC-MACBETH approach with the Delphi method. We depart from the classical collaborative knowledge acquisition process in expert systems literature and develop a three-step approach to involve an extended group of participants ("selected crowd") in different steps of multicriteria value modelling – the Delphi-DC-MACBETH collaborative approach. After an initial planning step, the Delphi-DC-MACBETH approach draws upon the features of the Delphi method to design a participatory knowledge construction process where we extract knowledge from a "selected crowd" within a non-face-to-face web environment. This knowledge is then used to inform a restrict number of participants that collaboratively analyse the information collected, verify and/or complete it in a decision conferencing setting. We describe potential uses of the Delphi-DC-MACBETH approach and exemplify its use in different real cases in which it fostered higher participation and collaboration in multicriteria modelling.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 14:30, Room - County LT Code: OR60A3678

Integrating Individual and Aggregate Diversity in Top-N Recommendation

Dr Ibrahim Muter *(University of Bath)*, Dr Tevfik Aytekin and Dr Ethem Canakoglu *(Bahcesehir University)*

Recommender systems have become one of the main components of web technologies that help people to cope with the information overload. Two of the most important metrics used to analyse the performance of these systems are accuracy and diversity of the recommendation lists. While all the efforts exerted in the prediction of the user interests aim at maximizing the former, the latter emerges in various forms, such as diversity in the lists across all user recommendation lists, referred to as aggregate diversity, and diversity in the lists of individuals, known as individual diversity. To the best of our knowledge, no study has been done to consider both individual diversity and aggregate diversity, along with accuracy. In this paper, we tackle the combination of these three objectives, and justify this approach by showing through experiments that handling these objectives in pairs does not yield satisfactory results in the

third one. To that end, we develop a mathematical model that is formulated using multi-objective optimization approaches. To cope with the intractability of this non-linear integer programming model, its special structure is exploited by a decomposition technique. For the solution of the resulting formulation, we propose an iterative framework that is composed of a clique generating genetic algorithm and constructive/improvement heuristics. We conduct experiments on three data sets and show that the proposed modelling approach successfully handles all objectives according to the needs of the system.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:00, Room - County LT Code: OR60A3459

Role of Multi-Criteria Decision Analysis Techniques in Achieving Circular Economy

Dr Maryam Masood and Dr Stuart R Coles *(University of Warwick)*

The concept of the circular economy, where the value of materials and resources is preserved, is gaining momentum across the majority of industries and research fields. However, similar to sustainability concepts, the circular economy approach is also multifaceted and requires a shift in more than one value domain. If an approach focusses only on one or a few of the important domains i.e. environmental, economic, social and technical, then it often delivers misleading results in terms of the benefits or impacts. The key in shifting towards a circular economy is to have a lifecycle perspective as well as a holistic approach where all relevant parameters and all stakeholders involved are considered. A key contributor to this shift can be the use of Multi-Criteria Decision Analysis (MCDA) techniques. This work explores how effectively MCDA techniques have so far been employed in achieving circular economy principles in multiple disciplines. The selection of MCDA techniques has been critically reviewed based on the nature of the problem and if there is any particular bias towards a certain approach. Findings suggest that the use of MCDA approaches in the literature in the context of the circular economy has so far been limited, however, the nature of defined problems and solutions required are generally very well aligned with the scope of application of MCDA techniques. Examples from existing literature on the circular economy will be used to build a case on the usefulness of MCDA application for this paradigm shift. Future developments must focus on building of a framework that may enable the selection of indicators for a specific problem to accurately and clearly describe benefits and impacts across all domains resulting in a transparent analysis of the shift towards a circular economy.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:30, Room - County LT Code: OR60A3348

Evaluating the Quality of Radiotherapy Treatment Plans for Prostate Cancer

Miss Emma Stubington and Prof Matthias Ehrgott *(Lancaster University)*, Prof Omid Nohadani *(Northwestern University)* and Prof Glyn Shentall *(Royal Preston Hospital)*

External beam radiation therapy is a common treatment method for cancer. Radiotherapy is planned with the aim to achieve conflicting goals: while a sufficiently high dose of radiation is necessary for tumour control, a low dose of radiation is desirable to avoid complications in normal, healthy, tissue. These goals are encoded in clinical protocols and a plan that does not

meet the criteria set out in the protocol may have to be re-optimised using a trial and error process. To support the planning process, we seek plans that would benefit from re-optimisation by proposing a method to evaluate the quality of the treatment plans. First, the clinical protocol is translated into a set of measurable variables and Principal Component Analysis (PCA) is used for dimension reduction to select the most relevant variables. Data Envelopment Analysis (DEA) is then applied to assess the quality of individual treatment plans. Each plan is compared against the entire set of plans to identify the ones that could realistically be improved. We further enhance this procedure with simulation techniques to account for uncertainties in the data for treatment plans. This allows us to make recommendations to the clinicians as to which plans we believe could potentially be improved. In this talk, we present a case study based on prostate cancer treatment plans from the Royal Preston Hospital, UK. Clinicians at Preston then re-plan the identified plans and our findings are presented here.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 10:00, Room - County LT Code: OR60A3496

Uncertain Data Envelopment Analysis

Prof Matthias Ehrgott *(Lancaster University)*, Prof Allen Holder *(Rose-Hulman Institute of Technology)* and Prof Omid Nohadani *(Northwestern University)*

Data Envelopment Analysis (DEA) is a nonparametric, data driven method to conduct relative performance measurements among a set of decision making units (DMUs). Efficiency scores are computed based on assessing input and output data for each DMU by means of linear programming. Traditionally, these data are assumed to be known precisely. We instead consider the situation in which data is uncertain, and in this case, we demonstrate that efficiency scores increase monotonically with uncertainty. This enables inefficient DMUs to leverage uncertainty to counter their assessment of being inefficient. Using the framework of robust optimization, we propose an uncertain DEA (uDEA) model for which an optimal solution determines (1) the maximum possible efficiency score of a DMU over all permissible uncertainties, and (2) the minimal amount of uncertainty that is required to achieve this efficiency score. We show that the uDEA model is a proper generalization of traditional DEA and provide a first-order algorithm to solve the uDEA model with ellipsoidal uncertainty sets. Finally, we present a case study applying uDEA to the problem of deciding efficiency of radiotherapy treatments.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:00, Room - County LT Code: OR60A3652

KEYNOTE: Learning from and for MCDA Practice

Prof Valerie Belton *(University of Strathclyde Business School)*

Ten years ago, at OR50, myself and Gilberto Montibeller concluded a presentation with thoughts on the key challenges facing MCDA. The integration of theory and practice was one of these, including the question of how to encourage a healthy community of MCDA practice. A decade later, although there is a growing literature describing a wide range of applications of MCDA methods, there is still relatively little that focuses on the actual practice of MCDA – ie

the practicalities of how MCDA methods are used and what works well in different contexts. This presentation will review existing theory relating to MCDA practice and the extent to which it informs practice before reporting on findings from recent work, including a series of interviews with MCDA practitioners, exploring approaches used and perceptions of key challenges faced, before concluding with discussion of the potential and ways to enhance future practice.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

Network Optimisation Applications

Organiser: Guglielmo Lulli

13/09/2018, 11:00, Room - LICA A27 Code: OR60A3530

Network Modeling Using Covariates with Application to Brain Data

Dr Swati Chandna *(Birkbeck, University of London)*

We introduce nonparametric methods addressing the setting where a sample of small graphs, along with additional information is observed. For example, in a connectome study, for each subject in the sample both a structural brain network, along with covariates such as age, gender, etc. is observed. Building upon the standard graphon model, we provide a framework that can test for any given node presenting significantly different behaviour across different values of the covariates. Further, we find that although a significant portion of the graphon literature focuses on block-model approximations of the graphon, in our setting full nonparametric inference is possible and computationally tractable. We illustrate our approach using a set of brain network observations from multiple individuals. This is joint work with P.A. Maugis.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:30, Room - LICA A27 Code: OR60A3602

Comparing Sampling Designs on Networks via Information Theory

Dr Simon Lunagomez Coria *(Lancaster University)*, Mr Marios Papamichalis *(University College London)* and Prof Patrick J. Wolfe *(Purdue University)*

In this paper, we propose a general approach for comparing sampling designs on networks. Our approach is based on the concept of data compression from information theory. The criterium for comparing sampling designs is formulated so that the results prove to be robust with respect to some of the most widely used loss functions for point estimation and prediction. The rationale behind the proposed approach is to find sampling designs such that preserve the largest amount of information possible from the original data generating mechanism. Our approach is inspired by the same principle as the reference prior, with the difference that, for the proposed approach, the argument of the optimisation is the sampling design rather than the prior. The information contained in the data generating mechanism can be encoded in a distribution defined either in parameter's space (posterior distribution) or in the space of observables (predictive distribution). In our simulation studies we consider both cases.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 14:00, Room - LICA A27 Code: OR60A3402

Robust Retrofitting Planning Under Endogenous Uncertainty

Dr Xuan Vinh Doan *(University of Warwick)*

Retrofitting planning aims to strengthen strategic links in an infrastructure network, which is subject to failures due to disasters. The main focuses are network connectivity and post-disaster travel costs. In this talk, we propose a robust optimisation framework to handle distributional ambiguity of decision-dependent random link failures in retrofitting planning. We analyse several properties of optimal solutions, which allows us to reformulate the problem as a mixed-integer linear optimisation problem. Computationally, we propose a constraint generation method to solve the problem given the large number of potential scenarios. We analyse the tractability of the proposed approach and demonstrate it with numerical experiments.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 14:30, Room - LICA A27 Code: OR60A3582

Exploiting Network Structures in Mathematical Modelling and Optimization

Dr Guglielmo Lulli *(Lancaster University)*, Mr Semih Atakan and Prof Suvrajeet Sen *(University of Southern California)*

Network optimization has been one of the most prolific research topics in operational research and computer science. Although, network optimization reached a “maturity” phase, it is often vital to capitalize on network (sub)structures in order to develop “efficient” formulations and/or solution methods when solving application oriented optimization problems. In this talk, we will present an application in the Energy domain that benefited from exploiting/embedding the network substructure of the problem.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

OR Consultancy and Case Studies

Organisers: John Medhurst and Ann Steptoe (not pictured)

13/09/2018, 09:30, Room - Private 1 Code: OR60A3305

OR in HMRC Policy Making - Putting the Cart before the Horse

Mrs Vivienne Raven *(HM Revenue & Customs)*

Viv shows how OR skills and techniques are used in policy costings and design. Together we will build up a policy and cost it for the upcoming budget, putting OR skills at the heart of decisions and policy making in government.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 10:00, Room - Private 1 Code: OR60A3468

Application of Systems Models in the Department of International Trade

Ms Hala Elsayed, Mr Richard Jackson and Mr Lee Zhao *(Dept for International Trade)*

The Department of International Trade (DIT) was established two years ago to help businesses export, drive investment, open up global markets and champion free trade. Systems thinking is widely used across the public sector to help shape operating policies and processes. Applying this approach to DIT, an employer of 4,000 staff in the UK and overseas, provides a unique challenge to understand and model processes and flows of information in a new and international government department. In DIT, this technique has been successfully demonstrated in the development of a customer-facing export promotion model and a business-facing whole systems model. The customer-facing model demonstrates how DIT export promotion support and services interact and work together to achieve a common objective: support UK businesses grow their exports. Since businesses have multiple interactions and touch-points with DIT as they progress through their export journey, this poses a significant challenge to understanding the impact of individual export promotion support to inform resource allocation decisions. To disentangle the individual contributions of different DIT Export Promotion Support to grow exports we have adopted a systems approach. This aims to reinforce the importance of different types of DIT support working together along a firm's exporting journey. The business-facing model considers the department as an intricate system of information flows and inter-dependencies between constituent teams. The challenge is to ensure that these flows of information are accurately mapped to enable future network analyses for efficiency and performance purposes. This work aims to demonstrate the benefits of mapping the flow of activity across the department, from which an operating model is generated and flows of Management Information (MI) are identified. The potential benefits

range from knowledge transfer, raising internal business awareness, reducing the administrative burden when sourcing MI, and identifying possible efficiency savings.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 11:00, Room - Private 1 Code: OR60A3543

Managing Risk When Outsourcing Part of a Complex Government Owned Enterprise

Prof Martin Parr *(Dstl)*

Efficiency in government systems involves ensuring that the systems operate with low long-term cost and risk. Outsourcing is seen by some people to help on the journey towards greater efficiency. Once a decision to outsource part of a complex enterprise is taken, a key challenge is to make sure that the public and private parts of the enterprise work together to reduce collective risk, rather than working independently to reduce risk in only one part of the business. This paper draws on an evidence-based review of successful, unsuccessful and catastrophically poor outsourcing endeavours to identify some of the key components of successful complex outsourcing. Mature organisations are those that work closely together to minimise risk and prevent issues 'falling between the cracks.' The research is distilled into a 'maturity matrix' that provides both the public and private parts of the organisation with (1) a way of measuring enterprise maturity and therefore risk (2) a set of steps that can be taken to improve the maturity of the organisation and reduce the possibility of serious creeping risks being neglected.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:30, Room - Private 1 Code: OR60A3546

Applying System Dynamics (SD) to Support Strategic Decision Making Within the Nuclear Sector

Dr Sion Cave *(Decision Analysis Services Ltd)*

System Dynamics (SD) is a modelling approach that enables complex systems to be better understood, and their behaviour over time to be projected using computer simulation. The technique tends to be used for strategic issues where longer time periods need to be considered, and where complex delays and feedback effects need to be taken into account. This presentation describes a number of instances where SD has been applied to support strategic decision making in the nuclear sector. For example, to support the planning of the future UK nuclear sector workforce (which covers a highly skilled workforce of approximately 80,000 FTE), and to provide a means to carry out cost-benefit analysis of alternative approaches for the treatment and disposal of radioactive waste. The author will describe how SD was applied during all stages of the modelling project lifecycle, from problem structuring, through data analysis and model building to policy analysis.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 12:00, Room - Private 1 Code: OR60A3615

Modelling the Condition of the School Estate

Dr Peter Curtis and Dr Adrian Fletcher *(Dept for Education)*

The school estate in England is huge - an estimated 62 million square metres of floor area. There is an estimated current backlog of repairs of approx £7bn. The Department for Education "Deterioration Model" is a Markov Chain simulation model, which predicts the state of the school estate over an extended period (20 years+). It incorporates assumptions about how quickly different building elements deteriorate, plus the money allocated each year to rebuild and repair schools in the estate to generate a predicted state of the estate each year. The talk will discuss the objectives, design and use of the model, examining case studies.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 13:30, Room - Private 1 Code: OR60A3567

KEYNOTE: A Principled Basis for Decision: Enduring Operational Research (OR) Subjects and Principles for Quality Assured Analytics

Mr Ian Mitchell *(BEIS)*

In a world of change some things don't. This presentation proposes that efficiency, effectiveness, interactions and behaviour remain perennial subjects of much OR Analytics. It proposes that quality analytics also depend on perennial principles, drawing on recent work implementing these in the Department for Business Energy and Industrial Strategy (BEIS). Recognising his role in pioneering OR the presentation introduces Professor Pat Rivett's three subjects for his 1964 BBC documentary about Operational Research: Cutting the Queue, Playing It Through and The Human Factor. It suggests that these are case studies of the analysis of efficiency, effectiveness, interactions and behaviour at the cutting edge of OR in their time. The presentation describes the current use of a five fold approach to assurance: Documentation, Structure and Clarity, Verification, Validation, Data and Assumptions. It considers the examples from Basis for Decision in these terms. The broad range of analytical tools for Big Data and Artificial Intelligence provide wider domains for OR Analytics to flourish. In that wider domain the assurance of quality will remain an essential selling point for those approaches.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 14:30, Room - Private 1 Code: OR60A3414

iPREP - Improving Perioperative Efficiency and Patient Throughput

Mr Gerard Doyle and Prof Anthony Staines *(Dublin City University)*

Eighteen months of perioperative clinical activity data reviewed from 30 theatre suites in a large UK teaching hospital in 2015. 2,823 operative sessions analysed. Late starts, delayed turnaround times and unplanned unfunded overruns identified. Research Question – Why is this and what can be done to introduce an improvement? Research proposal accepted and registered at Dublin City University, Ireland. Literature Review confirms a wealth of international work addressing the same issues. The majority of published work concentrates on one particular area of the whole journey to focus on improvement strategy. My research proposes

the development and sustainability of a cohesive service where stakeholders work in unison rather than individual units. Collaboration with statisticians at Queen's University Belfast established in 2016. Modelling of the data undertaken using SIMUL8 software to identify recurring bottlenecks. Discrete Event Simulation undertaken to analyse the sequence of events in time. This qualitative methodology will allow the research team to identify suitable points along the perioperative patient pathway to trial a clinical intervention. The trial will support the overall aim of using LEAN to establish a 'system' led surgical service in comparison to the 'silo' led service seen in healthcare institutions worldwide. Sustainability of the intervention if there is a measured improvement is also key to the research. In conjunction with this parallel project I am conducting the qualitative research through field work at the base hospital. This entails anonymised stakeholder interviews supported by a questionnaire. This will allow my research to benefit from opinion and suggestions for improvement strategies from the perspective of a broad range of practitioners. Structured observation is also being conducted which allows me to shadow and observe the practitioners who collect the surgical patients for theatres. This allows opportunity to review issues that occur during this important phase of the perioperative patient journey.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Relevant

OR in Schools

Organiser: Sophie Parker

11/09/2018, 13:30, Room - Faraday 2 Code: OR60A3608

TUE-Everything You Wanted to Know About OR in Schools

Miss Sophie Parker *(The OR Society)*

Want to know about the outreach and education work The OR Society do? Interested in giving career advice, inspiring the next generation or passing on your wisdom to students? Come along and find out what the OR in Schools initiative is all about, and hear how you can get involved in a school, college or university near you.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - Faraday 2 Code: OR60A3454

Practitioner for 30 Years and Now Going Back to School. Why You Should Consider Volunteering for ORiS and What You Will Gain From doing it

Mr Matthew Robinson *(IBM UK Ltd)*

This talk will focus on the presenter's recent experiences of volunteering and demonstrate through examples what he has gained personally and professionally. Having worked in OR and analytics for over 20 years, the presenter decided that he wanted to share his experiences outside the workplace and hopefully encourage young people to consider OR as a potential career.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:30, Room - Faraday 2 Code: OR60A3398

My OR in Schools Journey

Dr Penny Holborn *(University of South Wales)*

This talk aims to provide an insight into the Societies successful OR in Schools programme. It highlights not only the benefits of volunteering but the reasons why the initiative is so important and needs your support going forward. I will overview the reasons why and how I got involved, the varying events I have been involved in, and what I have both learnt and gained from the experience. It really is a rewarding and enjoyable experience.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:30, Room - Minor Hall Code: OR60A3702

WED-Everything You Wanted to Know About OR in Schools

Miss Sophie Parker *(The OR Society)*

Want to know about the outreach and education work The OR Society do? Interested in giving career advice, inspiring the next generation or passing on your wisdom to students? Come along and find out what the OR in Schools initiative is all about, and hear how you can get involved in a school, college or university near you.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 14:30, Room - Minor Hall Code: OR60A3703

THU-Everything You Wanted to Know About OR in Schools

Miss Sophie Parker *(The OR Society)*

Want to know about the outreach and education work The OR Society do? Interested in giving career advice, inspiring the next generation or passing on your wisdom to students? Come along and find out what the OR in Schools initiative is all about, and hear how you can get involved in a school, college or university near you.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

OR in Sport

Organiser: Philip Scarf

12/09/2018, 16:00, Room - Bowland LT Code: OR60A3311

Overall Champions at PyeongChang 2018

Prof David Percy *(University of Salford)*

In February and March respectively, the beautiful county of PyeongChang (South Korea) hosted the XXIII Olympic Winter Games and the XII Paralympic Winter Games. Both international multi-sport events were very successful, not only because they witnessed many incredible athletic achievements but also because they initiated peace talks and co-operation among disputing nations. The Olympic Games involved 2,922 athletes from 92 nations, competing at 102 events in 15 sports, while the Paralympic Games involved 569 athletes from 49 nations, competing at 80 events in 6 sports. An article published in JORS this year proposes a generalised shrinkage method for class handicapping, which enables comparisons to be made between athletes in different Paralympic classes, and between athletes in Paralympic and Olympic events. It also suggests that fair comparisons can be made between male and female athletes, between athletes from nations with differing resources, and even between athletes who compete in unrelated events. This talk presents preliminary findings from an analysis that puts this method to the test, based on some of the results observed at these Games. Although the method is not universally applicable, we identify clear potential for achieving its goal that is to enhance diversity and inclusivity in sport.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:30, Room - Bowland LT Code: OR60A3455

Analysis of the 2018 Snooker World Championship

Mr James Collingwood *(Lancaster University)*

The broad aim of my PhD research is to investigate what determines the outcome of a snooker match and what differentiates the best players from the rest. This presentation reports on my analysis of every shot played in the final stages of the 2018 Snooker World Championship, comprising 594 frames contested across 31 matches. Using these data I have reviewed the measures of performance commonly collated which cover ‘pot’ and ‘safety’ success, how effectively these reflect the outcome of each match, and the potential for developing and utilising alternative measures. This has led me to consider in more detail how individual frames progress in terms of the number of chances created and taken in each frame, and whether these tend to arise as a result of one player playing a good shot or their opponent making a mistake. I have also analysed the sequences of frames won and whether there is any indication

of momentum building during a match. Intuitively you would expect the probability of a player winning a frame to depend on the winner of the previous frame(s) and / or the current match score but this analysis suggests that – at least for this tournament - any effect is relatively insignificant.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 17:00, Room - Bowland LT Code: OR60A3283

Personalised Risk Strategies for Players in a Chess Team

Dr David Calvert

Chess teams of n players play matches against opposing teams of n players. Typically n is even and in the range 4 to 16. Each player is paired against one player of the opposing team. Third party, human or electronic, advice to any player once a game has started is generally prohibited. The result of each game for a player is a Win, Loss or Draw which are usually scored 1, 0 and 0.5 respectively. A team's score in a match is the sum of the scores of its players. The team objective is usually to score more points than the opposing team. The main components of this presentation are: (i) A general discrete approach to increasing the probability of a team winning before a move is made by considering all (and only) extreme risk strategy options for individual players. (ii) A general discussion of a Normal distribution model for team total score (iii) A brief discussion of the debateable, feasible and desirable objectives for individual players (iv) An application to Division 4 of the 4NCL in the 2017-18 season.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:30, Room - Bowland LT Code: OR60A3301

On Uncertainty of Outcome and Scoring Rates in Sport: The Case of International Rugby Union

Prof Phil Scarf *(University of Salford)*

We investigate the relationship between uncertainty of outcome and scoring rates in the framework of a "Poisson match". We argue that increasing scoring rates in the hope of increasing entertainment may have a detrimental impact on the popularity of sport. The basis of our argument is that in a Poisson match higher scoring rates decrease uncertainty of outcome. We use rugby to demonstrate our point and show that scoring rates have indeed increased significantly over the previous half-century. Therefore, rugby union administrators in particular may wish to consider the introduction of new laws to reduce scoring-rates, and sports administrators in general should recognise the general point. A scenario in which the scoring-rate is radically reduced is investigated in a simulation of the Rugby World Cup tournament.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

ORS Committee Sessions

Organiser: Graham Rand

One of our goals for this year's conference is to try and engage more people with The OR Society's activities. We've created a series of sessions in which the chair of an existing committee, including the General Council and Board, outlines some of the issues with which the committee is currently grappling, before encouraging discussion. We hope that the committee chairs will receive some useful feedback from the wider membership, and possibly some future members of the committee, while providing attendees with a sense of involvement and useful information.

12/09/2018, 12:00, Room - Faraday 2 Code: OR60A3633

ORS Diversity and Inclusion Benchmarking Framework Workshop

Ms Sayara Beg *(Datanut Sciences (London) Limited)*

Since 2015, the ORS has signed up to the UK Science Council's Diversity and Inclusion Charter. In 2016 the ORS took part in the D&I Benchmarking Framework pilot, contributing to its development. In 2017, working with the ORS General Council members, the ORS submitted its first internal assessment of the D&I Framework. This year, as the ORS Diversity Champion, I invite you to participate and contribute to the 2018 assessment of the D&I Framework, and put your questions to me, as the ORS Diversity Champion on the subject of ORS's D&I strategic initiative.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 16:00, Room - Faraday 2 Code: OR60A3636

Board and General Council

Mr John Hopes *(President of The OR Society)*

The Board is responsible for the overall management of the affairs of The OR Society and, together with the wider General Council, provides governance as well as developing and executing the Society's strategy in line with its charitable objects. This session will introduce the structure and activity of the Board and General Council, will present and discuss the Society's strategic priorities and will also feature the big issues that are dominating the Society's current leadership debate. This should be of interest to anyone who wants to know more about the Board and General Council, including those who might one day consider joining one of these bodies.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 17:00, Room - Faraday 2 Code: OR60A3639

Education & Research Committee

Dr Alistair Clark *(University of the West of England)*

The Education and Research Committee (ERC) oversees a lot of what most members would see as one of the key set of activities of the Society. The ERC has potentially many responsibilities within its remit, including some devolved to the Research Panel and the OR in Schools project, both of which have their own sessions. So this session will focus on other ERC activities, including Level 7 Apprenticeships. Come along, and hear about what we are doing, trying to do, and thinking of doing. We also want to hear your views on issues and what the ERC might or should be doing.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:00, Room - Bowland Hall BR Code: OR60A3638

Events Committee

Ms Ruth Kaufman

One of the most important functions of the OR Society is to support networks and interactions amongst OR professionals, and one of the most important ways of doing that is through our events. The Events Committee is responsible for developing and overseeing a programme of conferences, events and training that will help deliver the Society's charitable objectives and strategic goals. It also forms the link between the General Council and the Regional Societies and Special Interest Groups. At this session you can hear more about what we are doing and what we plan, and have your say on what we could do better.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:00, Room - Bowland Hall BR Code: OR60A3695

The Publicity, Members and Website Committee

Mrs Vivienne Raven *(HM Revenue & Customs)*

The Publicity, Members and Website committee (PMW) oversees membership issues. Recently we've been looking at analysis of our membership, developing the new OR Society website and 'reach' - our potential membership. We've set up student OR clubs at universities, made recommendations on subscriptions and members publications, and looked at the corporate partnership package. PMW would like to hear your views on engagement, membership and wider reach of the society.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 12:30, Room - Minor Hall Code: OR60A3714

Women in OR Network

Dr Penny Holborn *(University of South Wales)* and Dr Frances O'Brien *(Warwick University)*


This exciting session looks to launch the Women in OR Network. The gender imbalance in OR and STEM in general still presents many challenges both for academics and practitioners. This session will include a short talk overviewing the current picture of Women in OR. Recent findings of a number of postgraduate student projects looking at a range of aspects that effect the careers of Women in OR will also be overviewed. We hope that this session will not only entice membership to the Network, but will also map out the key targets for the Network to address for the future.

What is the nature of your talk? A Mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 14:00, Room - Bowland Hall BR Code: OR60A3637

Publications Committee

Prof Richard Eglese *(Lancaster University)*

Recent years have seen some radical changes in OR Society publications. OR Insight has been replaced by the Impact magazine, Inside OR has been given a makeover and we have moved our publisher from Palgrave/Springer to Taylor & Francis. This session is to provide some information about the workings of the Publications Committee, the issues that are of current concern and our plans for the future. If you would like to participate in this debate, ask questions and contribute to OR Society policy in the area of publications, then this session is for you.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

ORS Organisations & Careers

Organiser: Graham Rand

11/09/2018, 13:30, Room - LICA A27 Code: OR60A3709

Careers - Thinking Ahead

Mr Graham Rand *(Lancaster University)*

This is a unique opportunity for those exploring their career options to talk informally with organisations, including university groups. You can find out what it is like to work in the organisation, what the recruitment paths and timetables are, and what they are likely to be looking for. It will take place over a single session. Each organisation will have a table, where they will be able to meet interested OR/analytics professionals from industry and academia, whether PhD students or experienced practitioners.

At the time of writing the following companies have kindly indicated their involvement, however, we welcome more companies joining us for this very valuable session. Please register your interest at the OR60 registration desk or contact Graham Rand on g.rand@lancaster.ac.uk.

Organisations currently taking Part:
DecisionLab
McLaren
GORS
University of Lancaster

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

PRESIDENT'S MEDAL PRESENTATIONS

12/09/2018, 14:00, LICA building

The President's Medal is awarded for the best practical application of OR submitted to the competition (a wide definition of OR is used). Entries are accepted from both academics and industry-based OR workers and consultants. One of the main qualifications for entry is that the work has been implemented before submission.

Criteria for judging include:

- The level of demonstrable benefit
- The intellectual and novel content of the solution
- The likely longevity of the solution
- The excellence of the OR process

Conference delegates attending the President's Medal plenary session will have the opportunity to express their views as to their preferred candidate. The judges are required to take into account the views of the audience, but are free to arrive at their own decision. Ballot papers will be distributed at the start of the session.

PRESENTATIONS

12/09/2018, 14:00, Room - LICA A27 Code: OR60A3717

Transforming a National Institution: A Case Study in Bringing Together OR Best Practice and Engineering Expertise to Improve the Waterways of England and Wales

Ian Griffiths and James Adamson *(decisionLab)*, Richard Wakelen and Sheena Wilson *(Canal & River Trust)*

The Canal & River Trust (the Trust) has embarked upon a journey to transform the way it manages its assets and invests in their future. It engaged decisionLab to provide expert consultancy and operational research skills to help enable this transformation. It has very much been a partnership that has exploited the best of both organisations to achieve a greater whole. The project has not only directly affected the organisation but will also positively impact millions of people in the UK. Our aim was to enable the Trust to understand the true health of its network and all its assets – both now and projecting into the future – and transform the way it manages them.

The Trust wanted an approach that was meaningful to its engineers and justifiable to stakeholders requiring it to have a solid technical basis. It had to be practical and consistent for use across all asset classes to facilitate adoption across the organisation. Importantly, it wanted to be able to do more strategic planning, developing long-term asset plans that ensured that the Trust could truly manage risk in a sustainable way and based on a solid foundation. We also felt that the approach we developed had to be ownable by the Trust to maximise the chance of success and enable the Trust to be self-reliant. We will present our approach to addressing these challenges and how we worked together with the engineers to solve them. It began with a pilot study of three asset types (bridges, culverts and lock gates) to develop the approach and demonstrate its utility, before being applied to a much wider set of asset types.

We will also present how the Trust is able to use the information it previously did not have, and also how the approach could be applied more widely.

12/09/2018, 14:30, Room - LICA A27 Code: OR60A3718

Improving Sheffield's Health with the Public Sector Scorecard

Mr Max Moullin *(Public Sector Scorecard Research Centre)* and Mr John Soady *(Sheffield City Council)*

This paper examines how the Public Sector Scorecard was used in three projects: Sheffield's Stop Smoking Service; Sheffield Let's Change4Life (SLC4L) a £10 million programme addressing obesity in children and families in the city; and Sheffield Right First Time, a multi-million programme aiming to reduce unnecessary admissions to hospital. The Public Sector Scorecard (PSS) is designed to work across organisational boundaries and enables OR to contribute more effectively to major problems facing society. It focuses on desired outcomes, the processes which achieve those outcomes, and the capability and behavioural aspects that are needed to support staff and processes in achieving the outcomes.

All three projects involved working with a variety of stakeholders in a workshop setting. For example the project for Sheffield's Stop Smoking Service began with three interactive workshops attended by over 100 service users. One particular innovation in the SLC4L project was integrating the Theory of Planned Behaviour into the PSS. The projects produced significant benefits: for example, the numbers of users stopping smoking more than doubled, the numbers of reception-age children with healthy weight became better than the national average, and there was a progressive and sustained reduction in emergency bed-nights for avoidable hospital admissions. Feedback was excellent for all projects. The Director of Public Health commented that "the PSS Stop Smoking strategy map captures a useful strategic overview of the key interrelationships and shows how measures relate to the whole systems view." The SLC4L Programme Manager said, "The SLC4L Strategy Map visually told the story of SLC4L and helped all those involved understand the outcome and process measures the programme was trying to achieve", while Sheffield City Council's Chief Executive commented that "the PSS enables one to see what's happening across the health & social care system and where the balance of risks lies."

12/09/2018, 15:00, Room - LICA A27 Code: OR60A3719

Repurposing the Radio Spectrum: Delivering on the Promise of Next-Generation Mobile Services

Dr Robert Leese, Dr Jakob Blaavand, Dr Andrei Bejan and Dr Claudia Centazzo *(Smith Institute)*

We all rely on radio waves for our TV reception, smartphone connectivity, wifi access and other radio devices. The radio frequency spectrum underpins all these services and its use is carefully managed so that different services do not interfere with each other. The United States is currently implementing a once-in-a generation reorganisation of its radio spectrum allocations, which reallocates some parts of the radio spectrum from TV broadcasting to 5G mobile services. This repurposing of spectrum, from a relatively low-value use to a comparatively high-value use, has been made possible through a ground-breaking auction and optimisation mechanism. The Federal Communications Commission (FCC), which has responsibility for managing the commercial use of radio spectrum in the US, won the 2018 Franz Edelman Award for this substantial achievement. The mechanism itself has become known as the Broadcast Incentive Auction (BIA). It involved nearly 3,000 TV stations and 62 mobile operators.

The Smith Institute, as one of a small group of FCC contractors, was instrumental in successfully delivering this unique project. Our role was to ensure that the optimisation models and algorithms underpinning the BIA were all fit for purpose and worked with the required accuracy and speed at the first time of asking. This talk will highlight some of the intellectual and technical challenges that we faced and describe how the BIA was implemented. The Broadcast Incentive Auction performed flawlessly. Its outcome will shape the US broadcast and mobile industries for at least the next 20 years. Its importance is reflected in part by the total of $19.8 billion that the mobile operators paid for access to the repurposed TV spectrum.

Problem Structuring Methods / Soft Operational Research

Organiser: Alberto Paucar-Caceres

11/09/2018, 13:30, Room - Private 2 Code: OR60A3361

Using Soft OR Techniques in Developing an Evidence Strategy and to Prioritise Work within the Labour Market Area in DWP

Dr Tanya Powell *(Dept for Work and Pensions)*

The DWP Analytical Community has developed an Evidence Strategy approach to understanding where the gaps are in our evidence base and looking at how we fill those gaps. This has contributed to the publication of the DWP Areas of Research Interest (ARI), which can be found at https://www.gov.uk/government/publications/dwp-areas-of-research-interest. Within the Labour Market area of work, we have brought together analyst and policy colleagues, both from the Labour Market area of expertise and from other areas, to review and build our strategy. We have used a range of Soft OR approaches within workshops, including Rich Pictures, cognitive mapping, purposeful activity statements, and some elements of Theory of Change (developed by the Social Research profession) This has enabled us to bring together a broad range of views and experiences to develop an agreed strategy, which we have used to prioritise our work going forward, allowing us to balance short and long term work priorities. This presentation will cover some of the approaches we used, what worked and what didn't, and how we managed some of the approaches across a range of media, including face to face, over video conferences, through computer based Lync systems, and combinations of them all.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - Private 2 Code: OR60A3445

Using Adaptive Red Teaming to Explore Enabler Issues

Miss Julia Piotto and Mrs Patricia Dexter *(Defence Science and Technology Group)*

Land Capability Analysis of the Australian Defence Science & Technology Group conducted three studies leveraging adaptive red teaming to explore force structure issues and options relating to provision of enabler capability for the Army. Adaptive red teaming, grounded in judgement based operations research, was used to provide high-quality contestable outputs through minimising biases and group think as well as maximising alternative perspectives and critical analysis. These contributed to Army submissions to the Australian Army's Chief of Army Senior Advisory Committee for decision making regarding enabler capability. The first study compared the current structure of the Australian Army Reserve with proposed force structures using a workshop of all stakeholders. Issues with the structures were extracted and

assumptions identified. These contributed to a consolidated structural proposal. The second study identified key issues with a proposed concept for altering the structure of Australian Army combat brigades and associated enabler functions. A larger number of stakeholders were engaged through remote and distributed consultation using a survey method grounded in Delphi principles. The third study identified issues surrounding the generation of enabler mass for the Australian Army and subsequently explored options to address these issues. The study used multiple overlapping techniques of data collection and analysis from the adaptive red teaming space to generate the required outputs. These included workshops and surveys grounded in Delphi principles to undertake relationship mapping, functional and goal tree analysis, factor and causal map analysis, nodal analysis, option generation and critical option analysis. The application of the methods described above and an assessment of how suitable they were for each of these studies will be the discussion of this presentation.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 14:30, Room - Private 2 Code: OR60A3450

The Development of Soft Operational Research over the Last 40 Years: Mapping Themes and Concepts

Mrs Leila Abuabara *(UNIFESP/ITA)* and Mr Alberto Paucar-Caceres *(Manchester Metropolitan University Business School)*

Operational Research and its allied field Management Science established themselves in the early 50s by embracing the optimisation paradigm and championing the development of 'solving methods' based on mathematical modelling, optimization and iterative computing tools. These became associated with classic operational research techniques and the so called 'hard' approaches. In the 70's, the optimization paradigm started to be challenged and a new paradigm based on learning emerged. Advocates of this paradigm (mainly from the UK) claim that to tackle complexity a set of methodologies capable of considering the different perspectives of the actors involved as well as the context of the situation was needed. These management science methods tried to alleviate/dissolve problems rather than solving them, focusing on learning (and understanding human and socio-cultural aspects) rather than optimizing. In general, the set of methodologies adhering to this are: 'Soft' Operational Research /Problem Structuring Methods; Behavioral Operational Research and their derivatives especially in terms of multi-methodology practices. Over the last decades the use of these methodologies has grown amongst OR academics and practitioners. This paper focuses on analysing the development such methodologies by using content analysis through a text mining tool software called Leximancer, a software tool that identifies word concepts/themes based in their proximity in the text. We use a database composed by title-abstract-keyword of scientific articles and conference proceedings published over the last 40 years (1980-2018). The result of the analysis are maps of clusters of concepts/themes including information on the strength of the relationships among the themes; this enables to gain both of a wide overview and a rich understanding of the OR development over those years. The paper offers an exploration and interpretation of such maps bringing intellectual rigour to the analysis and knowledge discovery on Soft OR through time.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:00, Room - Bowland Hall S Code: OR60A3462

Developing a Generic Problem Structuring Method: the Philosophical, Theoretical and Methodological Development of WASAN from the Specific, to the Generic

Dr Chris Smith *(University of Manchester)*

This paper considers the philosophical, theoretical and methodical development of the context-specific approach WASAN into an approach that could be considered a generic problem structuring method. The Nuclear Installations Inspectorate commissioned the development of WASAN to analyse the reduction of avoidable radioactive waste. Such, it was developed with a very specific context in mind, adhering to specific regulations and using a particular jargon. The concept of waste reduction is useful for a wider set of clients, such this paper looks at how WASAN was developed to be used in a UK Police Force contact centre. WASAN was developed through an action research programme through 10 learning loops, providing learning about the area of concern, the methodology WASAN and the framework of ideas underpinning this. The focus of this paper is the learning related to the developing WASAN generically. This focusses on two important issues, first does WASAN exhibit the properties of other PSMs, shown through the 4 pillar framework. Second, focusses on the different classes of elements within the WASAN methodology that are required for it to be generically applicable. That is it can be applied to a variety of problem contexts without the need for further methodological development. Here the paper distinguishes between two classes of elements, those which required consistent replication regardless of context; termed methodological elements. Second, those which allow an approach to be applicable to the local context thereby bridging the gap between the problem context and methodology; we term these contextual elements.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

12/09/2018, 16:30, Room - Bowland Hall S Code: OR60A3490

Using SSM to Clarify the Role(s) of Personal Tutoring in Higher Education

Dr Stephen Powell and Dr Alicia Prowse *(Manchester Metropolitan University)*

Using SSM in any situation includes navigating the social and political dimensions (Analyses 2 and 3) that arise from multiple actors involved and the power relationships between them. In a higher education institution where 'academic freedom' means that models of change management are often loosely applied, this is a particular challenge. An extensive body of literature focuses on the high degree of autonomy that academics have traditionally had, being eroded by increased levels of management, with one view being that "there is a privileging of the general knowledge of those promoting change over locally held knowledge" (Blackmore and Kandiko 2012, p.113). In this paper, the tension between central management and the operational teaching functions of the university is discussed in the context of an SSM inspired change initiative. The established Soft Systems Methodology (SSM) (as described in Checkland and Poulter (2006)) was used to address the 'messy situation' of the role(s) of personal tutoring in an institution of Higher Education in the UK. Using activity models and an idealised purpose statement, an institution- wide conversation was instigated and pursued, resulting in some 'actions to improve', including a cross-institutional framework for personal tutoring. Reflection on the key social and political issues that were raised during the course of the investigation has helped develop a more rounded picture of insights gained into this complex activity. For example, a realisation that consistency of communications to staff and students would best be located in a single functional area of the organisation, does not

necessarily result in this coming to pass. The paper will be presented as a case study that discusses and identifies the key practical, political and cultural issues in using an SSM in similar organisational contexts. The project was undertaken for the HEFCE-funded Interventions for Success programme.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 17:00, Room - Bowland Hall S Code: OR60A3573

The Role of Stakeholders in OR Interventions - Evidence From JORS

Mr Harry Kogetsidis *(University of Nicosia)*

Within the field of OR a lot of attention has been drawn on the role of stakeholders. OR started as a collaborative discipline which placed particular interest on how different people view complex problems in organisations and society. This interest in multiple views and perceptions gained pace with the development of soft OR and problem structuring methods and more recently critical systems thinking. This paper looks into how articles published in JORS have approached the issue of the role of stakeholders in OR interventions. The paper aims to examine the trends in relation to how stakeholders are viewed during the OR process so that a better understanding of the contribution of OR as a problem solving discipline can be made.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:30, Room - Bowland Hall S Code: OR60A3580

Problem Structuring Methods and Multi-Methodology in Latin America: A Survey of Applications

Prof Maria Alejandra Castellini and Miss Melany Segarra Marinetti *(Universidad de Belgrano)*

The development of Soft Operational Research (or Problem Structuring Methods (PSM)) in Europe, the USA and other countries has been surveyed and discussed in various studies. This has not been the case of the Latin America (LA) region, even though there is some anecdotal evidence that since the mid 80 when Soft OR was at the peak of its popularity approximately, academics and practitioners LA have adopted these methodologies in particular Checkland's soft systems methodology. A quick review of OR and Systems journals also reveals that other PSM have been used in LA setting. This paper seeks to ascertain the degree of PSM applications in LA and discuss its development with the view to compare it with the development of PSM in other parts of the world, in particular in Europe. We surveyed PSM articles in abstracts in MS/OR Journals between 1980-2018. The OR journals surveyed were: European Journal of Operational Research, Journal of Operational Research society, Omega and International Transactions in Operations Research. In addition, we surveyed two journals from the systems thinking field: Systemic Research and Behavioral Science and Systemic Practice and Action Research. We do not include US-based journals: Management Science, Operation Research and Interfaces because previous studies have indicated the almost non-existence of PSM applications published in these journals. The initial results indicate that Brazil is the country where more PSM applications were published. Brazilian researchers have published mainly applications using Value Focusing Thinking, Cognitive and Conceptual maps, as well as Group Decision Making, SSM, multi-methodology and conceptual papers. There are

some papers published by Colombian, Peruvian, Venezuelan, Chilean, Bolivian and Argentinean authors, working together with UK researchers on PSM, Multi-methodology OR and Viable System Model applications. For the rest of LA countries, our survey suggest that the activity is either limited or non-existent.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

Revenue Management and Pricing

Organisers: Catherine Cleophas and Arne Strauss

11/09/2018, 10:00, Room - LICA A28 Code: OR60A3565

Allocation and Nonlinear Pricing for Capacitated Stochastic Container Leasing System with Dynamic Arrivals

Dr Wen Jiao *(Loughborough University)*, Dr King-Wah Pang and Prof Hong Yan *(The Hong Kong Polytechnic University)*

Container lease is a relatively new industry which flourishes successfully over the past two decades. In practice, container lease pricing problem is distinct from a consumer product rental pricing in the light of multiple-unit demand, monopolistic supply and oligopolistic demand market. Constrained by finite capacity and dynamic arrivals, the leasing company is grappling for the pricing issue. In this paper, we investigate the dynamic nonlinear pricing problem of a leasing company confronted with low and high type customers who randomly arrive at the company and have specific hire duration preferences. We derive the closed-form optimal pricing and rationing policy and further discuss the effect of capacity constraints and customer dynamic arrivals on the optimal allocation policy. In the setting with the same hire duration preference, the effect of capacity constraint becomes greater over time for customers with the same entry date and the dynamic arrivals accelerate the increasing rate of capacity constraints compared with the simultaneous entries case. In the setting with different hire duration preferences, the effect of capacity constraint increases for the low type customer and decreases for the high type customer. Dynamic arrivals only aggravate the increasing effect of capacity constraint for the consistent low type customers.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 11:30, Room - LICA A28 Code: OR60A3681

Revenue Optimisation for Branded Fares

Mr Jan Felix Meyer *(Swiss International Air Lines)*

By the introduction of entirely unrestricted fare products from the low-cost competition, legacy carriers were no longer able to the segment passengers by their length of stay and flexibility requirements. To overcome the loss of revenue, legacy carriers had to come up with a new way of designing their products, introducing the branded fares concept. Besides offering a product only including the transportation (baseline brand), a selection of bundled services, so-called brands (usually 2-3 bundles), are provided. Each of the brands adds a variety of additional services to the baseline brand such as a combination of baggage, meal, refund- and rebook-options for a upsell amount on top of the price of the baseline brand. The benefit of this strategy shows by the ability to compete with low-cost competition (pricing of the baseline brand) but also the recapture of revenue losses by the increase in ancillary revenue. Based on data from a large European group of network carriers, this paper shows that the upsell amount should depend on the price of the baseline brand and should be different between markets. We explain the dependence on the price of the baseline brand (baseline price) by the existence of passenger segments having different budget constraints within a single market and the market dependence on a change of these segments between markets. We identify the optimised upsell amounts by a statistical sampling technique (generation of information about the passengers' willingness to pay by temporarily pricing non-optimally) followed by price optimisation.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 12:00, Room - LICA A28 Code: OR60A3497

Dynamic Pricing of Flexible Time Slots for Attended Home Delivery Services

Dr Arne Strauss *(University of Warwick)*, Dr Nalan Gulpinar and Ms Yijun Zheng *(Warwick Business School)*

Many online grocery retailers offer home delivery within a time slot booked by the customer. Providing narrow time slots improves customer satisfaction but is expensive to provide. To allow more flexibility in the retailer's delivery schedules whilst maintaining customer satisfaction, we propose to apply the concept of so-called flexible products (known in the airline industry) to delivery time slots. The idea is that customers have different preferences, so that some may be willing to accept a wider time window (or, in general, several not necessarily adjacent time windows) in return for a reduced delivery charge. A flexible slot is defined as a set of not necessarily adjacent time slots communicated to the customer as potential delivery times at the time of booking. However, the retailer only needs to make the decision on the specific delivery time on the day of delivery operation. Thereby, flexible products promise to improve the efficiency of the vehicle routes and to accept more profitable orders during the booking horizon. In our analysis, we focus on managing prices of delivery slots (both regular and flexible ones) over a finite booking horizon for a single delivery day. The set of feasible prices is assumed to have finite cardinality. Customers with random shopping basket sizes arrive randomly over time, observe the offered delivery slot prices and choose a slot (or not to purchase) according to the multinomial logit choice model. The retailer aims to dynamically control slot prices in a way such that the expected profit-to-come over the remaining booking horizon is maximised. At the end of the booking horizon, we generate the final delivery routes

to serve all requests using a heuristic for the vehicle routing problem with multiple time windows (due to the flexible slots).

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 13:30, Room - LICA A28 Code: OR60A3674

Revenue Management for Indian Railways

Dr Faiz Hamid and Mr Ashish Sharma *(Indian Institute of Technology, Kanpur)*

Indian Railways is one of the biggest transport networks in the world. It provides tremendous scope of optimal planning in various areas. Revenue management is one of those. The problem addressed here is to decide how many seats to be allocated for reservation between every pair of stations along a route to maximize the overall revenue from a given train. The ticket fare per kilometer keeps decreasing with increasing distance. Thus passengers travelling shorter distance will be preferred over long distance passengers if revenue is to be maximized. However, customer satisfaction should also be kept in mind while maximizing the revenue. Therefore, in this study, we have developed optimization models based on linear goal programming approach with two objectives - (1) to maximize the total revenue, and (2) to minimize the number of demand rejections. The above two objectives may be realized even better if instead of optimizing individual trains, they are optimized together for the aggregated demand. This is because some trains may be running partially empty while some not satisfying its demand. The computational results with real life data confirm significant increase in revenue and decrease in demand rejection.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - LICA A28 Code: OR60A3649

Revenue Management: Bibliometric Analysis Based on Web of Science Database

Mrs Yun Prihantina Mulyani *(University of Manchester)*

Bibliometric analysis as quantitative study of publications is very useful to capture a clear understanding of conceptual structure and research progress of a specific discipline. This paper aims at presenting a general bibliometric analysis such as overview of research trends, leading publishers, influential articles, and identifying shifting concerns in revenue management (RM) over the years until 2017. Bibliometric data was collected from Web of Science core collection with a well-defined search strategy. Network Analysis Interface for Literature Studies (NAILS) Project scripts to delinate the year-wise and subject-wise research trends. Then, keyword analysis was utilised to get the detailed picture on how research topic, method, and domain shifted during the period. RM has experienced an increasing trend with exponential manner every year. The top influential journals are Management Science, Operations Research, Management Science Manufacturing & Service Operations Management, and Decision Sciences. Keyword analysis showed that the research foci of RM is related to three main decisions including price, quantity, and structural decision. In addition to this, consumer and competition recently become emerging topics. Future research demands empirical study and more advanced quantitative methods to deal with complexity

and real-time problems. For research domain, RM is now progressing on industries with semi-flexible capacity.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:30, Room - LICA A28 Code: OR60A3510

Room Allocation Problem in Hotel Revenue Management with Reservation Extensions

Dr Nursen Aydin *(University of Warwick)* and Prof Ilker Birbil *(Erasmus University Rotterdam)*

We study the hotel room allocation problem by considering the stay-over customers. Stay-over customers make advance booking and request to extend their reservations during their stay. Room allocation problem is the control of total room capacity when the customer demand is characterized by the length of stay and the room types. To formulate stay-over customers, we need to keep track of the accepted reservations in each booking type. Dynamic control of this problem is challenging for analysis and optimization due to the high dimensional state space. To alleviate this difficulty, we work on a product-based decomposition method by considering the stay-overs. We first focus on the case where only single-day stay-over extension is possible. By analysing the structural properties of the problem, we propose a solution method. Second, we consider the multi-day stay-over problem and present a two-period approximation, which combines product-based decomposition with deterministic linear programming. We conduct a thorough computational study and investigate the performances of our proposed models against some well-known approaches used in the literature.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 09:30, Room - LICA A28 Code: OR60A3411

Car Rental Network Revenue Management

Dr Dong Li *(Loughborough University)*, Dr Zhan Pang *(City University of Hong Kong)* and Dr Dali Zhang *(Shanghai Jiaotong University)*

This work considers the dynamic bid price control for car rental revenue management concerning a network of rental stations. Both round trip and one way rentals are considered. Moreover, cars can be transhipped between stations to adjust local capacities on a daily basis. Our aim is to develop efficient bid price control policies that maximise the total discounted revenue. We model this problem as a cyclic dynamic program. Due to the high dimension of the state space, we propose two approximation approaches based on booking limit policies. The first one only concerns the mean future demand and approximates the problem as a deterministic mixed-integer program. The second one considers the uncertainty of demand in a probabilistic non-linear program.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 11:00, Room - LICA A28 Code: OR60A3428

Balancing Revenue and Load under Customer Choice in Capacity-Based Revenue Management

Mr Felix Geyer and **Prof Christina Büsing** *(RWTH Aachen University)* and **Prof Catherine Cleophas** *(Lancaster University)*

While classical revenue management aims to optimise inventory controls to maximise revenue, secondary objectives play a significant role in the long-term success of a firm. Here, we focus on the number of sold units, also expressed as load, as it is related to strategical targets and stock valuations. The revenue-maximal solution may not align with such secondary objectives. Hence, we suggest including the secondary objective in the optimization model to calculate a Pareto-curve as decision support to revenue management analysts tasked with balancing multiple objectives. Thus far, the related literature exclusively considers the common independent demand model. This demand model assumes that customer choice of products does not depend on the set of offered products. While this assumption simplifies the problem of optimising inventory controls, it rarely holds in practice. Therefore, we formulate a bi-objective optimization problem based on a dependent demand model. We modify solution techniques designed for the independent demand model to calculate the Pareto-curve for the dependent demand model. Finally, we show the quality of the approach in a numerical study.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

Risk

Organiser: Matthew Revie

13/09/2018, 09:00, Room - Minor Hall Code: OR60A3492

UK Energy Supply Chain Risk Identification and Evaluation

Mr Amin Vafadarnikjoo, Dr Tiago Botelho and Prof Konstantinos Chalvatzis *(University of East Anglia)*

The inbuilt characteristic of energy security is undoubtedly risk management, although, it is inextricably intertwined with distinct disciplines such as political science, economics and engineering. Assessing risks of an energy supply chain would not be efficiently achieved without thoroughly addressing risks through a comprehensive risk identification framework and proper risk analysis. In all levels of power supply chains from upstream to downstream, the disruption concern is fundamental. This study tries to put emphasis on risk identification in the UK power supply chain along with their interrelationships analysis applying a neutrosophic revised-DEMATEL and a hesitant expert selection model. The method has been chosen because risks are closely interconnected and they can easily propagate from one risk to others. Hence, in order to capture their interdependencies along with properly handling experts' subjective judgements, the revised-DEMATEL is applied under neutrosophic decision making environment. A hesitant expert selection model is introduced to systematically assist researchers with the experts' selection process and experts' importance weights determination. Initially, through scrutinising the literature, a comprehensive framework was developed and twelve risk dimensions identified including climate change (CC), natural disasters (ND), environmental and health safety (EHS), technical reliability (TR), operational safety (OS), disease outbreak (DO), industrial action (IA), political instability (PI), sabotage and terrorism (ST), resource availability (RA), market failure (MF) and affordability (AF). The data collection carried out by participation of 31 experts with expertise in various UK energy fields via completing an online internet questionnaire. Taking a proactive perspective, risks, their interrelationships and rankings are discussed in order to provide a more reliable understanding of risks in the UK power supply chain for proposing mitigation strategies. The findings reveal that risk dimensions ND, CC, IA, AF, PI and ST must be paid more attention for mitigation strategies recommendations.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:30, Room - Minor Hall Code: OR60A3327

Identifying Hidden Patterns in Credit Risk Survival Data Using Generalised Additive Models

Prof Jonathan Crook and Dr Viani Djeundje *(University of Edinburgh)*

Modelling patterns in credit risk using survival analysis techniques have received considerable and increasing attention over the past decade. In these models, the predictor of the hazard of default is often expressed as a simple linear combination of the risk factors. In this work, we discuss how these models can be enhanced using Generalised Additive Models (GAMs). In the GAMs framework, the predictor is formulated as a combination of flexible univariate functions of the risk factors. In this paper, we parametrise GAMs for credit risk data in terms of penalised splines, outline the implementation via frequentist and Bayesian MCMC methods, apply them to a large portfolio of credit card accounts, and show how GAMs can be used to improve not only the application, behavioural and macro-economic components of survival models for credit risk data at individual account level, but also the accuracy of predictions. From a practitioner point of view, this work highlights that some accounts may actually become more (less) attractive to the lender if flexible smooth functions are used whereas the same applicant may be denied (accepted) a loan if the linearity assumption is forced.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

Robust Optimisation

Organiser: Marc Goerigk

12/09/2018, 12:00, Room - Bowland Hall S Code: OR60A3369

A Largest Empty Hypersphere Metaheuristic for Robust Optimisation with Implementation Uncertainty

Dr Martin Hughes and Dr Marc Goerigk *(Lancaster University)*

We consider robust optimisation problems with implementation uncertainty. In this setting, the solution that a decision maker wants to implement may become perturbed. The aim is to find a solution that optimises the worst possible performance over all possible perturbances. Previously, only few generic search methods have been developed for this setting. We introduce a new approach for a global search, based on placing a largest empty hypersphere. We do not assume any knowledge on the structure of the original objective function, making this approach also viable for simulation-optimisation settings. In computational experiments we demonstrate a strong performance of our approach in comparison with state-of-the-art methods, which makes it possible to solve even high-dimensional problems.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 12:30, Room - Bowland Hall S Code: OR60A3537

Robust Network Capacity Expansion with Non-Linear Costs

Mr Francis Garuba, Dr Marc Goerigk and Dr Peter Jacko *(Lancaster University)*

A lot of research has been done in the area of network planning, where the associated design and expansion costs are assumed to be linear. However, realistic non-linear cost functions have not been considered sufficiently. Hence, we examine the network capacity expansion problem under traffic demand uncertainty with non-linear capacity expansion cost. This non-linearity is treated under the framework of the fixed charge network to start with where any expansion exceeding the installed capacity on every link triggers an additional fixed charge and then extended to another variant, the piecewise-linear cost function. A robust optimisation approach is used to address this demand uncertainty. This methodology is geared towards producing results that are insensitive to the uncertain demand, by considering several possible demand variation scenarios around a base demand. We allow for the demand between every pair of nodes, analogously to the multi-commodity flow problem. The resulting mixed-integer programming model is developed with the objective of minimizing the sum of linear capacity expansion investment and the fixed charge across all the network links. We implement the models using a general purpose solver, i.e. Gurobi, and numerical experiments have been carried out for four network structures taken from the online SNDlib database, with 26-39

nodes, 84-172 links, and 67-1,482 commodities. When considering two demand scenarios, the model can be solved 68.54% of 480 instances to optimality within the time limit of 4,000sec while it takes 89% more time to solve compared with the linear cost. The solution time was also found to increase quadratically with increasing number of scenarios. The next goal is to improve on the solution time by investigating algorithms that deal with the challenge of a large number of variables.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

Simulation

Organisers: Stephan Onggo and Navonil Mustafee

11/09/2018, 11:00, Room - LICA A29 Code: OR60A3605

KEYNOTE: Writing About Simulation

Dr Christine Currie *(University of Southampton)*

The focus of the article is on the second half of a simulation project, after the model has been built. While less glamorous than model-building, the analysis of results and the descriptions of what have been done are still vital for a successful simulation project. We concentrate on three main themes: reporting simulation models; accounting for output variability and decision-making via simulation. Discrete Event Simulation, Agent Based Modelling and System Dynamics are all discussed and so we hope that the recommendations will be paradigm-agnostic.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 11:30, Room - LICA A29 Code: OR60A3523

The Applications of Agent-Based Simulation in Agri-Food Supply Chain

Dr Bhakti Stephan Onggo *(Trinity College Dublin)*, Dr Steve Eldridge and Mr Dhanan Utomo *(Lancaster University)*

This talk comprises of two related parts: The first part is based on Utomo et al. (2018), EJOR, 269 (3): 794-805. Agri-food supply chain (ASC) is an important application domain for Operational Research/Management Science. In particular, the use of agent-based simulation (ABS) has increased in ASC research in recent years. We study the characteristics of the models and modelling reported in the literature. It illustrates that existing research features extensive use of: single echelon supply chains; cases from high and middle-income countries; unprocessed food product cases; the use of empirical (as opposed to hypothetical) data; cases related to production planning and investment decisions; and the use of black box validation. We use bibliographic mapping to identify areas in ASC research which are yet to be addressed using ABS. We find that areas such as collaboration and competition, buyer-seller relationships, and service are under-researched. In addition, key actors in ASC such as food processors, supermarkets and retailers have not been included in the ABS models. The second part is built upon the literature. In this part, I will talk about our recent work on scenario-based questionnaire method that we use to calibrate and validate an ABS model of a dairy supply chain. The finding shows that this method increases the credibility of the model.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 12:00, Room - LICA A29 Code: OR60A3713

Using Simulation Software to Optimize Call Centre Staffing and Performance: Moving Beyond Erlang

Mr Liam Hastie *(SIMUL8)*

Technology advances and rising customer expectations are making today's contact centers increasingly complex to manage and effectively change. This presentation challenges the effectiveness of using existing performance optimization norms such as Erlang. As an alternative approach, experiences from several recent case-studies will highlight the benefits of using simulation software for optimizing staffing and performance and implementing process improvement initiatives. A view will be shared how teams can utilize these tools and how new SIMUL8 features are making it easier for anyone to create powerful, visual frameworks for capturing, analyzing and testing every aspect of a contact center.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 13:30, Room - LICA A29 Code: OR60A3686

RH-RT: A Data Analytics Framework for Reducing Wait Time at Emergency Departments and Centres for Urgent Care

Prof Navonil Mustafee, Ms Alison Harper and Prof John Powell *(University of Exeter)*

Right Hospital – Right Time (RH-RT) is the conceptualisation of the use of descriptive, predictive and prescriptive analytics with real-time data from Accident & Emergency (A&E)/Emergency Departments (ED) and centres for urgent care; its objective is to derive maximum value from wait time data by using data analytics techniques, and making them available to both patients and healthcare organisations. The paper presents an architecture for the implementation of RH-RT that is specific to the authors' current work on a digital platform (NHSquicker) that makes available live waiting time from multiple centres of urgent care (e.g. A&E/ED, Minor Injury Units) in Devon and Cornwall. The focus of the paper is on the development of a Hybrid Systems Model (HSM) comprising of healthcare business intelligence, forecasting techniques and computer simulation. The contribution of the work is the conceptual RH-RT framework and its implementation architecture that relies on near real-time data from NHSquicker.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - LICA A29 Code: OR60A3667

From Hybrid Simulation to Hybrid Systems Modelling

Prof Navonil Mustafee and Prof John Powell *(University of Exeter)*

Hybrid Simulation (HS) is the combined application of modelling approaches like SD, DES and ABS in the model implementation stage of a simulation study. Its objective is to better represent the system under scrutiny. Hybrid Systems Modelling (HSM), on the other hand, is

the combined application of simulation with methods and techniques from disciplines such as Applied Computing, Computer Science, Engineering and the wider OR. HSM can be applied to multiple stages of a simulation study. In this talk, we will present a classification of HS and extend it to include HSM approaches which use simulation with other OR techniques. The paper contributes to the debate on what constitutes HS and offers a unifying conceptual representation for mixing simulation approaches with HSM methods and techniques.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:30, Room - LICA A29 Code: OR60A3322

The Taming Wicked Problems Framework: Building Resilience to Medical Pluralism in Rural South Africa

Dr Chris Burman *(University of Limpopo)*

CONTEXT: In South Africa about 7.2 million people are living with HIV. Of those, about 3.7 million are on antiretroviral therapy (ART). Enrolling and retaining people in care is essential if the biomedical strategy to 'end AIDS by 2030' is to be achieved. Medical pluralism (the simultaneous use of traditional and biomedical health practitioners to treat the same set of symptoms) generates unintended delays in testing and interruption of treatment along the cascade of HIV care in eastern and southern Africa. Despite awareness of these bottlenecks, attempts to reduce them have been 'short-lived'. FOCUS IN THE PRESENTATION: A (NON-LINEAR) SYSTEMS PERSPECTIVE In 2014, a community-university partnership in the Limpopo Province, South Africa, began a programme to contribute to reducing the unintended consequences of medical pluralism. The outcomes include an increase in adherence to ART and a decrease in internalised stigma — both of which are now self-sustaining. The technique that the partnership developed to counter the unintended consequences of medical pluralism has been named the Taming Wicked Problems Framework. The Framework design was influenced by the 'Complexity sciences' and a resilience perspective in the context of indigenous decision making, intentionality and health seeking behaviours. The resilience perspective included identifying multiple 'mini-resilience strategies' which made sense to people living in rural communities which subsequently influenced social practices — rather than trying to 'solve' problems. During the presentation I will describe (1) the different phases within the Framework and the underlying rationale for each inter-connected phase; (2) the non-linear outputs that have emerged (a now self-sustaining strategy that contributes to an increase in adherence to ART and a decrease in internalised stigma); (3) the learning from the partnership, and (4) then propose synergies between the Framework design and Operational Research.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 12:00, Room - LICA A29 Code: OR60A3321

Quantifying Input Uncertainty and Bias Due to Input Modelling in Computer Simulation

Prof Barry Nelson *(Northwestern University)*, Miss Lucy Elizabeth Morgan, Dr Andrew Titman and Dr David Worthington *(Lancaster University)*

The "stochastic" element of stochastic simulation comes from the input models that drive the simulation. As we can only ever collect a finite number of observations from which to estimate these input models, they are never correct. This error propagates to the simulation output; causing input uncertainty and bias due to input modelling. Input uncertainty is the variability of the simulation response caused by input modelling. Whereas, bias due to input modelling, which occurs when the response of interest is a non-linear function of its inputs, as is common in simulation, is the average difference between the response from a real-world system and the output of the simulation of that system caused by input modelling. Often the estimated input distributions are assumed true, overlooking these sources of error, but it can be shown that in many cases the analysis of the response of interest can be very different when error due to input modelling is included. In this talk we introduce both forms of error, and the link between them, and present methods for quantifying input uncertainty and bias due to input modelling in simulation models with non-stationary piecewise-constant Poisson arrival processes.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:30, Room - LICA A29 Code: OR60A3664

Enabling the Automated Calibration of Simulations for Decision Support

Dr Catherine Cleophas and Dr Anas Elhag *(Lancaster University)*

When employing simulation modelling to support decisions, modellers have to validate that the simulation matches the empirical system behaviour. While validating input parameters is desirable, agent-based simulations, in particular, frequently include parameters that are not empirically observable. This creates the problem of calibrating parameter values to produce valid outputs. This talk presents a computational framework to evaluate the interplay of simulation models, calibration techniques, and validation approaches. Furthermore, we propose a general coding of parameter requirements to enable automated calibration independently of simulation domain knowledge. Finally, we exemplify these concepts through a computational study applying hyperheuristics for automated calibration.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 11:00, Room - Minor Hall Code: OR60A3707

Simulation SIG Meeting at OR60

Dr Navonil Mustafee *(University of Exeter)*

Simulation SIG Meeting at OR60

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

Stochastic Processes and their Application

Organiser: Kevin Glazebrook

12/09/2018, 09:00, Room - Minor Hall Code: OR60A3317

Combinatorial Multi-Armed Bandits for Border Surveillance Problems

Mr James Grant, Prof Kevin Glazebrook and Prof David Leslie *(Lancaster University)* and Prof Roberto Szechtman *(Naval Postgraduate School)*

We consider a scenario where a collection of searchers is available to patrol a border with a view to monitoring (and taking action upon) intrusions. The underlying rate at which intrusions appear is unknown and the deployment of searchers to cells of a grid along the border may be updated sequentially. The aim of the searchers is to detect as many intrusions as possible, and to realise this they must learn effective deployment of searchers to grid cells. We model the resulting exploration-exploitation trade-off using a combinatorial multi-armed bandit with non-linear rewards and a novel "filtered" feedback model. This filtering aspect arises since agents may not detect all intrusions and the number that are missed will remain unknown – introducing additional variance to the estimates of the underlying rates. Non-linearity arises since the larger a region an agent is assigned to, the less likely they are to detect events therein. In other words, pulling more arms does not necessarily lead to larger rewards. We propose an upper confidence bound approach to this problem which incorporates an efficient integer programming approach to determine actions in the face of the non-linearity. We derive a logarithmic order upper bound on regret for our algorithm and demonstrate that this matches the lower bound for the problem up to a constant. We conclude with a numerical study which demonstrates that the upper confidence bound approach is a more reliable choice than Thompson Sampling which can suffer badly from poorly selected priors in this setting.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 09:30, Room - Minor Hall Code: OR60A3363

Harnessing the Double-Edged Sword via Routing: Information Provision on Ride-Hailing Platforms

Dr Dongyuan Zhan *(University College London)*, Prof Leon Yang Chu *(University of Southern California)* and Prof Zhixi Wan *(University of Oregon)*

We consider a ride-hailing platform that provides free information service to taxi drivers. Upon receiving a rider's request, the platform broadcasts the rider information to the idle taxi drivers, who may accept or decline the request based on the customer's profitability. The first driver who accepts the request gets the ride. If no driver accepts it then the rider leaves. As a result, information disclosure is a double-edged sword for drivers' profits: they may take more

profitable rides via inefficient idling. We study the profit implication of this information disclosure, and propose a simple broadcast policy that can achieve close to the first best when the system is large.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 10:00, Room - Minor Hall Code: OR60A3373

Optimal Search in Discrete Locations Accounting for Detection Capability and Two Available Search Modes

Mr Jake Clarkson and Prof Kevin Glazebrook *(Lancaster University)* and Prof Kyle Lin *(Naval Postgraduate School)*

A hidden object needs to be found in many real-life situations, some of which involve large costs and significant consequences with failure. Therefore, efficient search methods are paramount. Further, there is often a choice regarding speed. Areas can be covered slowly, or quickly, with a faster search using less time but increasing the probability of missing the object. This trade-off is core to this research. We model a search for an object hidden in one of multiple discrete locations according to some known probability distribution. There are two available search modes, fast and slow, with the goal to use these modes to discover the object in minimum expected time by successive searches of individual locations. The same problem with one speed is well studied and a simple, optimal policy assigns each box a (Gittins) index, searching the box with the largest index. In the two-speed problem, each box has two indices, fast and slow, and any policy, as well as which locations to search, needs to determine at which modes to search them. We have two main results, for each location: 1. If the slow index is no smaller than the fast, slow should always be used. 2. If the fast index is sufficiently greater than the slow, with 'sufficient' depending on search parameters of the slow mode, fast should always be used. Outside these results, the optimal mode is complicated, depending on the object's hiding distribution and the search parameters of other locations. By examining the extra information about the object's location that the slow mode provides, we propose a threshold-type heuristic policy that demonstrates near-optimal performance in an extensive numerical study. In the future, we look to study the problem in a game-theoretic setting, where the object is an intelligent hider who wishes to evade detection.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 09:00, Room - LICA A29 Code: OR60A3375

Repeated Allocation of Assets with Short Lifespans

Mr Stephen Ford *(Lancaster University)*

Allocation of assets to tasks is a common real-life problem, and a much-studied one. However, the simple expedient of allowing the assets to fail and require repair renders simple allocation problems difficult, and more complex problems nearly unsolvable. The problem discussed arose from naval search problems, with the 'assets' being drones and the 'tasks' being search areas. Our problem falls within the broad area of routing and scheduling, and as formulated in this talk, is in many ways a prototypical stochastic optimisation problem. We formulate an approximate model for this problem in a restless bandit framework and derive the

corresponding Whittle index policy. Numerical simulations of the original problem indicate that two policies are effective depending on the problem details: said Whittle index policy, and a simple myopic policy. We also briefly look at possible extensions, particularly those with the tasks 'linked' in some way, so that the rewards gained depend on the overall state of the system, not merely on the assets assigned to each task.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 09:30, Room - LICA A29 Code: OR60A3511

New Stochastic Processes for the Failure Process of a Repairable System

Dr Shaomin Wu *(University of Kent)*

Most widely used models for the failure process of a repairable system have include too many unknown parameters and are for a one-component system. Nevertheless, real-world reliability systems are usually composed of multiple components. There may be a small sample of failure data, which makes it difficult to estimate parameters with high efficiency. This requires researchers to develop new models to overcome the drawbacks. This presentation discusses two stochastic processes to model the failure process of a repairable system. The processes model the failure process of a repairable multi-component system and contains a small number of unknown parameters. The probabilistic properties of the model are studied. The performance of the models, in terms of the AIC value, is compared with other models based on real-world datasets.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 10:00, Room - LICA A29 Code: OR60A3553

Effective Heuristic Policies for Time-Critical Intelligence Gathering Operations

Dr Christopher Kirkbride *(Lancaster University)*

We consider a multi-source intelligence-gathering problem where, over a finite horizon, an analyst is required to retain a subset of the sampled intelligence items of highest value (or reward) to allocate (or claim) for further processing. In each period, the analyst decides which one of the available information sources to sample from, guided by the posterior distribution of each source. Given the constraint that a small subset of intelligence items are to be collected, the analyst must further decide whether to claim a sampled reward or pass it over for potentially higher value rewards later in the horizon. Formulating the optimisation problem as a Multi-Armed Bandit Allocation model, the objective is to determine a joint source selection and reward allocation policy to maximise the expected total reward claimed. Classical solution methods are impractical for problems of realistic size, hence, the requirement is to develop effective heuristic polices for the problem. We approach this through the application of a Lagrangian relaxation to the problem, the solution of which allows for the development a class of index heuristics with source specific indices. Index generation itself is a significant challenge and we utilise an approximative method for their creation employing ideas from the Knowledge Gradient approach. The resulting index heuristic, in comparison to other approaches from the literature including Thompson Sampling and KL-UCB, is shown to have consistently strong performance.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 11:00, Room - LICA A29 Code: OR60A3413

KEYNOTE: Stochastic Modelling of Aircraft Queues: A Review

Dr Robert Shone, Prof Kevin Glazebrook and Prof Konstantinos Zografos *(Lancaster University)*

Many of the busiest airports around the world experience very high levels of traffic congestion for lengthy periods of time during their daily operations. This is due to a rapid growth in demand for air transport services, combined with physical and political constraints which usually prevent the expansion of airport infrastructure in the short-term. As airport slot coordinators and traffic controllers strive to improve the efficiency of their operations, there is considerable scope for new and innovative mathematical modelling techniques to offer valuable insight. In this talk we discuss some of the methods used by researchers to model aircraft queues over the last few decades. Aviation in general is currently a very active research area, and our review will touch upon some of the wider topics related to aircraft queue modelling, including demand management strategies and the potential of strategic and tactical interventions to improve the utilisation of scarce resources at airports. A common theme throughout this talk is the need to make decisions under uncertainty, which may be related to weather and wind conditions, variability of flight times, gate delays for departures and many other factors.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 12:00, Room - LICA A29 Code: OR60A3388

Optimizing Proactive Transshipments in Retail Networks

Prof Thomas Archibald *(University of Edinburgh Business School)*

Proactive transshipments aim to redistribute inventory in a retail network in order to better meet anticipated future customer demand. Proactive transshipment is warranted used when, for example, customers require immediate service or combining multiple transshipments in a single delivery has an economic advantage. Planning proactive transshipments involves deciding when to redistribute inventory, which locations to involve in the transshipments and how much inventory to transship between the locations. This research proposes a model that can be used to plan proactive transshipments in a general setting. A heuristic transshipment policy is proposed that is shown to perform well compared to commonly used policies on a wide range of test problems.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 13:30, Room - LICA A29 Code: OR60A3657

A Real Option Approach to Irreversible Investment in Petroleum Refinery under Revenue Uncertainty

Prof Sunday E. Omosigho *(University of Benin)* and Mr Esosa Enoyoze *(Edo University, Iyamho)*

Investment in petroleum refinery is industry specific. The real option approach is applied in the analysis of irreversible investment in the petroleum refinery industry under revenue uncertainty.

The value of the firm and the profit streams are assumed to follow a geometric Brownian motion in the development of a hybrid real option model for irreversible investment in petroleum refinery under uncertainty. Both stochastic volatility and capacity utilization volatility are imbedded in the hybrid model. This is different from the canonical real option model that utilizes only stochastic volatility in its development. Utilization volatility captures the empirical spread of revenue due to suboptimal production process. The spread in revenue when a production process operates at optimal level is measured by stochastic volatility. The hybrid model shows that the investment trigger under low utilization of capacity is greater than the investment trigger under normal conditions. The hybrid model explains why some regions of the world are favoured or preferred by investors for irreversible investment in petroleum refinery. This is illustrated by comparing investment triggers for different regions using standard refinery margins. The paper is a combination of theoretical and practical concepts. The work is motivated by the current drive and imbalance in the demand for petroleum refinery capacity.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 14:00, Room - LICA A29 Code: OR60A3665

Project Scheduling in Dynamic Stochastic Resource Constrained Multi-Project Environments

Mr Ugur Satic, Dr Peter Jacko and Dr Christopher Kirkbride *(Lancaster University)*

Successful Project Management is challenging as it involves high risks and uncertainties. According to a recent Project Management survey, only the 40% of projects are completed on time, and 46% of projects are completed at their predicted budget. When a project is beyond its completion date, specified in the contract, organisations may lose the rewards from project completion as well as their organisational prestige and goodwill. Many uncertain factors may affect projects that lead to delivery overruns such as the arrival of new projects, resource availability, unpredictable task durations, etc. Without considering these uncertainties, project schedules will be inaccurate and the completion of the projects may incur delays. The scheduling problem in this environment is known as the dynamic and stochastic resource-constrained multi-project scheduling problem. The motivation of this study is to create better tools for project planning by modelling these uncertainties together. In this initial study, we consider a system where projects (of multiple types) arrive at random to the resource-constrained environment for which rewards for project delivery are impacted by fees for late project completion. We model this problem as a discrete Markov decision process and use Dynamic Programming to determine a policy that maximises the average profit per unit time net of charges for late project completion. The results of computational tests will be presented and discussed.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 14:30, Room - LICA A29 Code: OR60A3675

Cutting Queues: Customer and System Behaviour in a Repeated Game

Dr Vasco Alves *(Coventry University)*

This paper analyses the individual decisions taken by customers when deciding whether to join an M/M/1 queue where a subset of regular customers who interact repeatedly can both cut the queue and be overtaken once they join, by-passing occasional users. This is shown to be an equilibrium in repeated games with perfect public monitoring for sufficiently patient customers: regular customers allow other regular customers to overtake them as long as the long-term discounted pay-off of doing so exceeds the costs of giving this permission. This equilibrium is shown to exist, and to be possible to describe as regular customers forming a sub-queue under the Last Come First Served discipline, inside the regular FCFS queue. The expected sojourn time for customers under this discipline is obtained, and this is then used to obtain a threshold joining strategy for arrivals.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

Organisers: Frances O'Brien and Robert Dyson

12/09/2018, 12:00, Room – LICA A27 Code: OR60A3308

"Whatever Happened to Rational Government – Issues of Democracy and Reason"

Mr Jeffrey Jones *(formerly Head of Civil Government OR and Director at the NAO)*

Jeff will survey his experiences as a policy analyst, and bring out some common issues concerning failure to adopt the most rational course. Factors identified will include the difficulty of communicating to non-scientists (a growing problem), political change, and counterintuitive behaviour.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

Sustainable Supply Chain

Organisers: Lampros Stergioulas and Masoud Fakhimi

12/09/2018, 09:00, Room - LICA A29 Code: OR60A3418

Understanding the Effects of Lead-Time Disturbances in Supply Chains

Dr Virginia Spiegler *(University of Kent)*, Prof Mohamed Naim and Prof Aris Syntetos *(Cardiff University)* and Dr Li Zhou *(University of Greenwich)*

Changes in the lead-time can lead to supply chain inefficiencies and risks. In this paper, we investigate the effects of lead-time disturbances on the system's output responses of a production and inventory control model. In the adaption process of the control system for lead-time disturbance analysis, the resulting model becomes nonlinear. Hence nonlinear control theory in combination with system dynamics simulation are used to analyse the impact of lead-time changes on the transient and steady state responses of order rate, inventory and work in process. We find that the output responses depend on the input type, amplitude and direction of changes in the lead-time. When lead-time increases, the system has a relatively slow transient response and, as expected, work in process inventory levels increase and order rates are higher. However, step decreases in the lead-time can cause significant underdamped dynamics in the system. This work demonstrates that, although lead-time reduction is associated with service level improvement, cost reductions and improved sustainability, its implementation has to be carefully planned since a quick time compression may lead to undesirable oscillations in the supply chain system, which in turn will negatively impact supply chain resilience and sustainability.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 09:30, Room - LICA A29 Code: OR60A3351

Decision Support Tool for Resource Recovery from Urban Waste Water to Enhance Circular Economy

Dr Seda Sucu and Prof Djamila Ouelhadj *(University of Portsmouth)* and Ms Maria Orhideea van Schaik *(HZ University of Applied Sciences)*

Based on the annual risk report of the World Economic Forum, water crises has been listed as one of the largest global risks in terms of potential impact. As a result of the population growth, the substantial increase in urbanisation, and improved living standards, there is a conspicuous increase in water stress. It is estimated that 45% of the world's population might face water stress by 2025. Accordingly, there is an increasing concern about resource consumption and the loss of nutrients due to linear urban wastewater management practices. This situation provides an explanation for the need for recovery of various resources from urban wastewater,

including energy, organic matter, nutrients and water. Developing suitable technical solutions for urban areas is not yet straightforward and quite complex. Moreover, it plays a crucial role in the concept of circular economy. The quality and the quantity of the resources are temporal and special variables. Therefore, the feasibility of the technical solutions is subject to change in time and space. In order to ensure sustainability, selection of the best technologies for resource recovery, technical environmental, economic and social factors need to be accounted. The aim of our study is developing a decision support tool which assists the decision makers to select the optimum technical solutions for resource recovery for urban wastewater. The evaluation criteria for each factor, the parameters as an input to the tool and the expected outputs from the integrated decision support tool will be presented.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 10:00, Room - LICA A29 Code: OR60A3404

KEYNOTE: Data for the Supply Chains or Supply Chains of Data? A Conceptual Framing

Prof Thanos Papadopoulos *(University of Kent)* and Dr Konstantina Spanaki *(Loughborough University)*

During the last decade, the reviews of the literature in the context of data management within logistics and supply chain have mostly focused on “Supply Chain Analytics (SCA)” as a way to develop supply chain strategies and efficiently managing supply chain operations at tactical and operational levels with the use of data analytics. This literature direction focused on how analytics can be applied to strategic decisions related to Supply Chain Management (SCM), how efficiency and effectiveness of supply chains can be improved through the use of data as well as the data strategies and servitization around supply chains. Acknowledging the role of data within SCM, research should also focus on the supply chains of data, setting data as a raw material/resource triggering a manufacturing process, analogous to the product/service manufacturing processes. This research reviews and discusses these two approaches, namely: a) the use of data for supply chains and b) the use of the supply chains of data while trying to highlight their conceptual differences. The implications and different approaches for these two concepts are analysed and further research directions are proposed.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

Systems Thinking



Organisers: Gerald Midgley, Giles Hindle and Angela Espinosa

11/09/2018, 11:00, Room - Faraday LT Code: OR60A3438

KEYNOTE: Why and How to Classify Systems Methodologies

Prof Mike Jackson *(University of Hull)*

There are many different systems methodologies. It is worth classifying them so that we can understand how they differ, assess their strengths and weaknesses, and make decisions about when to use them either singly or in combination. Three different ways of classifying systems methodologies are considered - drawn from cybernetics (Beer), complexity theory (Snowden), and systems thinking (Jackson and Keys). A revised 'system of systems methodologies' (SOSM) is derived from these sources. The revised SOSM is used to classify some important systems methodologies and the legitimacy, purpose and value of the classification is discussed.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 12:00, Room - Faraday LT Code: OR60A3408

How Should We Present Systems Thinking to People Coming to it for the First Time?

Prof Gerald Midgley *(University of Hull)*

There are now so many different systems paradigms, theories and methodologies that it is very difficult to say what systems thinking is in a two minute conversation with someone who has never heard of it before. Some systems thinking advocates get around this problem by picking their favourite methodology (never more than 5% of the variety of systems ideas out there) and then claim that this is all that systems thinking is. However, reducing the variety in such an arbitrary manner is doing a disservice to the rest of the systems community: it shows a lack of respect for the range of systems approaches that can be used for different purposes. The question is, how can we say what systems thinking is in just two minutes AND respect the rich variety of methodologies that the systems community has to offer? In this presentation, and adapting the work of Derek Cabrera and colleagues in the USA, I argue for a very simple story of what systems thinking is: four systems thinking skills. These skills involve thinking in terms of boundaries, interconnections, perspectives and systems. This is a very simple story, sufficient for an elevator pitch, but if the person wants to know more, we can then show how the systems methodologies all embody and enhance the use of these systems thinking skills in practice. Thus, the simple story provides a window onto the rich variety of methodologies and methods available to us.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 13:30, Room - Cavendish C Code: OR60A3594

Understanding and Addressing the Systemic Nature of Embedded Conflict

Prof John Davies and Prof Victoria Mabin *(Victoria University of Wellington)*

This paper reviews work showing how seemingly unrelated systems methodologies can be applied in complementary mode to a selection of common problematic situations, for example, dilemmas relating to tertiary education funding and the use of antibiotics. It provides an illustration of how the Causal Loop Diagrams(CLDs) of System Dynamics (SD) and the Shifting the Burden (StB) archetype can be employed in harness with the systems representation logic diagrams and tools of the meta-methodology subsumed within the field/domain known as the Theory of Constraints (TOC). The paper suggests novel ways for approaching such dilemmas, in terms of problem structuring, objective setting, action generation and solution implementation processes. The paper reveals methodological insights about the nature of TOC's conflict resolution process that allow it to identify and capture the embeddedness/nestedness of conflict.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 13:30, Room - Frankland C Code: OR60A3387

Mind the Gap! The Missing Body of Knowledge and Methodology for Assessing Practitioners' Systems Thinking Capability

Dr Niki Jobson *(Dstl)* and Ms Lorraine Dodd *(Cranfield University)*

Both the academic and corporate literature recognise the value of systems thinking in helping today's decision makers address the socially complex and dynamic challenges they face. However, as systems thinking is an emerging professional practice the knowledge base on the competencies of a systems thinking practitioner is only partially developed, hindering the ability of organisations and decision makers to develop staff, or access external resources, that have the requisite knowledge and skills. Specifically, the gaps are: 1) a coherent and comprehensive competency framework which defines the body of technical knowledge (concepts, methods tools and techniques), practitioner skills and behaviours 2) an assessment framework that enables competencies to be evaluated, measured and assessed and 3) assessment methodologies. This paper seeks to take the first step in addressing this knowledge gap by proposing an outline practitioner competency framework that describes the cognitive and application skills, behaviours and foundational knowledge of a systems thinker. The latter comprises both the underpinning set of systems concepts and laws that guide practice and core methods and tools. It will also explore some initial thoughts on assessment approaches and open the philosophical debate on the paradox of taking a reductionist approach to describing a systems thinker, using a set of competency statements, and describing them out of context.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Quite a lot
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - Frankland C Code: OR60A3494

A Systems Thinking Approach to Facilitating the Learning of Qualitative Research Approaches By Engineering Management Students

Dr Corrinne Shaw *(University of Cape Town)*

Abstract: In an engineering degree, the capstone project in the final undergraduate year is the first significant independent research project that the student undertakes. For those students who choose to undertake a qualitative or mixed methods research project in engineering management, the learning of research practice involves the navigation of discourse conventions and literacy practices that they may associate with the social sciences rather than engineering. The student as a novice researcher has had little to no opportunity to gain qualitative research experience or to produce written texts appropriate for such research prior to undertaking their capstone project. This paper addresses the question of how to structure learning interventions to accelerate management research practice in undergraduate engineering programs. It does this through an analysis of this problematic issue using critical systems thinking and drawing on the concepts of boundary analysis, identity and power. This analysis informs the conceptual design of a process to facilitate the learning of qualitative research practice by such students. The paper concludes with a narrative description of students' development of appropriate research practice.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 14:00, Room - Cavendish C Code: OR60A3519

Booze in Supermarkets in New Zealand - From Fixes That Fail to More Fundamental Solutions: A Case Analysis

Prof John Davies, Dr Bob Cavana and Prof Victoria Mabin *(Victoria University of Wellington)*

This case was prompted by the NZ Medical Association's reports that alcohol ('booze') is a harmful drug and that sales in the supermarket alongside bread and milk send the wrong signals that alcohol is an everyday item. Following law changes, supermarkets in NZ have been allowed to sell wine since 1989 and beer since 1999. However this has led to the normalisation of alcohol as an ordinary consumable product, rather than as the Medical Association describe it: a psychoactive drug that is a toxic substance to human tissue, including it being a carcinogenic (cancer-causing), as well as an aggressigenic (aggression-inducing) drug as much as methamphetamine is." Also supermarkets have been engaging in heavy discounting of alcoholic products through bulk purchasing. This easy access and cheaper young people to 'pre-load' before going to more expensive bars, night clubs etc. Hence more young people in NZ are getting drunk and engaging in 'binge drinking' activities, with consequential negative medical and social effects. Meanwhile supermarkets have been claiming a reduction in alcohol sold at their sites in recent years and there has been a shift to more purchases of low alcohol beer and wines. However, NZ Statistics figures reveal a sharp increase in purchases of high alcohol beer since 1999. Clearly substantial conflicts exist regarding the sale, purchase and effects of alcohol within NZ society. The analysis presented in this paper uses multiple frameworks including stakeholder maps, causal loop diagramming, Senge's archetypes such as fixes that fail and shifting the burden, and theory of constraints' thinking processes. Various solutions are developed and examined, many of which turn out to be 'fixes that fail'. Longer term solutions are put forward. The value of multi-frame analysis is discussed.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:30, Room - Frankland C Code: OR60A3366

Case Study in Applications of Systems Thinking and Design Methodologies toward Emergent Self-Governance Models

Dr John Pourdehnad *(Thomas Jefferson University)* and Mr Paul Welfer *(University of Pennsylvania)*

The Graduate and Professional Student Assembly (GAPSA) at the University of Pennsylvania anticipated stakeholder engagement constraints on its tenth anniversary of unified student governance. Partnering with the Organizational Dynamics program at the University, GAPSA sponsored a translational consulting work group and parallel systems thinking course, "Applications of Systems Thinking and Design Methodologies: Emergent Governance Models" to assess and anticipate client performance. The project developed consultant facilitators by inviting student leader participation from a cross-section of the multiplicity of PhD and professional disciplines to apply systems thinking approaches. Snowden's Cynefin framework was used for situational awareness of the client problem set. Taking a multimethodology approach, interactive planning was applied as the meta methodology along with an ensemble of systems and design approaches including: creative holism and critical systems practice, soft systems methodology, system dynamics, viable system model, and Porter five forces. Using hassle map, influence diagram, stakeholder engagement, and other systems thinking tools, the challenge was reframed and validated through crowdsourcing to one of relevance to users: the 13,000 diverse graduate student community. The project reformulated vision, mission statement, and value propositions for the organization, focused on stakeholder interrelationships through an integrated approach to sustainable student-centered culture and positive student experience. The resulting path and outcome produced: (1) a mindset shift from predominantly analytic to synthetic-based solutions informed by the complex domain, (2) true action-learning and emergent design by users, (3) renewal resolution integrating double-loop learning and feedback through a permanent sustainability system structure and function, (4) user demand satisfaction and co-creation, and (5) leadership development pathways through the emergent interactive systems thinking and design approach. Embarking on the project changed the system, creating user awareness, enthusiasm, and satisfaction through higher engagement rates. The case study therefore demonstrates a successful integrated system of systems approach.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

11/09/2018, 14:30, Room - Cavendish C Code: OR60A3347

Reconnecting Severed Heads: A Case for Subjective-Empiricism in Systemic Intervention

Ms Louie Gardiner *(University of Hull)*

My PhD research involves contributions at five levels of analysis. I have: Undertaken a substantial systemic action research case study building the capacity for systemic inquiry in two contexts – one involving employees/volunteers in an organisation; the second, with individual practitioners; Developed six new systems frameworks/methods which I have applied in the research; Evaluated these frameworks/methods through participant feedback,

ethnographic data and self-reflection; Experimented with new forms of emergent narrative construction and the use of multiple media in my thesis; Developed a new methodological approach called 'subjective-empiricism' to underpin and justify the above. I give first-person inquiry (critical self-reflection/reflexion) prominence alongside second and third person inquiry, and I express the emotional experience of being in a research process. I thus avoid the 'severed head' syndrome (abstracted rational thinking) advocated in the Academy, which demands the partial or total separation of the Self from the research process, and rational inquiry from the emotions – as if this were even possible. Instead, I take the stance that, without me (the active, reflective-reflexive agent) I could produce no research. Through my approach, I found my way to comprehending what I later discovered von Foerster conveyed through his analogy of the chicken, egg and rooster: when it comes to first, second and third-person inquiry, we need all three. I embody this inclusive stance in my thesis, writing in four voices/dimensions which I call 'state-waves'. These constitute ways of 'being-expressing' self-knowing. Each enriches my emergent narrative and research experience, contributing to my sense-making and a profusion of insights and novel contributions. In my presentation, I shall deploy my state-waves, sharing challenges and outcomes from my subjective-empirical research. I shall demonstrate how subjective empiricism enriches and augments the efficacy and impact of systems thinking and practice.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:00, Room - Faraday LT Code: OR60A3653

A Hard and Soft Systems Approach to the Development of a Business Model for an Integrated, Distributed Energy Facility

Mr Christopher Bouch and Prof Christopher Rogers *(University of Birmingham)*

The UK Government is looking to private investors to fund approximately half of its planned infrastructure pipeline, but existing business models are unfit for purpose and do not give investors the confidence that they will capture their fair share of the value generated. At the same time there is a move in the energy field away from the current paradigm of large-scale, centralised provision, towards a more distributed approach, which may be more complicated and complex: complicated in that a range of new technologies will need to be integrated; and, complex in that a wide range of stakeholders will potentially be involved. Against this background, the iBUILD project has been researching the development of new, alternative business models for infrastructure that capture as a wide a range of value as possible. A combination of systems engineering techniques and soft systems methodology is proposed as a framework within which the new models can be created and a means of identifying potential value-generating opportunities. This is demonstrated using a case study of Tyseley Energy Park, an integrated, distributed energy facility that is emerging near the centre of Birmingham.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 09:00, Room - Cavendish C Code: OR60A3698

Building Upon John Warfield's Vision for Applied Systems Science

Dr Michael Hogan *(NUI, Galway)*

Building upon the work of John Warfield past president of the International Society for Systems Sciences, this paper argues for a new synthesis of political philosophy, education, and technology design that supports the emergence of a higher-order 'wisdom of the crowd', specifically, a form of systems-thinking collective intelligence that is matched to the complexity of the societal problems we face. Warfield's collective intelligence and applied systems design methodology is described along with a number of recent EU project applications. Recent educational innovations are also described, in particular, the functional integration of Warfield's systems thinking tools with Argument Mapping tools as part of classroom education, and the development of a new systems science curriculum focused on the tools, talents, and team dynamics needed to support collective intelligence skill development and applied systems design work. While it is possible to further embed Warfield's methodology within educational and organisational practices, and within the World Wide Web, consistent with Warfield's view it is argued that a new politics of system change is needed that upholds freedom as non-domination as a principle of dialogic engagement in these environments. Furthermore, consistent with the principles and practices of design-based research (DBR), it is recommended that the systems sciences merge with the learning sciences to iteratively design and evaluate infrastructures that support new forms of collective intelligence and applied systems design work.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 09:00, Room - Frankland C Code: OR60A3584

A Comprehensive Worldview Model as a Discovery Framework in Systems Research

Dr David Rousseau and Mrs Julie Billingham *(Centre for Systems Philosophy)*

A worldview is a comprehensive set of interdependent personal beliefs that provide principles for making sense of the world and for guiding the making of judgements and taking actions in all encountered situations. Worldviews have long been recognised as of central significance in the methodologies of systems practice. Systems practice methodologies typically explore the worldviews of stakeholders in order to assess what aspects of the problem to model, what methodologies to use in addressing the problem, what kinds of outcomes might be possible in the context, and what kinds of outcomes the stakeholders would value. However, systems science does not yet include a canonical model of the structure and dynamics of worldviews, and hence does not provide for a consistent way of working with worldviews across systems theories and methodologies. To address these problems this paper proposes a comprehensive worldview model that was synthesised from studies in cultural anthropology, religious studies, philosophy, and theology. The model suggests that a worldview is comprised of six categories of tenets, named as ontology, metaphysics, cosmology, praxeology, axiology and epistemology. These categories of tenets interdepend in a systemic way so that a worldview tends towards forming a coherent whole that represents all the kinds of beliefs the person might need to orient themselves to the world. This model enables researchers to systematically and consistently capture all the relevant aspects of all the stakeholders' worldviews. Moreover, it will be shown that the model can be generalised to provide a model of all the kinds of knowledge one could have about any scenario, and hence the model can guide the framing of

research questions for any kind of systems research project having to deal with uncertainty, ambiguity or risk.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 16:00, Room – Faraday LT Code: OR60A3507

Library Managers' Use of Digital Technologies in Everyday Work Practices: An Application of Human Activity Systems Modelling

Mrs Niki Chatzipanagiotou and Prof Anita Mirijamdotter *(Linnaeus University)*

As has been argued by systems thinking scholars, science and scientific thinking can be seen as socially constructed systems of institutionalized sets of activities through which systems thinking emerged. In this paper, the development of systems approaches is discussed to argue for the research approach adopted. Further, main concepts of systems thinking such as complexity, worldview, and human activity systems are discussed and applied to empirical data on academic library managers' use of digital technologies in their everyday work practices. Recognizing that the use of digital technologies has changed the way we live, work and communicate, we explore in depth library managers' everyday work practices with a focus on the way they use information for managing their organization. Practices refer to what library managers do when they do their job using digital technologies. Their work practices are presented as a complex reality where different managers have different, although interconnected, perspectives and see different priorities. The use of digital technologies is part of library managers' everyday work practices. However not all managers have the same perspectives on the use of digital technologies. The various interacting perceptions of reality can be explored as different managers have different worldviews that affect their respective approach of managing and of using the technology for that purpose. The Library organization is conceptualized as an information-intensive ecosystem consisting of complex interplays among academic library managers, everyday work practices, digital technologies and content. Within the library system, several human activity systems constructed by managers exist. By the use of Soft Systems Methodology modelling we illustrate some of these existing human activity systems and relate these to purpose and function within the overall organization. Our focus is on information created and mediated within these human activity systems and discuss the means of technology to facilitate managers' everyday work practices.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 09:30, Room - Frankland C Code: OR60A3578

A New Approach to Designing Operational Teams in Evolving Contexts

Mrs Julie Billingham and Dr David Rousseau *(Centre for Systems Philosophy)*

This paper demonstrates a practical application of the comprehensive worldview model presented in [OR60A3584]. This prior paper argued that the worldview model can be generalized to provide a model of the kinds of knowledge one could have about any scenario, and can therefore guide the framing of research questions for any kind of systems research project dealing with uncertainty, ambiguity or risk. In the current paper, we show how this

model can be used in the specialized context of project conceptualization. We will then show an example of its use for a project aiming to evolve new methods for designing ecommerce operational teams. Digital commerce exists in a rapidly changing industry context where there are limited organizational precedents and traditional workforce models or 'best practice' organization designs are no longer applicable. In this presentation, we will discuss the research questions the worldview model prompted, and how answering those questions using Operational Research and Systems Thinking supported the development of a comprehensive methodology for operational team design in this novel context.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 09:30, Room - Cavendish C Code: OR60A3539

Adaptive vs Technical Approaches to Building Evidence for Public Health Leadership of Systemic Change: The Experience of a US Practice Based Doctoral Program

Dr Eve Pinsker *(School of Public Health, University of Illinois at Chicago)*

In the U.S., governmental public health agencies are only part of the picture of assuring public health, as recognized in the 1988 Institute of Medicine Future of Public Health report, which portrayed a networked view of the delivery of public health services as including not just governmental public health agencies, but other agencies, private health care providers, community-based organizations, schools, faith communities, etc. So the idea of the public health "system" as being more than organizations whose core mission is explicitly public health is now well recognized, as is the discussion of health care delivery systems that extend beyond the boundaries of any one organization. But organizational and cross-organizational service delivery systems, amenable to improvement via an engineering based OR "hard systems" perspective, represent only a narrow view of a "systemic" perspective on public health. A more ambitious agenda for bringing "systems thinking" to public health includes discussion beyond health care delivery, or even the establishment and implementation of occupational or environmental health policies, to the social and economic determinants of public health and the effect of structural inequities. Countering such inequity, however, requires adaptive rather than technical epidemiological approaches for building evidence about what is actually effective in practice, in community context, not controlled conditions. In the University of Illinois at Chicago's doctoral program for public health professionals, we have introduced "soft systems" tools addressing wicked problems, including analysis of multiple stakeholders' perspectives, expanding exploration and systematic reflection on problem definition, and utilizing qualitative as well as qualitative modes of data collection and analysis in applied research projects designed to expand the evidence base for effective public health leadership as well as to address immediate challenges.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 10:00, Room - Faraday LT Code: OR60A3302

Patterns of Strategy - A Systemic Approach to Understanding and Using Emergent Strategy

Mr Patrick Hoverstadt and Ms Lucy Loh *(Fractal)*

This paper is about Patterns of Strategy (PoS), the first systemic approach developed specifically to address the issue of organisational strategy. PoS draws on Beer's Viable System Model, Maturana's structural coupling, and Howard's game theoretic confrontation analysis. Formulating and executing strategy is an exercise in decision making to manage uncertainty, opportunity and risk. There is strong evidence that conventional approaches consistently fail with many authors citing a failure rate between 70% and 90%. Conventional strategy approaches are mostly rooted in understanding either the strategic environment, or the capabilities of the organisation. Instead, PoS focuses on the dynamics of the relationship itself – on the strategic fit between the two. We model strategic fit as a set of structural couplings where the organisation changes the environment structurally and the environment changes organisations structurally. We model the dynamics of shifts in strategic fit using 6 elements. Differentials in these 6 elements between the organisation and other actors drive shifts in the nature and trajectory of the strategic fit. By modelling: elements, differentials, and from those, the dynamics and trajectory, we can forecast the probable strategic direction of the organisation – its default emergent strategy; and also model and plan manoeuvres to shift this default direction to the organisation's advantage. In addressing strategic risk and uncertainty through strategy, we argue that PoS provides two critical advantages. First it explains the structural dynamics driving strategic direction (irrespective of formal strategic plans). Secondly, the PoS process is much faster than conventional strategy approaches, and this reduction in the decision-action cycle time can provide a critical advantage – a standard systemic precept is that faced with uncertainty, shortening feedback loops that allow you to learn is key to reducing uncertainty and risk.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 10:00, Room - Frankland C Code: OR60A3331

SASSY Architecture - Combining Two Logics for Understanding and Supporting Decision-Making

Dr Ivo Velitchkov

How we diagnose a society or an organisation depends on how we describe them. Descriptions are useful when coherent and coherence is assured by logic. A driving force in the Western world are the distinction between true and false, and between subject and object. They framed the laws of logic which are the basis of our science and technology today. Yet they are limiting when trying to understand social systems as those maintain their identity by self-reference. The logic of non-contradiction and the logic of self-reference fuel different worldviews. Combining them can be fruitful for both theory and practice. In the organisational domain, the first worldview is useful to identify and describe resources and their relations. The second is needed to understand how organisations maintain their identity by distinguishing themselves from the environment. Within the SASSY (Semantic Architecture for Social Systems) framework, the first kind of logic is applied through semantic technologies for information management which ultimately supports decision-making. The second uses social systems lens for understanding how decisions come about and to reveal their hidden dependencies. While the SASSY framework focuses on organisations, similar approaches are already advancing in other domains. For example, a combination of first and third person perspective is used in enactive cognitive science for studying conscience, sense-making, habits, and emotions. The objective if this talk is to show the benefits of combining two almost

incompatible paradigms when working with organisations. In the context of this conference, it might also provoke ideas for the collaboration between OR and systems practices.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:00, Room - Frankland C Code: OR60A3671

Using Organisational Health Assessments as Epistemological Devices for Anticipatory Intervention

Mr David Lowe and Dr Karen Clark *(Dstl)*, Prof Gerald Midgley *(University of Hull)* and Prof Mike Yearworth *(University of Exeter)*

The vast majority of organisational change is triggered in reaction to performance issues that threaten the viability of the organisation. The use of organisational health assessments has been proposed as a means to understand systemic issues underlying an organisation's performance and so target interventions in anticipation of performance issues. This presentation reflects upon the use of organisational health assessments as epistemological devices for guiding anticipatory interventions in the United Kingdom Ministry of Defence. In particular it evaluates how the routine internal use of organisational health assessments can bring enhanced levels of 'mindful organising' through integration within routine business processes.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 12:00, Room - Faraday LT Code: OR60A3658

A Methodological Proposal for Systemic Reflection about the Promotion of a Peace Culture in Bogota, Colombia

Mr Ricardo Abad Barros-Castro, Mrs Tatiana Cuéllar, Mrs Giovanna Fiorillo, Mrs Luisa García and Mrs Blanca Oviedo *(Pontificia Universidad Javeriana)*

The purpose of this paper is to propose a conceptual and methodological framework about peace building process in young people and, consequently, to reflect on the challenges associated with the facilitation of peace and reconciliation processes. The methodology that was designed to reach this purpose is based on systems thinking (appreciative systems theory and soft systems methodology) that proposes that, based on participatory action research, the improvement of problematic community situations can be promoted through dialogue between different actors, learning their different perceptions about the situation to be intervened. Hence, professionals from social, humanities, and engineering disciplines participated in reflections about the problematic situation, also supported by the theory of boundary critique, questioning about the purpose of a project seeking the promotion of peace, its beneficiaries, and the knowledge considered relevant. Consequently, there are propositions from each discipline that foster reflection on relevant and meaningful activities related to the promotion of peace. As a result, we have reached some agreements regarding central themes such as the notion of community, conflict, culture of peace, and leadership, that serve as conceptual and methodological guide for the implementation of projects related to peacebuilding. Another result has been the design of a project that seeks to promote a culture of peace among young people in a zone of Bogota named Usme, a place where there are people

in conditions of social and economic vulnerability. This project has been planned as a learning process where the direct experience of students, volunteers, and community members have the same value as the experience of researchers, who facilitate the process. Finally, we present reflections on the scope of academic work, actors' roles and capacities, and the use of systems methodologies in community projects.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 12:00, Room - Cavendish C Code: OR60A3318

Systemic Approaches to Action for Education Equity

Prof Kirsten Kainz *(University of North Carolina at Chapel Hill)*

Kirsten Kainz, PhD April 16, 2018 University of North Carolina at Chapel Hill Persistent education inequality is a complex problem in the United States, shaped by economic, residential, social, and individual forces. Characteristics of families, neighborhoods, and schools are highly related to student academic performance and subsequent education attainment, and the causal relations among these factors are not easily identified or agreed upon. Consequently, there are no silver bullets ready to remedy the situation. The purpose of this paper is to explore novel methods for disrupting patterns of education inequality. A general case will be scrutinized through a lens that incorporates aspects of Soft Systems Methodology (SSM: Checkland), Systemic Intervention (SI: Midgley), and related methods for structuring and analyzing problems from multiple perspectives. The case is a potent location for the emergence of education inequality starting in early childhood – early reading development – and research has demonstrated persistent gaps in both reading performance by student race and economic status. Further, the case reflects education processes that receive significant attention from researchers without achieving policy consensus or social remedy. Consequently, the application of SSM and SI represent novel attempts to shift focus and redistribute power for action in an attempt to support local approaches to foster education equity for young children.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 12:30, Room - Cavendish C Code: OR60A3364

Balancing Activity Drivers and Daily Cadence in Human Activity Systems

Dr Javier Calvo *(Oregon State University)*

Human activity systems are designed to fulfil a purpose -or set of purposes - within a given context, limited by a set of boundaries - spatial, temporal, etc. Therefore, human activity systems should emerge from the interaction of carefully crafted activity drivers that are aligned with the purpose(s), take into account the context, and respect the boundaries in which it should operate. However, in practice, human activity systems do not always emerge as designed mainly due to either absence or poor conception of activity drivers or misalignment between activity drivers and the daily cadence of the human activity system. In this research, activity drivers are defined as organizational thinking and the daily cadence of the human activity system is defined as organizational doing. Minimizing the gap between organizational

thinking and organizational doing is of paramount importance. In this presentation, a model for controlling the balance between the design and daily cadence of HAS requires developing communication and team maturity systems will be presented. The model is based on work being performed by the author with a large American aerospace manufacturer.
What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:30, Room - Frankland C Code: OR60A3427

Using Systems Thinking to Challenge Orthodoxy in Military Command & Control

Dr Gordon Niven and Lt. Gen. Sir David Capewell *(Dstl)*

It is recognised widely in Western military circles that the current approach to the management and regulation of operations has to change to make it fit for the challenging circumstances of the 21st Century. The current paradigm originates from the Napoleonic era, and has evolved gradually in response to the many societal, technological and military changes that have occurred since that time. The result is a complex system with a tendency to grow in size and become more difficult to understand and manage. Continued ad hoc modification is likely to exacerbate this situation and bring increased vulnerability and risk. The work described set out to reimagine Command & Control in a way that could meet the aspirations of the UK military for agility, holistic approaches to influence, information superiority, and suitability for both peer and asymmetric conflict. The approach was initially dialogic – a series of conversations between the authors that brought together systems concepts with a lifetime military experience and expertise, and sought innovation through two contrasting worldviews. The evolving ideas were tested through Soft Systems Modelling and observation of military exercises in an on-going iterative process. The result, which is still at the early stages of development, had at its heart the concept of Requisite Variety. It describes how a variety calculus could be used to configure a Command & Control system to the complexity of the operating environment and to inform the relationships between system components. It was found that this had potential implications across the military enterprise that challenge the orthodoxy of relatively fixed and homogeneous structures and command hierarchies. It introduces a new way of thinking about Command & Control that could see variety dominance added to the classic competition in firepower, protection, manoeuvre and tempo.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

12/09/2018, 12:30, Room - Faraday LT Code: OR60A3585

Governance of "Unsolvable" Conflict Situations as a New Challenge for OR: Principles of Systems Thinking and Systems Organization

Dr Viacheslav Maracha *(The Russian Presidential Academy of National Economy and Public Administration)*

The work deals with the problem of governance of “unsolvable” conflict situations as a new challenge for OR. “Unsolvability” in this case is connected with the fact that the conflict parties base their interests and actions on different worldviews. Their incompatibility often leads to various visions even of the concrete facts, generating phenomena of information wars and “post-truth”. Such conflicts are typical for contemporary international relations, which are the interaction of many formally equal subjects. These subjects are sovereign states, international organizations etc. which come to a compliance or a compromise usually after a long political

and diplomatic struggle (and sometimes an armed clash) when everyone strives to promote his vision of the future world order. And throughout this period (often “historically long” as the Arab-Israeli conflict) the situation remains controversial. Therefore, concerning “unsolvable” conflict situations we should set not the problem of resolving them, but the problem of governance that allows us to hold the conflict within acceptable limits. The parties are not obliged to share customs, values and worldviews of each other, but they must understand legal, value and ideological bases of the opponent's actions and how these grounds can be affected by their own actions. According to John Rawls, this “reflexive equilibrium” is a condition for the formation of an “overlapping consensus”, focused not on disagreements, but on general points in positions of the parties. The principles of systems organization for governance of similar situations based on the stabilizing role of institutions and Thinking-Activity scheme are offered. This scheme integrating the key components of the conflict situation is based on “recognition of Another” principle. It gives to the conflict parties a chance to build the inclusive communication surrounded with the reflexive space which allows identifying and then overcoming situations of mutual misunderstanding.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:00, Room - Faraday LT Code: OR60A3693

Strengthening Health Systems: A Salutogenic Community Operational Research Perspective

Dr Mike Walsh *(University of Stirling)*, Dr Markus Kittler *(MCI Management Centre Innsbruck)*, Dr James Antwi and Dr Khosi Mthethwa *(Ministry of Health, ESwati)* and Mr Mike Robbins *(University of Stirling)*

This paper presents the range of problems facing Eswatini from a Ministry of Health perspective and sets out the aims and methods of proposed salutogenic Community Operational Research (COR) projects aimed at improving sustainability and resilience in healthcare in a variety of Eswatini (formerly Swaziland, Africa) communities facing a range of challenges. Although the United Nations prioritised sustainability in their “Development Goals” in 2016 the lack of sustainability in health related aid projects in poorer countries undermines their vital work. For instance in Eswatini many aid projects have produced substantial healthcare improvements e.g. the HIV incidence among adults and children per 1,000 uninfected population was 2.2 in 2014 but is now 1.85. But often the end of an aid project leads to the dilemma facing Governments and communities that sustaining an improvement means sacrificing improvement elsewhere. It has been assumed by WHO that this is caused by maldistribution of resources which can be addressed by health systems strengthening but outcomes of this vary between countries. However over the last thirty years there has been increasing focus on understanding healthcare as a salutogenic, co-produced, community owned and community led process. This is exemplified by the Alaskan NUKA health system which is credited with turning around the quality of healthcare for Inuit people over thirty years from amongst the worst to amongst the best in the world. A salutogenic Community OR approach piloted by the authors in Scotland and published in 2018 in the European Journal of Operational Research showed that communities often have underutilised health assets that can be mobilised by working with the people of those communities to support sustainable improvement. It is proposed to apply a salutogenic COR approach in several linked projects in Eswatini with implementation from around January 2019.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 16:00, Room - Frankland C Code: OR60A3384

Enhancing Leader-Member Exchange Theory with Boundary Critique: Implications for Intervention to Improve Working Relationships in Organizations

Mrs Oralia de la Pena de Torres *(University of Hull)*

Leader-Member Exchange (LMX) is a leadership theory centered on the interactions between a leader and a group of followers. It asserts that leaders form unique exchange relationships of different quality (high/low) with each of these followers depending on the result of role expectations and evaluations of whether these expectations have been fulfilled and informally negotiated over time. Depending on the relationship's quality, followers can be categorize into an in-group (high quality) or out-group (low quality). Employees recognize differentiation and have a fairly good sense of who is 'in' and who is 'out' with their supervisors because leaders can have both types of exchanges within the same work group. Thus, followers can compare how different people are treated by the leader. While LMX theory has been published in the management literature on leadership, a complementary theory called 'boundary critique' has been proposed in the systems/OR literature. Boundary Critique is a theory and set of methodological ideas for exploring the inclusion, exclusion and marginalization of both people and issues in an analysis or intervention. One aspect of boundary critique is the theory of marginalization processes in social situations, and this would appear to map onto LMX in the sense that the latter theory also claims that there are some participants who are relatively privileged and others who are treated less well. However, there is more to the theory of boundary critique, because it suggests that there are issues of value judgment, framing, ritual and wider social discourse involved in determining in-group and out-group status. These things have either not been considered, or have only been considered in a relatively superficial manner, by LMX writers. This suggests the possibility that the theory of boundary critique could be used to further develop LMX.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:30, Room - Faraday LT Code: OR60A3595

Semiotics Machine Named "Kaleidoscopical Configurator": A Model of Digital Economy Existence Mode and an Instrument of Digital Economy Improvement

Prof Dmitry Reut

A semiotics machine is an instrument of system thinking. It is more or less steady organization of functional places in the space of discourse. Their inhabitants interact definitely. The mentioned organization allows to create heterogeneous representation of a possible static or dynamic object. The iterative interaction of inhabitants allows to provide the property of integrity for the representation – to create a mental construct of the system. Systematization of semiotics machines appertain to OR nomothetic aspect. A configurator is a system of several different descriptions of an object. Integrative knowledge has to be reconstructed according to the structure of an estimated object. A kaleidoscope contains two (parallel) or more mirrors (making an equilateral polygon), and a handful of colored splinters. The mirrors

create repeated reflections, forming an ornament. We suggest to allocate one more semiotics machine in human practice – "a kaleidoscopical configurator", spontaneously arisen, but suitable for rational use. Perceptual-virtual space. We conditionally divide the reality surrounding us on perceptual and virtual parts. The perceptual reality is perceived by our sense organs without means of channels of mass information and communication at present moment. The virtual reality is perceived by our sense organs by means of the specified channels. We approximate each part by the respective area. The entities of these worlds are references at each other, but not exact reflections. They interact iteratively. The system is non-stationary. One of the entities of perceptual world is real economy. It is complemented by virtual economy. They create each other simultaneously. Sometimes specialized areas arise in space of virtual economy, impact-investing for example. Real economy, virtual economy and impact-investing can be assimilated to three mirrors of a kaleidoscope. Together they form the configurator of modern digital economy that reflects the space of its development. Digital economy represents the real economy complemented by virtual components.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 16:30, Room - Frankland C Code: OR60A3557

Systemic Design of Online Learning Tools to Support a Radical Transformation in a Primary School

Dr Angela Espinosa *(University of Hull)* and Mrs Gabriela Ramirez

Nowadays, many academic and commercial projects aim to offer tools for supporting students and teachers in learning by doing projects (PBL), as their main learning strategy. Even if the idea of PBL offers an example of what most systemic approaches to education aims to achieve and a few international PBL service providers have even progressed their classroom e-support into offering school radical transformations, the way they suggest to develop new (systemic) schools, is still not widely diffused. Not surprisingly, the proportion of schools around the world transforming themselves radically into 'new (systemic) schools' is minimal; and so it is the number of reported cases of a full systemic transformation in primary schools in the educational research /systemic literature. In this paper, we reflect on the learning from a previous experience re-thinking the Colombian School system, which included prototyping a fully transformative approach in rural primary schools; and in a more recent experience testing a prototype systemic design of an online platform for supporting primary education in a Colombian primary school. Based on these experiences, we reflect here on how this can inspire the design of a comprehensive and fully systemic approach to support primary schools transformation towards PBL and a fully systemic learning structure.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 16:30, Room - Cavendish C Code: OR60A3464

Digital Transformation in Public Agencies - Oh Roadmap, Where Art Thou?

Prof Anita Mirijamdotter *(Linnaeus University)*, Dr Mari Runardotter, Dr Diana Chroneer and Prof Anna Stahlbrost *(Luleå University of Technology)*

Swedish public agencies are struggling with how to accomplish digital transformation throughout their organisations. The reason for their efforts rests with the highly set IT-goal; Sweden should be superior in seizing the opportunities that digitalization brings along. Our research shows that public agencies are clear over what is expected, but for most of them, it is not obvious how to tackle this challenge. Digital transformation aims at changing the way of working, roles, and business offerings enabled by adoption of digital technologies in an organization. As such, it requires changes at various levels from operational, via organizational and managerial to societal levels. We reason that public agencies are in need of systems thinking – when the challenges around developing organizational preconditions and processes for digital transformation are as diverse as, e.g. digital capability, innovative capability, create open engagement between stakeholders (external and internal), and new ways to manage it all; a change of mindset is required. Only with new ways of looking at and doing things, public agencies will reach the policies on openness, transparency and collaboration, which are expected outcomes of digital transformation. We aim to explore what strategies, plans and activities are needed, in order to ensure that digital transformation actually happens in public agencies. In addition, we argue that approaches and methods for user involvement must be applied among various involved stakeholders – we focus especially on issues of participation and user involvement. Thus, our intention is to explore using Soft Systems Methodology for guiding two involved public agencies in this project, in search for a, so called, digital transformation roadmap. Moreover, we also aim to include the Viable System Model to guide accurate diagnoses of the systems, thereby being capable of suggesting viable ways forward.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:00, Room - Frankland C Code: OR60A3446

The Development of a Framework for Improvement of Intensive Care Delivery in South Africa: a Systemic Intervention

Prof Juan Scribante *(University of the Witwatersrand)* and Prof Theo Andrew *(Durban University of Technology)*

Intensive care is a small but complex system; context-specific and continually confronted by dynamic changes and challenges in the environment. The aim of this research was to develop a systemic framework for the improvement of intensive care delivery. The factors affecting the delivery of intensive care was elucidated by a comprehensive review of the intensive care literature. A further understanding of intensive care delivery in South Africa was obtained by "making sense of the mess" using a systems approach. Systemic intervention served as the meta-methodology and methods and techniques from interactive planning, critical systems heuristics, soft systems methodology and the viable system model were employed. Making sense of the mess emphasised the complexity of intensive care delivery, on both a situational and a cognitive level. It became clear that a single methodology would not suffice, but that a pluralist methodology was required to guide improvement in intensive care delivery. Based on this understanding, nine principles were formulated to guide the development of a framework. Systemic intervention was again used as the meta-methodology. Interactive planning was identified as the key methodology, incorporating methods and techniques used in the making sense of the mess phase to build a systemic framework for the improvement of intensive care delivery. Embedded in the proposed framework are matters relating to systemicity, complexity, flexibility, empowerment, and transformation of intensive care delivery. The proposed

framework allows for multiple-perspectives, including that of marginalised stakeholders, the mitigation of multi-vested interests and power relationships. It is both flexible and adaptable to promote learning about the complex problems of intensive care delivery and it accommodates the strengths of various relevant approaches to complex problem solving. The proposed framework aims to facilitate sustainable improvement of intensive care delivery and to ensure the "just-use" of resources to foster distributive justice.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:00, Room - Cavendish C Code: OR60A3581

Exploring Threshold Concepts When Teaching Systems Thinking and Soft Systems Methodology

Dr Patrik Elm, Dr Sarfraz Iqbal and Prof Anita Mirijamdotter *(Linnaeus University)*

It has been argued that the threshold concepts of a discipline are the gateways to a deeper understanding of disciplinary knowledge. These are also keys to improving student learning outcomes and progressive learning. Research has been done on systems as a threshold concept for understanding other disciplinary issues, like sustainability. However, we explore the threshold concepts of understanding systems itself, that is, in this case, the disciplinary framework of systems thinking and Soft Systems Methodology. The term threshold concept is stated as having emerged from the UK project Enhancing Teaching and Learning Environments in Undergraduate Courses. It is argued to be a means leading to a transformed way of understanding or learning. Five key characteristics of threshold concepts have been identified in previous research. These are troublesome knowledge, transformation, irreversibility, integration, and boundedness. Later on, reconstitution, discourse, and liminality were added. We have explored threshold concepts for teaching systems thinking and Soft Systems Methodology in a mixed knowledge environment, including students from different disciplines, in a developing country. The students were presented with an issue related to their everyday life as university students and with the aim of applying systems thinking ideas and techniques for the betterment of their university and, in the long run, their society. They were also asked to write a reflection paper related to the learning objectives of the course and on what they have learned about Soft Systems Methodology (theory) and when applied to the specific case. We report on which pertinent threshold concepts we have identified, both of our own experience as teachers and of the students' reflection papers.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

12/09/2018, 17:00, Room - Faraday LT Code: OR60A3340

A Paradigmatic Systems Approach to Leadership of the Church in Germany

Dr Gottfried Claussen *(SHB)*

The evolutionary deterioration of the leadership dynamic is all too evident in German churches. The absence of a structured model to aid the leadership process, invariably culminates in the neutralisation of effective church leadership dynamics, and triangulation setting in, adding to the complexity and associated complex phenomena relating to leadership in the church in Germany. Furthermore, the fear to change church leadership dynamics, result in not only the

disillusionment of prevailing leadership, but also in poorly self-differentiated leaders; and also, a degradation of overall orderly administrative leadership resulting in anarchy and disorder. In mitigation of the above adverse dispensation, two hypotheses served as the basis of research that was conducted, which reads: "A paradigmatic systems approach to leadership model has the potential to revolutionise leadership in German churches culminating in a measurable leadership dynamic"; and "Leadership issues can be successfully mitigated in German churches by dynamically applying a systemic, systems thinking approach". Applied research served as research type, so designed as to apply its findings to solving a specific, existing problem, within the research environment. The research furthermore took place in the social world, as the research involved the systems in which people operate, implying that an interpretive paradigm applied. Scientific research served as a research method juxtaposed with an application of the formulated model within a live pilot environment to test the dynamics thereof underpinned by epistemological research assumptions. The research culminated in a paradigmatic systems approach to leadership being formulated for application within German churches aimed to improve the current ineffective leadership dynamic in German churches; provide a measurable mechanism to measure leadership success in German churches; contribute to the limited scientific body of knowledge relating to leadership in German churches; and to facilitate new areas of research within the context of leadership based on the systems approach.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 17:30, Room - Faraday LT Code: OR60A3527

The Significant Loose Ends of Systemic Leadership? A Personal Story of Complexity, Systems Thinking, OR, Innovation and the Scope for Public Policy Learning

Dr Catherine Hobbs

Following three decades of working in local government, I recently completed a Systems Science PhD at the University of Hull that explored the subject of leadership to address complexity in local governance networks. This presentation is not about my doctoral research, although I'm pleased to have separate conversations about that. As my research encompassed a variety of approaches drawn from complexity, systems thinking and OR my presentation is just about some loose ends I've picked up along the way. They are tacit, nuanced, always tantalising and could amount to something if forces were galvanised. So for today, I've identified seven loose ends which could signify an opportunity to help build capacity to lead networks of people to learn together systemically in pursuit of an aim of designing 'services to the public' collaboratively and tailored to the locality, rather than the design of silo-based public services – a crucial distinction. This fundamental transition needs to be managed. In no particular order, these loose ends include: - research hats, are they different? - systems thinking: an empty phrase - supply/demand dysfunction: a continuing frustration - the making of the 21st Century public servant - rooting innovation - an OECD viewpoint and - the contemporary value of soft science. Could this be a timely opportunity to help foster a sophisticated form of adaptive, learning leadership in local governance? Research which fosters reticulist skills would let a good way develop and evolve between academia and practice, for those who are willing. Despite essential differences between specialisms, it's sensible also to identify commonalities and agree what should be paid attention to. What matters? Building human capacity to develop a working practice of systemic leadership demands that facilitative complexity, systems

thinking and operational research approaches could be joining forces to address this crucial arena of public policy.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:30, Room - Frankland C Code: OR60A3316

Exploring a Synergistic Relationship between Operational Research and Systems Thinking

Dr Luis Arturo Pinzon-Salcedo and Mrs Maria Alejandra Torres-Cuello *(Universidad de los Andes)*

In this paper we explore ways to establish systemic approaches to problem structuring and stakeholder engagement as main elements of operational research practice. Although the relationship between the traditions of operational research and systems thinking has sometimes been perceived as problematic, we will illustrate how this relationship can be understood as a synergistic relationship by exploring the assumptions of both traditions and illustrating its symbiotic potential in a real situation. In particular we show how during a systemic intervention methods from the qualitative and the quantitative traditions were mixed to improve a complex problematic situation. We illustrate new ways of developing multimethodologies useful for operational research practice by means of mixing methods based on learning about what constitutes effective practice in the 'meaningful engagement' of stakeholders and communities. Our paper reveals a vision of what has been called 'enhanced operational research', because it illustrates the joint use of operational research and systems methodologies for guiding research practice. In this way the paper offers the reader an opportunity for learning across research community boundaries. In the practical research inquiry that we discuss we mixed diverse problem structuring methods (methods that have been highlighted by community operational research practitioners), systems thinking methods, conflict resolution methods, and analytical methods. The creative design of methods guided the research and contributed to develop an evolving and participative multimethodology that manages to mix methods from the qualitative/quantitative spectrum in an effective way. We take advantage of this research to discuss some of the advantages but also the challenges of participatory processes. Finally, we discuss alternatives for enriching the operational research practice by using systems thinking.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:00, Room - Frankland C Code: OR60A3514

Towards Engaged Scientific Communities. Application of Community OR to Research Routines and its Potential in Stimulating Transformational Research

Prof Pawel Kawalec *(John Paul II Catholic University of Lublin)*

I apply the concept of engagement presented recently in (Midgley et al. 2018) to further elaborate my evolutionary model of science dynamics. My detailed case studies (forthcoming monograph, 2018) in life sciences (epidemiology, molecular biology) identify "research routines" (social practices sustaining a shared symbolic representation within the invisible college) as the unit of the twofold dynamics: cognitive and institutional. While the routines evolve by empirically grounding the symbolic representation, it is, I argue, the institutional setup

which frames the process by stimulating the choice of a research strategy (breakthrough vs novel) and the use of evidence (integral vs partial). The cognitive engagement is elaborated in my presentation in terms of "situated evidence", namely the integral use of the available evidence by the research community enacting a particular routine. On this account, the cognitive engagement constitutes a precondition of the breakthrough research strategy. In contrast to 'market fundamentalism' on the one hand and the principal-agent theory on the other, I argue that the institutional engagement is enhanced by adoption of pluralistic public policies including the embedded network governance of research communities. Both kinds of engagement are critical to increase the potential to advance transformative research in science which is a prerequisite to addressing the grand challenges of humanity and designing new trajectories of socio-technical systems (see e.g. the EC report: Perez, Kawalec et al. 2016).

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 09:00, Room - Cavendish C Code: OR60A3433

2 Feedback Loop Axiom and Implications for OR, Systems Thinking and Wicked Problems in Planning and Crime Prevention

Dr Terence Love *(Design Out Crime and CPTED Centre)*

The paper identifies 3 ways that the 2 Feedback Loop Axiom identified by the author impacts on the practical and analytical foundations of OR and Systems theories. In particular, it identifies limitations on the validity of data collection and theorization. The paper concludes by describing a modelling and theory-making approach for use in OR and Systems Thinking that uses the 2 Feedback Loop Axiom limitations as the basis for addressing wicked problems in Planning and Crime Prevention.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:00, Room – Faraday LT Code: OR60A3482

Digital Capability for Practice: Implications of Appreciative Systems Model on Analysing Organisational Strategies

Mr Behrooz Golshan, Prof Anita Mirijamdotter and Dr Patrik Elm *(Linnaeus University)*

IT-enabled innovations continually disrupt logics of value, competition and organisation in a growing number of industries. Increasingly, value is created, delivered and captured in complex cross-industry value networks through which external resources and capabilities are accessed. Accordingly, strategic intentions for interorganisational collaborations have become an integral part of the overall strategic framework for firms operating in such environments. Driving from the Appreciative Systems Model, Digital capability and Strategy as Practice perspectives, the proposed model illustrates how and why strategic decisions are made and sustained in complex digitalised environments. That is, events and ideas such as technological change, competition, business trends or internal shortcomings leads to formulation of strategic intentions that are validated by the organisational digital capability. The action phase that follows might involve business model reconfiguration and investments in new IS competencies. Lessons learnt during such cycle adding to the newly acquired IS competencies reinforces the organisational digital capability, which elevates the standards used for

formulating future appreciations. In line with the emerging literature on the concept of digital capability, the proposed framework accounts for the two-way relationship between IS/IT and organisational strategies. That is, previous investments in IS/IT functions affect standards and perceptions of events and ideas, which lead to changed appreciations. The action phase that follows might include investments in new IS/IT functions which in turn affect the future cycles. The concepts of appreciation and action also comply with the notions of strategy as intended (appreciation) verses strategy as executed (action), and how both of them affect future cycles.
What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:30, Room - Cavendish C Code: OR60A3509

Epistemological Considerations of Modellers as Active Participants in Stakeholder Engagement - Examples from a Drunk Driving Prevention Project and an Antimicrobial Resistance Project

Dr Amber Elkins, Prof H. Morgan Scott, Prof Dennis Gorman and Prof Mark Lawley *(Texas A&M University)*, Prof Gerald Midgley *(University of Hull)*, Prof Nathaniel Osgood and Mr Wade McDonald *(University of Saskatchewan)*

Governments are increasingly using systems models in decision-making processes and in implementing a variety of policies, including social, environmental, cultural, and even international policies that can fundamentally transform the lives of the citizens they affect. When social systems are complex, every modeller, every citizen within a community, every government worker, and every other stakeholder is likely to hold different perspectives on how that system is shaped, what its purpose is, and what forces within it are most important for implementing change when an agreed upon goal is set. Operational researchers often account for differences between stakeholder perspectives in data collection and analysis to achieve a quantitative representation in their models. However, the modeller's own perspective is rarely accounted for in how it might influence each stage of the research process, such as in framing the research focus, in bounding the analysis, and in creating visual and/or statistical representations of the system-of-interest. A modeller is a stakeholder because they can, and most likely will, make relatively simple inputs that may seem unimportant for a team to agree upon, but these inputs could radically transform what we come to know or learn from a model. Seemingly innocuous assumptions made by a modeller can fundamentally shape how others understand a model or process, the significance of results, and, ultimately, policy-making. For some issues, lives may depend on the modelling. A few practical examples from government-funded projects in the United States affecting health policy decisions will demonstrate how treating the modeller as one amongst a number of stakeholders with influential perspectives makes a significant difference to the outputs of modelling activity. Communication between modellers, team members and other stakeholders is crucial to assuring stakeholder-based models truly account for all influential perspectives important to that model's purpose.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 09:30, Room - Faraday LT Code: OR60A3659

Preventing and Managing Tower Block Fires: Findings from the Application of a Systems Thinking Approach to the Grenfell Tower Disaster

Mr John Foley *(ChessPlus Limited)* and Miss Kerry Turner *(Hull University)*
"At daybreak on 14 June 2017, a large malodorous cloud hung over West London. You could see it for miles, acrid and acrimonious, the whole country waking up with a sense of disorder. And people required an answer….." Andrew O'Hagan, London Review of Books (7 June 2018). This paper aims to explore whether a systems thinking approach can offer useful insights in dealing with the consequences of the Grenfell Tower disaster. Society wants to know what caused the disaster, what could have been done to prevent it, and what precautions should be taken to manage fire risks in residential tower blocks. The public enquiry will produce reports from technical experts and subsequently legal action will take its course. This paper is written to address a more pressing personal concern: what should we as citizens be aware of when considering our safety in our home? The paper considers the cause and effect relationships behind the tragedy at Grenfell and how the risks could have been mitigated. We consider whether the deployment of systems thinking might benefit residents facing a hazard who must decide whether to adhere to the official guidelines or whether to form their own judgements about the best course of action. We examine the scenario from the perspective of the various stakeholders. Grenfell forces society to re-evaluate and confront the traditional top-down approach to risk management. The paper articulates the need for individuals to be an active part of the risk management system. It suggests that causal reasoning and systems thinking are vital intellectual tools for the modern citizen.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 09:30, Room - Frankland C Code: OR60A3569
Systems Thinking for Sense Making in Tackling Wicked Problems
Dr Yingli Wang *(Cardiff Business School)*
This research reflects how systems thinking has been used for sense making by when tackle a wicked problem – food poverty. We demonstrate how system thinking underpins the efforts of academic researchers in making sense of a complex social problem, observing various stands of efforts invested by different stakeholders in addressing the problem, and co-developing more systemic interventions that change the dynamics of the ecosystem. We emphasise the importance of boundary critique in this sense making process and its critical value to various stakeholders (e.g. government bodies, social enterprises, charities as well as commercial organisations) to afford them not to be overwhelmed by the complexities of the issue and thus develop manageable initiatives to improve the problematic situation. We utilise design thinking and problem structuring methods to shape behaviours of the organisations we engage with in order to deliver positive impact to the target beneficiaries from local communities.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 10:00, Room - Frankland C Code: OR60A3541
Framing Policy Development with Systems Thinking
Mr Stefan Blachfellner *(Bertalanffy Center for the Study of Systems Science)*

The presentation will highlight the opportunities and constraints of Systems Thinking in policy development. The author has been Special Adviser of the European Commissioner for Transport in 2016-2018. He has developed an integrated Systems Model based on a Nested Systems View for the EC to analyze and communicate the interdependencies of the technological, economic and political systems which co-evolve the European Transport Eco-System, purposefully to frame policy developments focusing on the domain of digitalization to enable multimodal cross boarder transport of passengers and freight. Understanding the technological architecture to transform the European Multimodal Traffic System into an Intelligent Digital Multimodal Transport System will be key for further developing appropriate policies and regulations, but its architecture must be understood with its social and economic consequences. The advisory project argued towards a European Multimodal Transport Eco-System. An Eco-System is a living and resilient system. It is an open system, that enables innovations as an adaptive pattern and that shows properties of structural resilience: Redundancy, modularity and requisite diversity. Insights towards the necessity of de-centralised socio-technological systems architectures (from data architecture, to business models and governance change) which win over centralized systems in innovation capabilities, security and resilience was one of the key results. In the future development multi-stakeholder approaches, from learning communities, to negotiation platforms and joint execution institutions will be the leverage points of the Eco-System, putting systems thinking into action.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 10:00, Room - Cavendish C Code: OR60A3502

Non-Linear Modeling to Handle Surprises in Our Society

Dr Cor van Dijkum *(Amsterdam University)*

We do live in times that we are surprised and sometimes shocked by societal events, such as the financial crisis, the Arabian spring, the exit referendum of Britain and the outcome of the elections in USA. We perhaps did not want it, many of us did not expect it and in one of another aspect our system of democracy seems to fail controlling such events in the right direction. We did hope that in our modern society the social sciences could guide us in understanding those phenomena and prevent disasters. But only a minority of economists could foresee the financial crisis, election pols guided by social scientists were terribly wrong and trust the idea that our democracy supported by science can regulate our living together in a society in the right direction the worse is fading away. From the viewpoint of system dynamics and complexity science we are not surprised. We argued in a number of publications that understanding and handling of complex phenomena need a new interdisciplinary approach such as is elaborated in the COMPRAM Methodology (DeTombe 2015). In 1996 Grutzmann and Hofinger wrote an article in our book (DeTombe & Dijkum) about the surprises of the election in Austria using the model of system dynamics and complexity science. In a number of publications (Dijkum 2001, 2002, 2013) we demonstrated that non-linear differential equations models are better equipped to describe and understand complex phenomena of human communication and interaction. We will demonstrate with examples how complex (non-linear) models can explain and simulate (by using software) shocking surprises of our modern society. Thereby giving starting points for science to support democratic society in handling those societal events.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 10:00, Room - Faraday LT Code: OR60A3298

Evaluating the Benefits of Systems Thinking in UK Education and Identifying the Critical Success Factors for Implementation

Miss Kerry Turner *(University of Hull)*

I am a management consultant with a passion for systems. (See http://kerrylturner.blogspot.co.uk/). Systems Thinking is the key technique I use in all my projects to rapidly understand the drivers of problems and to design and understand the consequences of interventions for myself and my clients. I wish I had been taught these techniques at school. The key issue is that Systems Thinking is not on the curriculum… so no teachers are trained to teach it… so no one learns it… so no-one knows what it's about… so no-one is in a position to notice its absence… or to realise that the world might be a better place if it were taught… so there is no pressure to put it on the curriculum… My vision for UK education is that we migrate from 3Rs to 4Is. The 3Rs are Reading, Remembering and Regurgitating (in exams). It's what gets measured so it's what gets done! However, it doesn't help with thinking skills. The 4Is are Impact, Interactions, Insight and Intervention. The 4Is are linked in a continuous cycle of learning by thinking and doing. The 4Is together help create a 5th I, which is Imagination. And together these all lead to Intelligent Action. I coined the term 4Is as it is snappy, it links nicely to a progression from 3Rs and it sounds like seeing (for eyes). There are numerous K12 initiatives in schools in the USA spearheaded by the Creative Learning Exchange and the Waters Foundation. I would like to see the UK building on these initiatives and I am designing an action plan to test these techniques in UK schools. I hope to be able to quantify the benefits of a systems education and make recommendations for UK education as a result.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:00, Room - Cavendish C Code: OR60A3419

The FoRSE® Matrix System: Overview of a Systems Thinking Software for Decision-Making, Consulting and More

Dr Blane Després *(Ripple Deep Consulting)*

The FoRSE® (Family of Related Systemic Elements) Matrix system works to equip and empower decision-makers, consultants, businesses, organizations and researchers to achieve efficient, effective and sustainable change or knowledge management. The results provide a "broadly deep," truer big(ger) picture of an inquiry (problem, issue, question, analysis, policy, query), and point the way to more focused interventions, many of which might never have been considered. This Pecha Kucha presentation will provide a brief overview of the FoRSE® Matrix, its roots and development in systems thinking, and its many applications across multiple fields, including in OR. The FoRSE® Matrix system is a product of 18 years of R&D and application in diverse settings, from education and research to business and organizational consulting. Development of the Matrix has been informed by the writings of Flood, Midgley, Checkland, Jackson, Ackoff and Senge, to name a few. It has also been influenced by soft systems thinking, visual analytics, complexity theory, operational research, architecture and house construction,

alternative learning and human dynamics. The FoRSE® Matrix has evolved as online software that guides users in their decision-making, analyses, consulting, research or reporting processes via three stages through which the depth and complexity of inquiry progress. Attendees will gain another view of systems thinking in application and its union with OR as well as an introduction to a functional tool with broad applications and utility. There will be opportunity for Q&A. (A follow-up presentation is planned (separate proposal) that would walk attendees through the FoRSE® Matrix theory and practical examples.)

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:00, Room - Frankland C Code: OR60A3338

Opening the Toolbox: A Practitioner's Contemporary Application of Systems Methodologies to Support Strategic Transformation in an English Local Authority

Mr Michael Walker *(Kirklees Council)*

This paper is a companion piece to a first research paper (Walker, 2017) which described a series of case studies in English local government suggesting an implicit influence of various tenets of the Viable Systems Model (Beer, 1985) within transformative change of organisational strategy and process. Now responsible for the facilitation of such transformation within an English Metropolitan Council, the author seeks to outline how the purposeful application of various systems and Community OR methodologies, currently being utilised within that organisation, is helping support its strategic and operational change. Moreover the assessment considers how the synergistic coupling of such methodologies (as examined by such as Jackson and Keys, 1984 and Schwaninger and Perez Rios, 2008), can provide a framework for change for practitioners in response to the complex environment faced by such public agencies. This application of methodologies involve: i. A programme of engagement with residents and community organisations to rebalance the state / citizen relationship and enhance the concept of active citizenship, employing 'enhanced OR' and critical systems approaches to explore issues and boundaries of place, identity, power and responsibility (as considered in Midgley and Chichirau, 2017); ii. A cross-Council action learning initiative, centred on understanding the system of the physical activity of residents, using complementary methodologies to assess both 'content' and 'context' of the system (Schwaninger, 2004), and so inform holistic outcome-based budgeting rather than traditional service-specific allocation of public funds; iii. The development of a new organisational design for the Council's management and operation, to better respond to the complexity of environmental requirements while seeking financial viability, using the Viable Systems Model as an underpinning framework and rationale for a changed operating model.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:00, Room - Faraday LT Code: OR60A3320

Beyond Ambidexterity with Emergent Quality Management. Using Dilemmas Such as Explore-Exploit to Reach Innovative Quality Improvements in Operations

Prof Tomas Backstrom, Prof Anders Fundin and Dr Peter E Johansson *(Mälardalen University)*

There are a number of challenges in terms of dichotomies that seems to be keys for improvement in operations. The dichotomies are part of four interrelated processes that together constitute the central elements of a production system. To aim for stability or for change is the dilemma for the production process. Control and creativity is the dilemma for the innovation process. While exploitation and exploration is the dilemma for the knowledge creation process and efficiency and effectiveness for the value creation process. For company survival there is a need to have them both at the same time, but it seems impossible to achieve this since they compete for resources, include two conflicting types of activities which are iteratively self-reinforcing, and they demand different ways to work, as well as different knowledge and cultures to be performed. Thus, the ambidexterity of having both parts of the dichotomy, for example, exploring and exploiting, at the same time seems to be a paradox. Suggested solutions typically include some sort of separation between the two. Organisational separation is, for example, the primary solution to the exploration vs. exploitation dichotomy. We suggest the Emergent Quality Management (EQM) paradigm as an alternative perspective, which recognize the dichotomies as mutually dependent. The parts of the production system and the system as a wholeness are in a mutual process of emergence where they construct and re-construct each other. While parts and individuals may introduce change, creativity, exploration and effectiveness, the organising structures of the wholeness ensure stability, control, exploitation and efficiency. The two parts of the dichotomy cannot anymore be understood independently; the interconnection between them is instead the most important feature of the organisation.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 11:30, Room - Faraday LT Code: OR60A3457

Complexity Theory Provides an Alternate Lens through Which to View Contracting Difficulties

Ms Judy Oakden *(Massey University)*

This paper will look at where concepts from complexity theory can explain difficulties in contracting. It will also make suggestions of how contracting may look if complexity rather than NPM was underlying paradigm. Much of our current procurement and contracting practice within public sector is still influenced through New Public Management (NPM), which assumes NPM promotes greater accountability, sets clear performance measures and goals, and focuses on performance and results. NPM also suggests a decentralised public service delivers efficiency gains through purchasing arrangements. Proponents of NPM believe operating in a competitive environment achieves similar results with less funding. There are several critiques of NPM, including from a complexity theory perspective. Practically, NPM informed contracts have a number of difficulties. These include dealing with continual change, managing contractual relationships, and maintaining effective project monitoring and reporting processes. NPM informed contracts can also be too inflexible to take advantage of unanticipated opportunities. This paper draws on a literature review on contracting and a separate literature review on complexity and public administration /management. A set of six complexity concepts were identified that can be used to explore contracting. The review also identified possible contracting mechanisms that take into account complexity concepts. Many difficulties identified that occur with contracting can be explained using a complexity theory lens. Several key difficulties will be discussed in this presentation. Next steps in the process

will be to explore how a complexity framed contract may practically be developed, drawing on key informant interviews of experienced public-sector contract managers.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 11:30, Room - Frankland C Code: OR60A3491

Re-Designing Information Boards: Interwoven Design Thinking and Doing

Dr Ulrika Florin and Dr Carina Soderlund *(Mäladalen University)*

Pulse meetings are a meeting format in many different industries and organizations. These meetings are short and are held on a daily basis. Information boards (i.e. visual management boards) are at the center of these meetings, and provide information on work performances, goals, schedules, sick-leave and prioritizing work tasks etc. During the meetings managers and/or co-workers share information, exchange knowledge and involve all the participants in continuous improvement. The purpose of this research is to investigate how visual and spatial oriented participatory design methods, VSPDM, (i.e. variations of business origami) can be applied to explore systems relating to information boards in industry and public organizations. The questions are: Which parts of the system become visual when applying VSPDM, methods? What influence does the method have on the participants' perception of the system(s) that they are working within? Empirical data were collected via workshops conducted in the ongoing research project on visual and spatial communication and management, Vis'man. The project is funded by The Swedish Knowledge Foundation and aims to develop theories and design solutions for information boards, and their space, from users' perspective. Managers, group-leaders and co-workers within four industrial companies and the municipality participate and are involved in the design and research process. Findings indicate that the information boards, and their content, relate to different systems within the organizations' structures, although not always transparent to individual users. The systems are communication and information systems and the boards mirror the management itself and their overall policies trough symbols and color choices. We learned that design and systems thinking are interwoven perspectives, useful when performing user involved design processes in early phases. When applying participatory methods that really involve users, they engage in the development within their organizations, vital when trying to apply a democratic design, research and development process.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 11:30, Room - Cavendish C Code: OR60A3420

The FoRSE® Matrix System Demonstration: Systems Thinking Software for Decision-Making, Consulting and More

Dr Blane Després *(Ripple Deep Consulting)*

This follow-up to the Pecha Kucha presentation on the FoRSE® (Family of Related Systemic Elements) Matrix will provide a more in-depth view of the Matrix, its theory, roots and development in systems thinking, as well as demonstrations of its applications across multiple fields, including in OR (see the Pecha Kucha presentation abstract). This presentation satisfies

the four categories or foci for the conference: Applications to (and across) organizational, social and environmental issues; theoretical and methodological innovations; thoughts on the diversity, impacts and ethics of systemic OR practice; and reflections on the future of systems thinking in OR. Four archetypes, or patterns, of human activity systems underpin the FoRSE® Matrix: 1) Systems have at least a main purpose. 2) Systems exhibit form or design. 3) Systems are supported to achieve implementation, sustainability and success via governance, actions and communications, resources and time. 4) Furthermore, systems are infused with and influenced by Individual, Community, and Principles elements or factors. These "Elements Categories" elicit further details about the system or inquiry through a series of pertinent questions that pertain to personal well-being or "cost," social or corporate or environmental well-being, and rationale. Some assumptions that guide the working of the FoRSE® Matrix include: 1. Problem Clarification, analysis and reformulation. 2. Interventions. 3. Status check. 4. Future or ideal state. 5. Systems identification. 6. Systems boundary. 7. Systems elements or critical mass of key components or attributes, interconnections. Alignment in the FoRSE® Matrix system requires that individual cell contents are mutually supportive. Failure to align elements will have repercussions on and throughout the organization. Attendees will gain another perspective of systems thinking and be able to see and try the FoRSE® Matrix in multiple applications. There will be opportunity for Q&A and, ideally, a live input demonstration.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 12:00, Room - Cavendish C Code: OR60A3403

Systemic Interventions. To Increase Expertise Rather Than Knowledge

Dr Eliseo Vilalta-Perdomo *(University of Lincoln)* and Dr Cesar Garcia-Diaz *(Universidad de los Andes (Colombia))*

Five different vignettes will be explored under the lens of 'systemic interventions'. In all these illustrations, triggers and barriers to Systemic Thinking will be discussed, and a complementary strategy will be introduced. Rather than following a traditional 'black box' approach based on tuning inputs with the available outputs, this framework proposes a stronger focus on the quality of interactions among different actors, through a wider interpretation of what is an available resource. The aim of this framework is not to increase knowledge, but to boost the expertise in each of the people involved in systemic interventions.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 12:00, Room - Frankland C Code: OR60A3304

Project Failure through the Lens of Systems Thinking

Mr Paul Summers *(University of Winchester)*

This presentation proposes that the reasons for project failure are poorly understood and taking a Systems Thinking perspective will improve our understanding of the root causes; for as Churchman (1968, p. 231) states 'The systems approach begins when first you see the world through the eyes of another.' Changing the perspective from project managers onto business managers provides greater insights into project failure. Historically project success has been measured against the triple constraints of cost, time, and quality; often referred to as 'the iron

triangle' (Atkinson, 1999; Cicmil, Cooke-Davies, Crawford, & Richardson, 2009; Cooke-Davies, 2000; Ika, 2009; Jenner, 2011), this labels projects that overrun on cost and/or time, and/or do not meet quality requirements as failures. This view of project success is very narrow and views success from the singular lens of project managers rather than other stakeholders especially the business managers who commission projects. This '…working on the basis of a single unquestioning perspective…' leads to a trap of not using Systems Thinking – dogmatism per Reynolds & Holwell (2010, p. 6). Reasons for project failure are well documented in the literature e.g. The Standish Group (1995, 1999, 2009, 2013), Nelson (2005,2007), Flyvbjerg et al., (2003) Labib & Read (2013) Serrador & Turner (2014). Nonetheless projects still disappoint in their results (Besteiro, Pinto, & Novaski, 2015; Calleam Consulting Ltd., 2014; Coombs, 2015; Hammer, 2015; Kapsali, 2013; Matthews, 2016; Stanley & Uden, 2013; Thomas & Mengel, 2008), suggesting a rethink is needed of failure and success and that project failure is understood at a symptomatic level only. The presentation has value for both academics and practitioners and shows how a Systems Thinking approach to project failure leads to deeper understanding and have a significant impact on organisational performance.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 12:00, Room - Faraday LT Code: OR60A3434

Machiavelli: Using the Distribution and Dynamics of Variety to Change the Locus of Control of Complex Socio-Technical-Political Systems

Dr Terence Love *(Design Out Crime and CPTED Centre)*

This paper focuses on roles that the distribution and dynamics of variety play in shaping the locus of control in complex systems and operations involving people, technology, politics and power. The paper outlines how the Variety Axioms of Love can be used to change power relationships in a variety of contexts, including: personal, political, environmental, organisational, governance, business competition, corruption, information warfare and asymmetric warfare. The paper concludes by introducing practical ways that the power of these and other not yet published variety axioms can be integrated into OR and Systems Thinking theories and practices.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 13:30, Room - Faraday LT Code: OR60A3344

The Global Sustainable Development Goals: A Wicked Agenda for Operational and Systems Research?

Prof Yasmin Merali *(University of Hull)* and Dr Geoff Royston

In 2015 193 member states of the United Nations signed up to 17 global Sustainable Development Goals (SDGs) and 169 associated targets for 2030. The SDGs were successors to the Millennium Development goals, but aimed to be more comprehensive (with social, environmental and economic dimensions), more interconnected, universal across all nations, and inclusive across contributors such as academia, the private sector, and civil society. The SDGs are deliberately ambitious and present numerous demanding challenges for every country, particularly lower and middle income countries but also higher income nations. These

challenges include implementation, integration, monitoring and evaluation. The current rate of progress in many areas is far slower than needed to meet the targets by 2030. The presentation, informed by recent participation in a UN inter-agency and expert group meeting on SDG monitoring, will examine these challenges and how they might be addressed effectively. For example it will examine how understanding potential synergies and network effects across time could orchestrate the allocation of resources to specific goals in different national contexts and could also inform evaluation criteria and timeframes for assessing systemic impact. The presentation will conclude with suggesting an associated agenda for future operational and systems research that could assist and even accelerate progress towards achieving the global goals.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 13:30, Room - Frankland C Code: OR60A3513

Could Smart Communities Improve the Efficiency of Cancer Services in Sheffield?

Mr Tim Woolliscroft *(Sheffield Hallam University)*

This digital health study draws upon smart community and smart city literature to gain insights into how to address the complex issue of improving healthcare, with a focus on cancer services in Sheffield. The study's approach brought together ideas from literature and primary data together through a process of theory informed critical reflexivity. It applied a critical systems heuristics methodology that included 3 workshops and 30 semi-structured interviews. Workshops focussed on creating rich pictures of what future systems might look like based on the smart community concept. The interpretation of data applied Bourdieu's Practice Theory to help understand and highlight power dynamics in existing and proposed solutions. The three corners of the study's sense making process were; expressed ideas of interviewees and workshop participants, reflections of the researcher based on his life experience and ideas expressed in journals. By reflecting on potential power distortions opportunities and limitations of utopian visions within smart city, smart community and digital health literature strengths and weaknesses of emergent ideas were identified Theory emerges through the creation of a framework that maps out what a more efficient system of cancer services might look like based on the concept of smart community. Whilst smart city and community literature acknowledges differences between top down and bottom up approaches the divisions within top down and bottom up approaches are rarely given much consideration. To address these limitations a framework was developed that subdivides top down into private vs government led and bottom up between individual and collective approaches. The study concludes that the most desirable approach to improving the efficiency of cancer services in Sheffield would be to focus on the collective bottom up sector of the framework.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 14:00, Room - Frankland C Code: OR60A3596

Stakeholders Take the Stage: Forum Theatre and Systemic Awareness in Community OR

Mr Tom Scholte *(University of British Columbia)*

Inspired by the critical pedagogy of Paulo Freire (1996), "Forum Theatre" was originally developed by Brazilian director, activist and, later, city councilor, Augusto Boal as part of his program of the "Theatre of the Oppressed." It has been developed further by, among others, Vancouver's David Diamond, whose "Theatre for Living" website describes the Forum Theatre component of their work as follows: In Forum Theatre, we show the audience the play all the way through once – the play builds to a crisis, and stops, offering no solutions. The play is then performed a second time, where audience members can then stop the action and enter the stage themselves, by replacing characters with whom they identify and try to solve problems or issues inside the story. The rest of the cast stays in character and improvises. […] The theatre becomes a creative laboratory where we can try ways to transform ourselves, our communities, and the world. (theatreforliving.com) As director of Conflict Theatre @ UBC, I have continued to evolve this practice in combination with embodied learning tools for systemic awareness co-creating plays with, and for, a diverse group of employees at the University of British Columbia exploring blockages to authentic and productive communication in situations of workplace conflict. This paper will explore the ways in which this modality might play a key role in achieving the objectives around stakeholder engagement and knowledge production articulated in much of the literature in Community OR. The presentation will feature video clips of audience interventions at Forum performances supported by empirical evidence of its efficacy in, not only, facilitating the co-creation of knowledge around particular systemic issues, but also, heightening such reflexive competencies as self-awareness, other awareness, systemic awareness self-regulation and relationship management.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 14:00, Room - Faraday LT Code: OR60A3564

Putting Some Systems Thinking Back Into SSM through the Practice of Business Modelling

Dr Giles Hindle *(University of Hull)* and Prof Richard Vidgen *(University of New South Wales)*

Soft Systems Methodology (SSM) is an approach to tackling messy, ill-structured problems based upon systems thinking. SSM is novel in the way it distinguishes between hard and soft systems thinking and uses a flexible modelling language based upon the concept of a purposeful activity system. Drawing on the authors' Action Research programme, we argue the practice of business modelling enables a more explicit use of systems thinking within the application of SSM and also challenges the traditional definition of hard and soft thinking. The notion of 'business model' has received increasing attention from both academic and practitioner communities dating from around 1995. It is emerging as a new unit of analysis, but unfortunately its systemic and organization-level nature has led the literature to become fragmented within disciplinary silos. The approach we have developed is novel, drawing on Osterwalder and Pigneur's business model canvas in combination with SSM. The presentation will outline the application of this approach in various case studies.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Highly

13/09/2018, 14:30, Room – Faraday LT Code: OR60A3620

Personal and System Archetypes as a Model Foundation for Explanation of Socio-Economic Dynamics and Increasing the Quality of Life of People

Ms Svetlana Shchepetova *(Financial University under the Government of the Russian Federation)*

In the life of modern society, persistent (hardened) problems are remain (and are expanding by new), despite the development of technical and technological progress and the measures taken to solve them. This indicates that root causes of problems have not yet been eliminated. Given that the problems lie in the structure of systems, it is important to understand the types of socio-economic structures and the peculiar to them causal contours of connections. These problems are largely determined by the organization of society and the worldview of individuals. Despite the diversity of mental and institutional norms, the diversity of socio-economic systems, the essence of what is happening in society can be explained by the scheme: personal archetypes - systemic archetypes - structure of system - systemic patterns. Personal archetypes (generalized, essential mental models of individuals) germinate systemic archetypes (generalized principles of its organization, prototypes of the system), systemic archetypes give rise to the structure of the system (constituent parts and relationships/links between them), the structure of the system generates systemic patterns (essential regularities as a result of cause-and-effect (causal) interactions). This method of soft modelling makes it possible to explain the existence of hardened problems in the society life and ways to solve them. The mentality of the consumer society, the widespread practice of organizing socio-economic systems based on coercion (overt, indirect, hidden), control and punishment instead of help inevitably drive to the phenomenon of "shifting goals and functions" and multiplying problems in the life society in whole as well as in the life of a separate individual. A necessary condition for the essential solution to these problems is a shift in mentality, and as a result of it, a change of systemic archetypes and a transition from a society of consumption and coercion to a society of creation and voluntariness.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 14:30, Room - Frankland C Code: OR60A3299

Smart Model-Based Governance: Systems Thinking and Data Analytics to the Rescue of Policy Making!

Dr Eduardo Franco *(University of Sao Paulo)*, Dr Stefano Armenia and Prof Carlo Maria Medaglia *(Link Campus University)* and Dr Alessandro Pompei *(Sapienza University of Rome)*

Although Big Data initiatives are currently presenting promising results, there are still some scepticisms about their real capabilities as they are contextual dependent, and their objective and accuracy are somehow misleading. Approaches underlying the extraction of knowledge from large amount of data are surely important to understand how a system has behaved until a certain point in time. However, they unfortunately lack the capability to infer future system's behaviour and its relationship with other systems (some of which might even have counterintuitive behaviours). As a direct consequence of this, the Systems Thinking approach may help fill the gap, as it advocates the ability to see the world as a complex system where everything is connected. Joining Analytics techniques and Systems Thinking models brings us to the definition of a new governance approach, based on "smart" models.

What is the nature of your talk? Very theoretical

Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

Third Sector OR: Modelling for a Better World

Organiser: Malcolm Fenby

12/09/2018, 16:00, Room - Bowland SR20 Code: OR60A3469

Some Observations from Working in the Third Sector (After a 25 Year Career in Aviation)

Mr Malcolm Fenby

Following a 25 year career in aviation, the presenter has spent 4 years working in the third sector (including 5 projects within the ORS pro bono scheme). Based on all this experience, this presentation covers a number of observations on the Third Sector: some are merely observations; some are key features of the Third Sector; some are observations that raise open the question of change (although it might not be clear what change); and others suggest the need for a very definite change (although how these might be achieved is another question).

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 16:30, Room - Bowland SR20 Code: OR60A3598

Pro Bono OR and the State of the Third Sector

Miss Amy Hughes *(The OR Society)*

Take a look at the pro bono OR scheme processes, its challenges and how we overcome barriers. Find out how projects are defined and offered to volunteers. The pro bono experience offers volunteers the opportunity to experience light touch project management skills whilst working in the third sector. This session will review the current state of the third sector; in accordance with this, the pro bono scheme achieves its aims to help third sector organisations improve efficiency, whilst providing OR analysts an opportunity to practice in a wider arena and develop their knowledge and skills.

What is the nature of your talk? Theoretical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Relevant

12/09/2018, 17:00, Room - Bowland SR20 Code: OR60A3441

Pro Bono Operational Research in Support of Charityworks: Simple Modelling with Incomplete Data, Together with an Assignment Problem

Mr Howard Turner *(HM Revenue & Customs)*

Charityworks is a paid 12-month graduate scheme for the UK social sector. It aims to attract, grow and retain future managers and leaders, to increase the reach, quality and impact of its services and improve the lives of the people they serve. The paper describes a project carried

out under the OR Society's Pro Bono scheme to streamline the selection process and improve the matching of candidates to posts. We discuss issues connected with applying OR in a new organisation and the possibility of discovering classic OR problems in such settings. We make some recommendations that may be useful in future such engagements.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

12/09/2018, 17:30, Room - Bowland SR20 Code: OR60A3463

"The Leading Cause of Death in Young Men" Conveying the Suicide Crisis in a Single Sentence
Mr Malcolm Fenby

Suicide is the leading cause of death for men aged 15-44 within the UK. This is an often quoted statistic - because it is true (and has been for many years). Nevertheless there are caveats to this statement (and these caveats themselves have caveats). However, possibly the most significant criticism of this statement is that it understates the seriousness of the situation. This talk will present some of the key (data) facts relating to the above statement – including the caveats and caveats of caveats. Attendees will be invited to comment.

What is the nature of your talk? Very practical
Does your talk require prior knowledge of the subject area? None
Is your talk accessible and relevant to practitioners? Highly

Timetabling and Scheduling

Organisers: Jonathan Thompson and Ahmed Kheiri

13/09/2018, 09:00, Room - Bowland SR20 Code: OR60A3401

KEYNOTE: Two Example Optimisation Problems from the World of Education

Dr Rhydian Lewis *(Cardiff University)*

This talk will consider two distinct combinatorial optimisation problems related to education, namely lecture timetabling and school bus scheduling. In both cases we will see that, by getting to the heart of these problems through the identification of their underlying sub-problems, we can design suitable algorithmic operators that are very useful in the production of high quality solutions. The first problem considered is the post enrolment-based course timetabling problem, which has crossovers with both graph colouring and bipartite matching. For this problem we focus particularly on the issue of solution space connectivity and demonstrate that when this is increased via specialised neighbourhood operators, the quality of the returned solutions is generally enhanced. We also make note of problem instances where our algorithm struggles in comparison to others and will offer some compelling evidence as to why this is so. The second part of this talk will look at the problem of designing real-world school transport schedules. Our problem model extends those previously used by considering some important but hitherto overlooked features such as the splitting and merging of routes, gauging vehicle dwell times, the selection of stopping points, and the minimisation of walking distances. This problem also contains a number of interacting combinatorial sub-problems; in this case, set covering, bin packing, and the vehicle routing problem. As a result, a number of new and necessary algorithmic operators will be discussed that can be used alongside other recognised heuristics. Primarily, the aim of this algorithm is to minimise the number of vehicles used by each school; however, secondary issues concerning journey lengths and walking distances can also be taken into account through the employment of suitable multiobjective techniques. The intention is for this talk to be accessible to all OR enthusiasts, not just those specialising in timetabling and scheduling.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

13/09/2018, 11:00, Room - Bowland SR20 Code: OR60A3587

Dynamic Scheduling Strategies for Continuous Bioprocesses

Mr Folarin Oyebolu, Prof Jürgen Branke *(Warwick Business School)* and Prof Suzanne Farid *(University College London)*

The biopharmaceutical industry has been moving from batch processes to semi-continuous manufacturing processes. These continuous bioprocesses are more failure-prone and process

failure is more consequential. In addition, the probability of failure is dependent on process run time which generally is determined independent of scheduling considerations. Prior scheduling or planning frameworks are static, deterministic, and almost exclusively consider batch processes. Those that model any continuous processes either do not account for stochasticity or do not intend on optimising facility schedules. This work presents a discrete-event simulation framework that models continuous bioprocesses in a scheduling environment. With this we can utilise dynamic scheduling policies to make operational decisions in a multi-product manufacturing facility and react to changes such as process failure events and uncertain demand. We first adapt different scheduling policies from the stochastic economic lot sizing literature and propose a novel look-ahead scheduling policy. Then, we apply an evolutionary algorithm to tune the policy parameters as well as the process duration. We demonstrate the benefit of parameter tuning and show that the tuned policies perform much better than a policy that estimates parameters based on service level considerations.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:30, Room - Bowland SR20 Code: OR60A3644

Exam Timetabling as a Grouping Problem: A Hyper-Heuristics Approach

Dr Anas Elhag *(Lancaster University)* and Dr Ender Ozcan *(University of Nottingham)*

Grouping problems are combinatorial optimization problems that require division of a set of objects into a minimum number of mutually disjoint subsets while simultaneously optimising another additional objective. Many real-world NP-hard problems are grouping problems, such as exam timetabling, graph colouring and data clustering. Each one of these problems has been tackled on its own, and there are many problem-specific solutions for each one of them in the scientific literature. This study presents a generic selection hyper-heuristic search approach, that deals with a single solution at any given decision point during the search process and employs a fixed set of standard reusable low level heuristics especially designed for the grouping problems. The application of standard low level heuristics enables the re-usability of the whole approach with different grouping problem domains with minimal development effort. The performance of different selection hyper-heuristics combining different components, implemented based on the proposed framework is investigated on a range of sample grouping problem domains, including exam timetabling, graph colouring and data clustering domains, and best result obtained in each domain are compared to the previously proposed problem-specific algorithms from the scientific literature. The empirical results show that the proposed approach is sufficiently generic and is able to find high quality solutions that are highly competitive to some previously proposed problem-specific approaches.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 12:00, Room - Bowland SR20 Code: OR60A3549

Solving Urban Transit Route Design Problem Using Selection Hyper-Heuristics

Mrs Leena Ahmed and Dr Christine Mumford *(Cardiff University)*, Dr Yong Mao and Mr Philipp Heyken *(Nottingham University)* and Dr Ahmed Kheiri *(Lancaster University)*

The design of routes and schedules for a public transportation system is a hugely challenging problem that faces urban societies. With the increasing congestion and pollution resulting from dependency on private vehicles, it has become important to attract people into public transportations. In this work we address the urban transit network design problem (UTNDP) that deals with the design of efficient routes and schedules for public transit systems. We propose a new approach to solving the route design aspect of this problem based on hyper-heuristics and demonstrate that it is fast, flexible, efficient, and highly adaptable to real-world constraints. The UTNDP is considered a highly complex problem, in which exact methods failed. Therefore most of the recent published research on the UTNDP focused on heuristics and meta-heuristic techniques particularly GAs. However, population-based solutions such as GAs have the disadvantage of requiring long run-times when handling even the modest size networks. Thus, finding alternative methods that reduce run-times and scale to real size networks is a key concern. Another serious issue that has hampered research to date is the lack of public benchmarks with realistic dimensions and constraints. Fortunately, our team has developed techniques to extract realistic instances from publicly available UK data, on which we will be applying our methods. Hyper-heuristics are general search methodologies that work on the space of heuristics, controlling a set of low-level operators to improve a given solution. Previously on this project, hyper-heuristics have been applied on published benchmarks and provided better results than the current state-of-the art with much improved run times. This present work focuses on implementing a more realistic model of the problem, utilising real-world size instances and imposing real-world constraints such as restricted start and end points of routes.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Very

Transport and Logistics

Organisers: Burak Boyaci and Djamila Ouelhadj

11/09/2018, 11:30, Room - Market Pl Code: OR60A3555

Rapid Charger Installation Problem in One-Way Electric Carsharing Systems

Ms Seyma Bekli, Dr Burak Boyaci and Prof Konstantinos Zografos *(Lancaster University)*

One-way station based carsharing systems (OCS), at which the origin and the destination of trips may not be necessarily the same, can attract more customers than round-trip carsharing systems. Yet, OCS companies face an unbalanced vehicle distribution at the stations since the demand is not distributed equally to each station. This is why OCS companies have to relocate the vehicles between the stations in order to meet the demand. Daily operations of such companies with electric vehicles are even more problematic because of the vehicle battery charging requirements. A vehicle may spend up to 6-hours at stations in order to be fully charged. With the new advancements in charger technologies, rapid chargers can charge vehicles in less than 30 minutes. Carsharing companies are now considering adopting this new technology to their systems. In this study, we aim to decide the number of charging units that are going to be replaced by newly purchased rapid charging units. We develop an integer programming model that maximizes the profit and decides on the charging units while considering the relocation operations. Since solving the exact model is time-consuming and computationally intractable, we consider a clustering approach in order to reduce the size of the problem. Finally, we apply the model to real-world system data from Nice, France and measure the effects of rapid charging unit installation in terms of profit, and met demand.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Somewhat

11/09/2018, 12:00, Room - Market Pl Code: OR60A3590

Introducing User Preferences in Modelling One-Way Electric Carsharing Systems

Dr Burak Boyaci and Prof Konstantinos Zografos *(Lancaster University)*

Carsharing is an advanced car rental system that allows its users to rent vehicles for a short period with increased flexibility. Depending on their properties, carsharing systems can be categorised in various ways. In this research, we are dealing with the operational decisions in one-way station-based electric carsharing systems with dynamic relocations. In these systems, the users are not restricted to return the electric vehicles to their origin stations and a group of personnel relocate vehicles during the system is in operation to balance vehicle distribution among stations. In this research, we allow users to express their preferences regarding the place and time for picking-up and dropping-off the vehicles. We do this by offering them the flexibility of choosing the pick-up and drop-off time windows and the maximum

distance to their ideal locations. Our aim is to develop an operational framework that maximises the profit of the operator while providing cheaper alternatives to the users. We model the main problem as an advanced network flow problem. To increase the efficiency of the solution process, we developed a solution framework composed of consecutive mathematical models each of which is run iteratively until a feasible solution is found. We applied this framework to plan everyday operations of an electric carsharing system operating in Nice, France. Preliminary results show that the model is efficient enough to solve operational planning problem of real carsharing systems.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 13:30, Room - Market Pl Code: OR60A3422

A Learning-Based Population Variable Neighbourhood Search Algorithm for Solving a Real-Life Gas Delivery Problem

Dr Niaz Wassan, Dr Gabor Nagy, Prof Said Salhi and Dr Lina Simeonova *(University of Kent)*

In this paper we consider a real-life Vehicle Routing Problem, characterized by heterogeneous vehicle fleet, demand-dependent service times, maximum allowable overtime and a special light load requirement. A new learning-based Population Variable Neighbourhood Search algorithm is designed to address this complex logistic problem. The computational experience suggests that savings up to 8% can be achieved when overtime and light load requirements are considered in advance. Moreover, accommodating for allowable overtime has shown to yield 12% better average utilization of the driver's working hours and 12.5% better average utilization of the vehicle load, without incurring extra running costs. The proposed metaheuristic method also shows some competitive results when applied to the special case of the real-life Vehicle Routing Problem, namely the Fleet Size and Mix Vehicle Routing Problem.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Highly

11/09/2018, 14:00, Room - Market Pl Code: OR60A3406

Efficient Routing of Personnel to Offshore Maintenance Tasks

Mr Toby Kingsman and Dr Burak Boyaci *(Lancaster University)*

The rapid growth expected in the offshore wind sector means there is an increasing opportunity to find savings from conducting operations and maintenance activities more efficiently. The predicted increase in the size and quantity of offshore wind farms means mathematical tools for scheduling maintenance activities will be necessary to exploit economies of scale fully. In order to complete a maintenance activity, a pre-specified combination of skilled personnel, equipment and vessel support is required to be present at its location for the duration of the task. A fleet of heterogeneous fleet of vessels is typically responsible for transporting physical assets around the wind farm and conducting personnel transfers. Vessel movements must also satisfy any limitations in wind turbine accessibility imposed by offshore weather conditions, as well as the need to return all resources back to port. In this research, we have developed a mathematical model capable of determining the best routes for vessel movements and the ideal times to undertake crew transfers. Our mixed integer programming formulation can compute high quality schedules that minimise the costs of performing maintenance and

lost production. This approach allows the model to complete the best subset of tasks, with the results highlighting the potential benefits of splitting pick-up and drop-off operations across different vessels. We extend our optimization model to include a set of scenarios that represent the stochastic evolution of weather and sea conditions in future shifts. Solving the resulting model with a rolling horizon approach allows us to produce a detailed solution for the current shift, which contains actions informed by the relative likelihoods of future weather patterns.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

11/09/2018, 14:30, Room - Market Pl Code: OR60A3394

Symmetry-Free Polynomial Formulations of the Capacitated Vehicle Routing Problem

Prof Jens Lysgaard and Dr Sune L. Gadegaard *(Aarhus University)*

In this paper we propose new polynomially sized formulations of the well known symmetric capacitated vehicle routing problem. Several polynomially sized formulations have been proposed for this problem, but they all possess the problematic feature that they contain many equivalent solutions. As such, the optimal set of routes will be represented by several equivalent integer feasible solutions to the formulation, potentially leading to excessive computation times. Given that a route describes a path starting and ending at the depot, the equivalence between solutions results from the possibility of reversing the order of visit on any route without affecting feasibility or route length. In this paper we propose formulations which eliminate the existence of equivalent integer solutions. In particular, instead of describing a route as a path starting and ending at the depot, we represent a route as two paths originating at the depot and ending at a so-called peak customer on the route. In our models there is only one possible peak customer for any such two paths, resulting in a unique representation of any route. Computational experience is reported.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:00, Room - Market Pl Code: OR60A3589

A Multi-Phase Solution Algorithm for a Multi-Objective Vehicle Routing Problem with Environmental Criteria

Mr Ramin Raeesi and Prof Konstantinos G. Zografos *(Lancaster University)*

We propose a multi-phase solution algorithm for a multi-objective, time and load dependent, fleet size and mix green vehicle routing problem with time-windows, flexible departure times, and multiple trips on congested urban road networks. In the first phase of the proposed solution algorithm, synthetic driving cycles are generated using a new integer programming model to account for the lack of truck instantaneous acceleration/deceleration data over the network links. Following this, an exact path elimination algorithm that guarantees all redundant road-path are discarded from the road network without eliminating ad-hoc ND solutions, is applied on the roadway network in a fast pre-processing phase. The reduced network is then submitted to a new hybrid multi-objective evolutionary algorithm (HMOEA) with a target attainment scheme for the approximation of the true efficient frontier of the problem. The proposed HMOEA benefits extensively from new lower-level heuristics for the emerging multi-objective optimisation problems of (i) the road-path and departure time optimisation, (ii) the

fleet size and mix optimisation, and (ii) the multi-trip optimisation. We further introduce a new neighbourhood search approach, called the Exhaustive Neighbourhood Search, and a fast and efficient spatiotemporal route construction and improvement heuristic that are used within the proposed HMOEA. Results from the application of the proposed algorithm on real-life instances will be presented, and the efficiency of the algorithm is evaluated against the true efficient frontier of a set of benchmark test instances.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 09:30, Room - Market Pl Code: OR60A3425

A Two-Stage Biased Randomised Heuristic for the Green Location Routing Problem with Constrained Distances

Mr Abdullah Almouhanna, **Dr Banafsheh Khosravi** and **Prof Djamila Ouelhadj** *(University of Portsmouth)*, **Prof Angel Juan** and **Dr Javier Panadero** *(Open University of Catalonia)* and **Dr Carlos Quintero-Araujo** *(Universidad de La Sabana)*

The introduction of electric vehicles (EVs) in modern fleets facilitates a shift towards greener road transportation. However, the driving ranges of EVs are limited by the duration of their batteries, which causes new operational challenges. Therefore, distance constraints are introduced into the Location Routing Problem (LRP), which is a natural extension of the LRP when EVs are utilised. The new problem is called Location Routing Problem with Constrained Distance (LRPCD). We propose a two-stage biased-randomised heuristic to solve the green LRPCD, which combines biased-randomised techniques with the well-known Tillman's heuristic for the Multiple Depots Vehicle Routing Problem (MDVRP). During the first stage, a selection of 'elite' solutions is completed; during the second stage, these elite solutions are improved. Thus, in the first stage, an iterative approach is employed to choose the best solution with regard to the minimum location and routing cost for different combinations of depots. The second stage consists of two levels. In the global level, a biased-randomised extended savings heuristic is developed to improve the result of the MDVRP generated during the first stage. In the local level, we adapt a biased-randomized savings heuristic from the literature to solve the corresponding vehicle routing problem for each depot which is resulted from the global level. In both global and local levels, the biased randomisation is introduced by employing a geometric probability distribution, which generates a probability of selection for each pair of routes in the savings lists of the devised classical and extended savings heuristics. In order to evaluate the performance of the proposed algorithm, we have generated new data sets by adding distance constraints to three well-known LRP benchmarks. The computational results show that the proposed approach achieves good results in a reasonable computation time and it is promising for further developments in terms of quality.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 10:00, Room - Market Pl Code: OR60A3324

Environmental Routing: Introduction of Load Factor in Local Search Operators

Prof Said Salhi, **Dr Adolf Acquaye** and **Mrs Norfaieqah Ahmad** *(University of Kent)*

In this talk, we explore the environmental vehicle routing problem that considers both the total operating cost and the amount of CO2 emitted. As vehicle load is one of the factors contributing to the amount of fuel consumed by a vehicle and hence the amount of CO_2 emission, our study focusses on assessing such impacts when designing routes. Consequently, we introduced a load factor into the mathematical formulations of some local search operators commonly used in combinatorial optimisation in general and in routing in particular. To our knowledge, this is the first attempt, which defines mathematically such new formulae. To assess the performance of these newly developed operators, we conducted an extensive computational test using the well-known three sets (small, medium and large) vehicle routing problem (VRP) instances. Comparison against the crude approach is first tested to demonstrate the need for such formulae. Interesting results relating to the solution quality and computational time are obtained. Suggestions on how to extend such work to other related routing problems are also given.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:00, Room - Market Pl Code: OR60A3705

Optimization of Order Picking Operation under Different Storage Location Assignments

Prof Jiyin Liu *(Loughborough University)*

Order picking is often considered as one of the most labour-intensive activities in distribution centre operations. Therefore, optimizing the order picking operation can reduce cost and improve the efficiency of the distribution centre. Most previous order picking models assume that all items of the same stock keeping unit (SKU) stored together. In this study we allow items of the same SKU to be stored in multiple locations and develop an integer programming model for this more general setting to optimize the order picking operation. The model decides the assignment of picking tasks to pickers and the route for each picker. It has been tested on illustrative small instances. The performances of the multiple-location assignment strategy and the traditional storage method are compared under different picking policies (picking-by-article /picking-by-order). The results show that the proposed multiple-location storage method has advantages.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant

13/09/2018, 11:30, Room - Market Pl Code: OR60A3379

Real-Time Railway Rescheduling Using Branch and Price

Mr Edwin Reynolds *(Lancaster University)*

This talk will give an introduction to the practical and theoretical aspects of my PhD research, which is partnered by Network Rail. It is concerned with the computation of new railway schedules in the face of disruption, with the aim of minimising the knock-on delay that occurs as a result of an initial disruption. This knock-on delay is thought to account for over half of all delay in Britain's railway network. I will present a multicommodity-flow-type integer programming formulation for this problem, and show how this can be efficiently solved using Branch and Price (column generation) techniques. I will finish by mentioning some possible improvements to the way in which the problem is modelled and solved.

What is the nature of your talk? A mix
Does your talk require prior knowledge of the subject area? Some
Is your talk accessible and relevant to practitioners? Somewhat

13/09/2018, 12:00, Room - Market Pl Code: OR60A3448

Biased Randomised Iterated Greedy with Local Search for Railway Scheduling in the Presence of Uncertainties

Mr Nattapol Paisarnvirosrak, Dr Banafsheh Khosravi and Prof Djamila Ouelhadj *(University of Portsmouth)*

Railway scheduling and rescheduling play a central role in day-to-day railway operations. Trains on a railway network are scheduled and controlled according to a timetable. However, trains are not always run based on the proposed timetable because there might be some unpredictable disruptions due to excessive dwell times at stations, infrastructure and/or train faults, and the late arrival of crew. In this study, we aim to minimise the total delay of trains while considering passenger safety and regulation principles including running times, headway and signalling system constraints. The problem is formulated as a Modified Blocking Job Shop Scheduling (MBJSS) model, which is adapted from the classical job shop scheduling model.

We propose the Biased Randomised Iterated Greedy with Local Search (BRIGLS) to solve the railway re-scheduling problem in the presence of delays caused by travelling/dwell time delay and late departure time. BRIGLS algorithm employs two phases in the search process for each iteration, namely destruction and construction. The destruction phase eliminates randomly some trains from the current solution, thus obtaining a partial solution. The construction phase inserts some trains into the partial solution until a complete one is obtained. The biased randomised concept is applied in the construction phase to select a train which is not sequenced before to be inserted it the partial solution. The local search is employed to intensify the search for better solutions around the complete solution generated by the construction procedure. To evaluate the performance of the proposed optimisation model and the solution method, we have conducted computational experiments using a real-world case study from the railway network in Thailand. The results show that the BRIGLS algorithm has outperformed the solution used by the railway network in Thailand and it can improve the efficiency of Thailand railway management by decreasing the total train delays.

What is the nature of your talk? Practical
Does your talk require prior knowledge of the subject area? A little
Is your talk accessible and relevant to practitioners? Relevant