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OPTIMISE 18

MATHEMATICAL INNOVATION

PROGRAM BOOKLET

THE UNIVERSITY OF MELBOURNE

18–22 JUNE

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AMSI OPTIMISE 2018

Decision Making Under Uncertainty and Humanitarian Applications

The University of Melbourne | Monday 18 – Friday 22 June

DAY 1: MONDAY 18 JUNE 2018

Optimisation Under Risk

0800 - 0830	**Opening Business Breakfast *sponsored by Biarri*** University House at The Woodward, Melbourne Law School
0830 - 0900	Welcome to be delivered by: Professor Geoff Prince, AMSI, Professor Kate Smith-Miles, The University of Melbourne, Professor Peter Taylor, ACEMS Opening remarks by **Joe Forbes,** Biarri
0900 - 0930	
0930 - 1000	**RELOCATE to Melbourne School of Design, The University of Melbourne**
1000 - 1030	**Plenary:** Risk and Reliability in Optimization Under Uncertainty **Professor Emeritus R. Tyrrell Rockafellar** University of Washington, USA
1030 - 1100	
1100 - 1130	Uncertainty and Monetary Policy in Good and Bad Times **Dr Gabriela Nodari** Reserve Bank Australia
1130 - 1200	Reconstruction of missing data by optimal transport: applications in finance **Professor Gregoire Loeper,** Centre for Quantitative Finance and Investment Strategies, Monash University
1200 - 1300	**LUNCH**
1300 - 1330	**Plenary:** Progressive Hedging in Nonconvex Stochastic Optimization **Professor Emeritus R. Tyrrell Rockafellar** University of Washington, USA
1330 - 1400	
1400 - 1430	Predictability, and its Discontents **Dr Darryn Reid** Defence Science and Technology Group
1430 - 1500	
1500 - 1530	**AFTERNOON TEA**
1530 - 1600	Industry Challenge: Plan, React, Repeat **Alan Dormer** Opturion
1600 - 1630	
1630 - 1700	Day 1 Wrap Up

DAY 1 – Monday 18 June

OPENING REMARKS

Joe Forbes, Biarri

Joe believes that commercial mathematics is only truly powerful when it is simple to use and produces real world results. Joe is creating a group of Biarri businesses that blend good design and mathematics, providing accessible business analytics and optimisation. Most importantly he wants to work with smart people who build clever solutions that Biarri's clients love to use.

PLENARY: RISK AND RELIABILITY IN OPTIMIZATION UNDER UNCERTAINTY

Professor Emeritus R. Tyrrell Rockafellar, University of Washington, USA

Problems of optimization are concerned with making decisions "optimally" however in many situations in management, finance and engineering, decisions have to be made without knowing fully how they will play out in the future. When the future is modeled probabilistically, this leads to stochastic optimization, yet the formulation of objectives and constraints can be far from obvious. A future cost or hazard variable may be a random variable which a present decision can influence to some extent, but maybe only in shaping its distribution in a limited way. For instance, it may be desirable to keep a hazard below a particular threshold, like building a bridge to resist earthquakes and floods, and yet it may be impossible or too expensive to guarantee that the threshold will never be breached.

One needs to have a standard according to which a cost or hazard is "adequately" below the desired threshold in line with its probability distribution. That is the role for so-called "measures of risk," which started to be developed for purposes like assessing the solvency of banks but now are being utilized much more widely. Measures of risk also offer fresh ways of dealing with reliability constraints, such as have traditionally been imposed in engineering in terms of bounds on the probability of failure of various manufactured components. Probability of failure has troublesome mathematical behavior in an optimization environment. Now, though, there is a substitute, called buffered probability of failure, which makes better sense and is much easier to work with computationally.

R. Tyrrell ("Terry") Rockafellar is an American mathematician and one of the leading scholars in optimization theory and related fields of analysis and combinatorics. He is professor emeritus at the departments of mathematics and applied mathematics at the University of Washington, Seattle.

His research interests span convex and variational analysis, with emphasis on applications to stochastic programming, optimal control, economics, finance, and engineering.

For his contributions to convex optimization, nonsmooth analysis, and stochastic programming, Rockafellar was awarded the John von Neumann Theory Prize by the Institute for Operations Research and the Management Sciences (INFORMS) in 1999. His decades long career in the field was celebrated, ranging from his 1963 PhD dissertation to his more recent work on scenario analysis and epiconvergence.

UNCERTAINTY AND MONETARY POLICY IN GOOD AND BAD TIMES

Dr Gabriela Nodari, Reserve Bank of Australia

We investigate the role played by systematic monetary policy in the United States in tackling the real effects of uncertainty shocks in recessions and expansions. We model key indicators of the business cycle with a nonlinear vector autoregression model that allows for different dynamics in busts and booms. Uncertainty shocks are identified by focusing on historical events that are associated with jumps in financial volatility. Our results show that uncertainty shocks hitting in recessions trigger a more abrupt drop and a faster recovery in real economic activity than in expansions. Counterfactual simulations suggest that the effectiveness of systematic US monetary policy in stabilising real activity in the aftermath of an uncertainty shock is greater in expansions. Finally, we provide empirical and narrative evidence pointing to a risk management approach by the Federal Reserve.

Gabriela Nodari is an economist at the Macroeconomic Modelling division of the Reserve Bank of Australia. She is also an Ambassador of the RBA's Public Access and Education Program, and has given a number of educational talks to external audiences. Prior to joining Macro Modelling, she worked in the Research Department of the RBA. Her research interests and expertise are in the area of monetary policy using techniques based on time series econometrics and network analysis. She has published in international academic journals on topics including economic uncertainty and fiscal policy. Dr Nodari obtained her Ph.D. in Economics and Finance from the University of Verona in 2015. She has a M.A. in International Economics and a B.A. in Business Administration and Economics. She completed a postdoctoral research fellowship at UNSW Sydney, and has been a research visitor at the Reserve Bank of New Zealand, before joining the RBA in early 2016.

RECONSTRUCTION OF MISSING DATA BY OPTIMAL TRANSPORT: APPLICATIONS IN FINANCE

Professor Gregoire Loeper, Centre for Quantitative Finance and Investment Strategies, Monash University

Optimal Transport is an old optimisation problem that goes back to Gaspard Monge in 1781. Following the seminal work by Benamou and Brenier in 2000 on the time continuous formulation of the Optimal Transport problem, we show how similar techniques can be used to address a problem of model calibration in finance.

Gregoire Loeper is a Professor of Mathematics at Monash University since September 2015. He completed his PhD in mathematics in 2003, then was appointed Assistant Professor at Claude Bernard Lyon 1 University. He then moved to the finance industry where he worked during 9 years for Global Equity and Commodity Derivatives within BNP Paribas. He occupied there several positions, as a quantitative analyst, then as head of Structured Products Pricing in London, and finally head of Systematic Strategies and Hybrids Quantitative Research. Since his arrival at Monash, he is the director of the Master of Financial Mathematics, and the director of the Centre for Quantitative Finance and Investment Strategies.

His areas of research are: Non Linear PDE's, Stochastic Control, Mathematical Finance, Fluid Mechanics, Optimal Transport.

PLENARY: PROGRESSIVE HEDGING IN NONCONVEX STOCHASTIC OPTIMIZATION

Professor Emeritus R. Tyrrell Rockafellar, University of Washington, USA

The progressive hedging algorithm minimizes an expected "cost" by iteratively decomposing into separate subproblems for each scenario. Up to now it has depended on convexity of the underlying "cost" function with respect to the decision variables and the constraints on them. However, a new advance makes it possible to obtain convergence to a locally optimal solution when the procedure is executed close enough to it and a kind of second-order local sufficiency condition is satisfied. This can moreover work not just for an expectation but also for minimizing a risk objective or buffered probability of exceedance.

R. Tyrrell ("Terry") Rockafellar is an American mathematician and one of the leading scholars in optimization theory and related fields of analysis and combinatorics. He is professor emeritus at the departments of mathematics and applied mathematics at the University of Washington, Seattle.

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PREDICTABILITY, AND ITS DISCONTENTS

Dr Darryn Reid, Defence Science and Technology Group

We find ourselves, happily, on the cusp of scientific revolution. Recent years have seen a rapidly growing recognition, across many scientific fields, of the ubiquitous presence in application domains of deep uncertainty and complexity. We often hear the problem couched in terms of a metaphoric hedge of uncertainty and complexity phenonema that has sprung up and flowered over our familiar methods, as if complexity and uncertainty were something new, at least in measure if not in essence, and as if our growing awareness were primarily an empirical matter. Yet arguably what is new is not the presence of complexity and uncertainty phenomena in the worlds of our studies, nor the availability of the empirical evidence, but rather the expanding transdisplinary scientific basis in theory by which we look for the evidence in the first place and then comprehend its meaning.

Uncertainty manifests in defence and military circles overwhelmingly in problem contexts dominated by the potential for catastrophic failure, particularly cascading systemic failure; indeed, it is difficult to imagine a defence problem domain where unpredictability and failure are not predominant – the predominant – features. Yet traditional analysis approaches often struggle to handle multiple kinds of failure and often fail to treat deep uncertainty at all. The convenience of degenerate symmetry conditions that do not hold in messy application domains is simply unsustainable. Moreover, uncertainty also creates opportunity just as readily as it does the possibility of failure; there is more to handling failure and opportunity under uncertainty than maximising expected future utility. While defence and military matters are hardly unique in this regard, the extreme nature of the problem environments here perhaps brings manifestations of deep uncertainty through failure potential and opportunity into starkest relief.

The need for expansion of both the fundamental theory about the nature of uncertainty and how we might effectively deal with it and the application of theory to practical matters across the sciences suggests mathematics may find itself again poised in a uniquely central position. In a time when the almost ubiquitous emphasis in research resource allocation remains on demonstrating immediate application, the need and opportunity for the development of coherent new mathematical theories to support and enable the applied sciences has ironically perhaps never been greater. We find ourselves, happily, on the cusp of a mathematically enabled revolution.

Dr Darryn J Reid is Principal Scientist in the Defence Science and Technology Group, and has been with DSTG since 1995. He has worked in distributed systems, machine learning and artificial intelligence, semantics and interoperability, formal reasoning and logics, operations research, optimisation and control, electronic warfare, intelligence analysis, missile targeting and control, command support systems, complexity, nonlinear dynamics and ergodic theory, web-based technologies, software development, functional languages, formal languages and model theory, theory of computation and algorithmic information theory, crowd modelling, economic theory and military theory. He holds the degrees of Bachelor of Science in Mathematics and Computer Science, Bachelor of Science with First Class Honours in Mathematics and Computer Science, and Doctor of Philosophy in Theoretical Computer Science from the University of Queensland. He has strong research interests in pure and applied mathematics, theoretical and applied computer science, philosophy, military theory and economics.

INDUSTRY CHALLENGE: PLAN, REACT, REPEAT

Alan Dormer, Opturion

Alan has a track record of growing high technology companies based on research & development, innovation, and mutually beneficial partnerships with multi-national customers.

He has created significant value from the development and application of technology in a number of areas including information management, decision support, analytics, automation and, most recently, big data and behavioural science.

His work is informed and enriched by his international business experience and is making a significant contribution to creating sustainable wealth creation in the digital and knowledge economy of Australia.

DAY 2: TUESDAY 19 JUNE 2018

Disaster Management

0900 - 0930	**Plenary:** Applied network design problems to support humanitarian operations **Associate Professor Marie-Ève Rancourt** HEC Montréal
0930 - 1000	
1000 - 1030	Burning down stereotypes **Craig Brownlie** Country Fire Association
1030 - 1100	**MORNING TEA**
1100 - 1130	**Industry Challenge: Disaster Management and Public Safety** Black Swans and Perfect Storms: Challenges in disaster management and resilience research, **Professor Greg Foliente** Critical incidents and next generation public safety, **Ged Griffin** Centre for Disaster Management and Public Safety (CDMPS)
1130 - 1200	
1200 - 1300	**LUNCH**
1300 - 1330	**Disaster Management and Public Safety Panel Discussion** Professor Greg Foliente, CDMPS, Ged Griffin, Victoria Police and CDMPS, Steve Tsikaris, Department of Treasury and Finance, David Williams, CDMPS, Paul Barnard, The University of Melbourne
1330 - 1400	
1400 - 1430	Optimisation and quantitative risk opportunities in preparedness, mitigation and emergency management **Dr Simon Dunstall** CSIRO Data61
1430 - 1500	
1500 - 1530	**AFTERNOON TEA**
1530 - 1630	Hands-On Session: Influence Charts **Associate Professor Maria Antónia Carravilla** Universidade do Porto, Portugal
1630 - 1730	
1730 - 1930	**RELOCATE**
	Informal offsite dinner

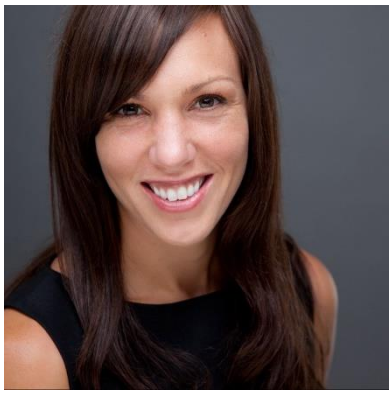
DAY 2 – Tuesday 19 June

PLENARY: APPLIED NETWORK DESIGN PROBLEMS TO SUPPORT HUMANITARIAN OPERATIONS

Associate Professor Marie-Ève Rancourt, HEC Montréal

In Africa, annual weather patterns cause recurrent shocks that expose populations to severe food insecurity. Conflicts across the region, the population health and economic vulnerabilities generate crises and trigger the need for humanitarian assistance and development programs. In April 2015, Nepal was hit by a 7.8 magnitude earthquake, which caused important damages. Many of the most affected communities were located in remote mountainous areas and were left out of access to secure water sources due to the destruction of the supply system. During this presentation, different research projects related to logistics decision planning for mitigating the consequences of such issues will be presented. All these projects are based on studies made in collaboration with different humanitarian organizations and use real data. The solution approaches were developed using techniques rooted in operations research principles, such as optimization, simulation, mathematical programming and statistical analyses.

The studies that will be presented concern network design problems arising in three different contexts: relief item prepositioning (Uganda), community healthcare services (Liberia), and water supply system restoration (Nepal). The rewards and challenges of OR applied research to support humanitarian operations in developing countries will also be discussed.



Marie-Ève Rancourt is an associate professor of operations management at HEC Montréal. She is also a member of the Interuniversity Research Center on Enterprise Networks, Logistics and Transportation (CIRRELT) and the Canadian Research Institute on Humanitarian Crisis and Aid (OCCAH), and affiliated with the Massachusetts Institute of Technology (MIT). Her research interests are in the areas of humanitarian logistics, supply chain and transportation using techniques based on operations research and econometric.

Her recent work focusses on the use of mathematical modeling to solve real problems in applications with social impacts, particularly logistics problems related with relief operations, food security and healthcare delivery in developing countries. She is working in collaboration with different organisations, such as the WFP, Red Cross, and Last Mile Health to develop analytical methods for managing supply chains and access populations located in underserved areas. She received her Ph.D. in management science from HEC Montreal in 2013; a M.Sc. in modeling and decision support from HEC Montreal in 2007; and a B.Sc. in mathematics from the University of Montreal in 2004.

BURNING DOWN STEREOTYPES

Craig Brownlie, Country Fire Association

This presentation will examine contemporary firefighting and what fire services need to continue to meet community expectation now and into the future. It will look at what role technology has in delivering services to a diverse range of communities and incident types.

In 2014 CFA led a National fire service response to Hazelwood mine in the Latrobe Valley after neighboring bushfires resulted in large areas of the brown coal open cut to catch fire. This highly complex fire posed many challenges that needed to be overcome, we will discuss the science and technology used to inform decision makers and assist firefighters in suppressing this incident.

The world around us is continually changing with research, scientific discoveries, equipment development and innovation occurring continually. In this dynamic environment firefighter's safety is vital to CFA's ability to respond to emergencies. New safety initiatives of health science, vehicle design, crew burn over protection and plume modelling will be reviewed in the context of exposing firefighter stereotypes.

Craig joined the Country Fire Authority (CFA) Victoria as a Volunteer firefighter in 1991, and was successful in obtaining a position as a career firefighter with CFA in 1995. After completion of recruit training, Craig was stationed to Melbourne's vibrant multicultural South Eastern suburbs, where he became involved with the migrant and refugee communities. It was during this time, that he worked on projects to improve safety of newly arrived migrants, including the Multilingual Guide and Multicultural Recruitment Campaign. Subsequently, the Multilingual Guide was recognised with a Fire Safety Award in 1998.

Craig's career has seen him attend some of Victoria's largest emergencies, including the rescue of 85 people from Arthurs Seat chairlift in January 2003; coordination of Urban Search and Rescue to support Victoria Police – Disaster Victim Identification Unit post Black Saturday fires in February 2009; and Deputy Incident Controller for the Hazelwood mine fire in February 2014. One of Craig's career highlights was his selection to represent Australia during the 2015 deployment supporting the United States Forest Service. This saw him work as part of Incident Management Teams supporting in-field safety.

In 2009, Craig accepted the position of Operations Officer Specialist Response at CFA headquarters. This diverse portfolio is responsible for planning and implementing CFA's Hazardous Materials, in addition to Technical and Road Accident Rescue programs. Some of the key achievements that Craig has led include the design, construction and deployment of specialist operational vehicles, and the development of multi-agency technical rescue teams in Regional Victoria. Craig is currently the Operations Manager Structural Fire Planning look at operational capability improvements for urban fire response.

BLACK SWANS AND PERFECT STORMS: CHALLENGES IN DISASTER MANAGEMENT AND RESILIENCE RESEARCH

Professor Greg Foliente, Centre for Disaster Management and Public Safety (CDMPS)

The evolving hazards and risk landscape, and the global trends in urbanisation, technology and societal behaviours have significant influence on how we plan against and recover from extreme events. The implications of the broad typology of extreme events – based on the levels of uncertainty, its duration, the warning-time window – on resilience planning are explored. The characteristics of "black swans", "perfect storms" and cascading failures are described. The data/information requirements and the critical research and development challenges from the perspective—and for the benefit—of key stakeholders, considering their primary decision goals and context, are identified. Understanding system interdependencies and developing methods of assessing or modelling the broader socioeconomic impacts of extreme events on communities and industries are key challenges. These could provide guidance in setting priorities for disaster management and resilience planning investments. Other emerging research challenges such as sense-making and decision-making under deep uncertainties, incomplete information and sometimes intense pressure are explored.

CRITICAL INCIDENTS AND NEXT GENERATION PUBLIC SAFETY

Ged Griffin, Victoria Police and Centre for Disaster Management and Public Safety

Emergencies and disasters are becoming more frequent and having a greater impact on communities around the world. Against this background public safety officials and response agencies are faced with more complex, dynamic and time critical decisions using a management system that appears to struggle to cope with catastrophic events. The development of new algorithms and approaches to support decision making during these events has the potential to provide significant community value. In order to bridge the gap between theory and practice, it is essential that researchers understand the practical environment in which their novel algorithms and systems will be applied. This presentation will outline some of the practical challenges associated with disaster management and provide participants with an overview of the operational context in which public safety officials operate in.

DISASTER MANAGEMENT AND PUBLIC SAFETY PANEL DISCUSSION

Professor Greg Foliente, CDMPS

Professor Greg Foliente is Enterprise Professor in the Melbourne School of Engineering and Deputy Director of the University of Melbourne's Centre for Disaster Management and Public Safety (CDMPS). He leads interdisciplinary and transdisciplinary research, education, consulting and collaboration initiatives that advance innovation in the built environment and urban systems sectors, with a primary focus towards improved sustainability, liveability and resilience. He has an international reputation in research innovation and science leadership that have been recognised through numerous honours and awards (18 so far including the ASCE James Croes medal), invitations as a keynote speaker in international conferences (35 so far) and to esteemed positions in international scientific committees and leading overseas institutions. His research has encompassed diverse areas that include engineering safety and performance assessment under extreme events, quantitative risk

analysis and system reliability, disaster mitigation, socio-economic impacts and resilient design, spatial diffusion of technology and innovation, and more recently, urban community wellbeing and resilience. He is a strategic leader and facilitator, with a number of internationally recognised achievements and successful projects, including those undertaken with industry, UN agencies, the World Bank, AusAID and various Australian federal departments and state agencies.

Ged Griffin, Victoria Police and CDMPS

Ged Griffin has been a member of the Victoria Police Force for approximately 32 years and is currently an Inspector at the Capability Department. He has performed duties in general operations, disaster management, marine policing, criminal investigations, intelligence and counter terrorism operations. He has performed a wide range of international roles including duties at the UN Serious Crimes Unit (Timor Leste), Victoria Police Contingent Commander and as Liaison Officer supporting the former Victorian Premier Hon Mr Steve Bracks during his work assisting the new government of East Timor. Ged was involved in establishing the Victoria Police Counter Terrorism Coordination Unit and was the project manager responsible for replacing Victoria Police's metropolitan analogue radio network for a new state of the art digital radio network. Ged actively researches new and evolving technologies that impact on police operations and public safety and is regularly invited to conferences around the world to speak about his work. Ged is also a member of the Australian Civil Corps and has been a Team Leader for the Post Disaster Response Team. He has also conducted assessments in the Asia/Pacific region regarding national disaster risk management arrangements on behalf of the Department of Foreign Affairs and Trade. During 2015 Ged took leave from Victoria Police to establish and manage the Centre for Disaster Management and Public Safety at the University of Melbourne. In 2016 he was invited to take on a role as a Visiting Fellow at the Australian Institute of Police Management in Sydney New South Wales. In 2017 he established the International Critical Control Room Alliance with a number of colleagues involved in public safety communications.

Steve Tsikaris, Department of Treasury and Finance

Steven Tsikaris is an Executive in the Commercial Division of the Victorian Department of Treasury and Finance. He has over 30 years experience in government, and for the last 20 years has worked on government reform programs and delivering a range of commercial projects within the Victorian Treasury. He has focussed on energy, transport and environment sector issues, and more recently, Victoria's infrastructure and technology requirements. His work involves assessing the rationale, the risk, the viability and the commercial considerations associated with project delivery. His professional interests are in risk management, dispute resolution and public policy, and an advocate for using evidenced-based decision making in government administration. He is Treasury's senior official to the Victorian State Crisis and Resilience Council and on the International Advisory Committee of the Centre for Disaster Management and Public Safety at the University of Melbourne. Steven has a Bachelor of Science (physics) from the University of Melbourne and a Executive Master of Public Administration also from the University of Melbourne and the Australia and New Zealand School of Government.

David Williams, CDMPS

David Williams is a Senior Industry Advisor at the Centre for Disaster Management and Public Safety within the University of Melbourne. David holds a Master of Education and a Graduate Certificate in Applied Management. He retired from Victoria Police in July 2015 after 38 years of service. During the course of his career, David received numerous formal awards including the disaster management medal for his significant role during the Black Saturday Bush Fires response. He was also involved in response and recovery management for both the significant floods and the Hazelwood fire events. During the last 6 years of his career he was the manager of the Victoria Police Critical Infrastructure Protection Unit. David was the state representative at a number of national industry sector forums and worked closely with a number of Federal Government departments and agencies. David's active promotion of partnership approaches saw many successful local, state and multi-jurisdictional exercises conducted to benefit a broad cross section of stakeholders. Prior to his last role with Critical Infrastructure David managed Communication Infrastructure Programs for Victoria Police and in particular the Computer Aided Dispatch and Geospatial Service state wide delivery models. David was a past president of the Australian Association for Public Safety Communications Officials and has presented extensively in many forums in both the USA and UK. In 2014 David was appointed a Visiting Fellow at the University of Melbourne.

Paul Barnard, The University of Melbourne

Paul Barnard is currently employed at the University of Melbourne to implement a comprehensive Incident Management approach to critical incidents and emergencies that can impact the University's staff, students and campuses here and overseas. Melbourne University has approximately 65000 students, 12500 staff at the main Parkville campus and 5 other campuses as well as international sites. There are about $6.5B worth of physical assets that also require preventative protection. He has had a career of over thirty years in Emergency and Business Management. He has tertiary qualifications in Forestry, Business Management and has recently completed a post as the CEO for Integral Institute (a systems and emotional intelligence framework approach) for 3 years. Previously, he has provided consultancy services for over fourteen years, to a diverse range of State and Local governments, large private sector firms and individuals in strategic, emergency management, organisational reform and leadership. Senior operational roles in the rural fire services over the mid part of his career (16 years) saw him manage inter-agency Regional and State control-centres with teams of over 100 individuals operating under significant pressure. It was here that Paul became interested in and has been an advocate of building upon enterprise excellence principles and systems approaches to elevate personal and team performance. These techniques are about developing shared values and behaviours for groups, defining processes that enable measurement and continuous improvement and integrating system thinking and communication.

OPTIMISATION AND QUANTITATIVE RISK OPPORTUNITIES IN PREPAREDNESS, MITIGATION AND EMERGENCY MANAGEMENT

Dr Simon Dunstall, CSIRO Data61

Natural hazard preparedness, risk mitigation and emergency management give rise to a range of problems in optimisation and quantitative risk which are challenging to solve. Great value, in economic and social terms, can be generated through putting in place well-crafted solutions to these problems. With increasing regularly, such solutions are indeed being developed and applied in full in practice. In this presentation I will walk through a set of case studies and future opportunities drawn from real applications in our region, where researchers are partnering with organisations including Australian state governments, forestry companies and water authorities in South America, and the UN World Food Program. These include the planning of utility infrastructure changes, the logistics of relief and recovery operations to islands, matching humanitarian donations and needs, data science for understanding wildfire combat effectiveness, and applying real options techniques for long-term coastal hazard mitigation and firefighting resource deployment.

Simon Dunstall is the Director of the Decision Sciences program in CSIRO Data61. Simon has been the leader and/or principal investigator in numerous research project teams looking at supply chain and logistics, service delivery systems, infrastructure and natural hazards during an R&D career spanning two decades. He is an Operations Research (OR) practitioner with a record of publications at international conferences and in academic and industry journals, and over the past ten years has delivered many talks, seminars and short courses to industry on data science, logistics, warehousing and distribution, and infrastructure planning. He is the Victorian and immediate-past National President of the Australian Society for Operations Research, and has been a national committee member for the Logistics Association of Australia.

HANDS-ON SESSION: INFLUENCE CHARTS

Associate Professor Maria Antónia Carravilla, Universidade do Porto, Portugal

Influence charts are simple diagrams which can provide a high-level view of a problem in the early, conceptual stages of a modelling process. They are graphical representations of the relations between decisions, external factors and outcomes.

During this session, we will build influence charts for several proposed problems. We will make some examples together, and, based on these examples, you will draw the other ones in small groups.

Influence charts are a tool which supports teams through the modelling process and can be very effective in communicating the essence of a modelling approach to others, and you will be able to use it at the end of this hands-on session.

Maria Antónia Carravilla is a teacher at Universidade do Porto (U.Porto) since 1985 and a researcher at INESC-TEC since 1990. She has been also visiting professor at Universidade de São Paulo. She is the Director of the Doctoral Program in Engineering and Industrial Management since 2016.

The applications of combinatorial optimization are related with Nesting Problems, Lot-Sizing, Staff Scheduling, Retail Shelf Planning, Supply Chain Management, Fleet Management, Pricing, etc. Methodologically the emphasis has been on optimization, namely through mathematical programming and constraints programming models and their hybridization with heuristics methods.

Maria Antónia received twice the award for best paper published in the previous two years by members of APDIO and as a result of the work developed in Retail Shelf Planning, our team was a finalist of the "Wagner Prize", awarded by INFORMS.

As a teacher at U.Porto, she has been responsible for several courses related with Operations Research, Operations Management and Logistics that were taught at the BSc, MSc and PhD levels. She has supervised several PhD and MSc students whose theses were developed in academia as well as in industry.

DAY 3: WEDNESDAY 20 JUNE 2018

Optimisation Practice

0900 - 0930	**Plenary:** OR Inside **Associate Professor Maria Antónia Carravilla** Faculdade de Engenharia da Universidade do Porto, Portugal
0930 - 1000	
1000 - 1030	Case Study (Introduction): Redesigning medical wards by optimally allocating specialties to minimize outliers **Dr Vicky Mak-Hau,** Deakin University
1030 - 1100	**MORNING TEA**
1100 - 1130	Hands-On Session: Solving a logistics distribution problem using mixed-integer programming and matheuristics **Dr Alysson Costa**, The University of Melbourne & **Pedro B. Castellucci**, The University of Melbourne and University of São Paulo
1130 - 1200	
1200 - 1230	
1230 - 1330	**LUNCH**
1330 - 1415	**Women in Optimisation Panel** *Chair: Professor Kate Smith-Miles* Assistant Professor Marie-Ève Rancourt Associate Professor Maria Antónia Carravilla Alison Harcourt
1415 - 1500	Optimisation in the Darkness of Uncertainty: When you don't know what you don't know, and what you do know isn't much! **Professor Kate Smith-Miles**, The University of Melbourne
1500 - 1530	**AFTERNOON TEA**
1530 - 1630	Case Study Continued Workshop **Dr Vicky Mak-Hau,** Deakin University
1630 - 1700	Case Study Continued Solutions Presentation **Dr Vicky Mak-Hau**, Deakin University
1700 - 1730	APR.Intern Presentation & Poster Presentations
1730 - 1930	**Networking Drinks & Research Workshop Welcome** Melbourne School of Design, The University of Melbourne

DAY 3 – Wednesday 20 June

PLENARY: OR INSIDE

Associate Professor Maria Antónia Carravilla, Universidade do Porto, Portugal

The main objective of this talk is to present some experiences of our research group on OR projects with industry/services/government. These projects have been running for several years and some time ago we made some reflexions about the characteristics that led some of them to be successful and others not so much. In this talk I will describe some of these projects and make a characterization of their risk of success.

A project concerns a chemical company and the goal was to optimize the production and storage of several products and by-products of the production chain so that demand is met and the capacity of the production elements is not exceeded. Another project regards a rent-a-car company and aimed at assigning reservations to vehicles, including the decisions of accepting or not a reservation and of moving cars to a different station, with the objective of maximizing the overall profit. In this third project, we have been challenged by the municipality of Porto in order to rationalize their use of the buildings spread throughout Porto.

These projects resulted in decision support tools that are being regularly used by the organizations, with OR Inside.

Maria Antónia Carravilla is a teacher at Universidade do Porto (U.Porto) since 1985 and a researcher at INESC-TEC since 1990. She has been also visiting professor at Universidade de São Paulo. She is the Director of the Doctoral Program in Engineering and Industrial Management since 2016.

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Case Study: Redesigning medical wards by optimally allocating specialties to minimize outliers

Dr Vicky Mak-Hau, Deakin University

In this case study, we will work on the optimal allocation of medicine specialties to a number of medical wards in a hospital, subject to a number of business requirement constraints, e.g., specialties in the same program must be close to each other, no more than a certain number of specialties can be allocated to the same ward, some specialties cannot be in the same wards, and some wards must be in the same floor level. A set of simulated data will be provided: the daily patient number by specialty over a two-year horizon, these data are simulated based on the distribution and seasonal change of specialty patient numbers featured in the real data provided to us by a hospital. The objective is to allocate the specialties to medical wards optimally such that the total number of patients that cannot be allocated to the ward that is designated to the specialty he/she is treated for will be minimized.

Dr Vicky Mak-Hau is Associate Head of School, Industry Research in the School of Information Technology at Deakin University. Her research interest and expertise is in combinatorial optimisation with a focus on mixed-integer linear programming, meta-heuristic methods, polyhedral combinatorics, and graph labelling. Areas of application include machine scheduling, vehicle & robotics routing, aircraft/fleet routing & maintenance scheduling, timetabling, telecommunications and wireless network architecture design, and various areas of healthcare such as kidney matching, day oncology unit patient scheduling, medical ward allocation, and radiotherapy treatment planning. Her research aims at developing efficient solution algorithms with computational results that outperform leading reports in the literature at the time. Dr Mak-Hau obtained her PhD in mathematics from the University of Melbourne in 2002, and completed postdoctoral research fellowship at CMIS/CSIRO and at the University of Melbourne before joining Deakin University in 2004. She was one of the chief investigators in two Australian Research Council discovery projects, and is currently a collaborating university researcher with the Defence Science and Technology (DST) Group.

HANDS-ON SESSION: SOLVING A LOGISTICS DISTRIBUTION PROBLEM USING MIXED-INTEGER PROGRAMMING AND MATHEURISTICS

Pedro B. Castellucci, The University of Melbourne and University of São Paulo
Dr Alysson M. Costa, The University of Melbourne

Logistic distribution problems concern the transportation of goods from origin (supplier) to demand (consumer) points, usually with the goal of minimising routing costs. In this hands-on session, we will describe a simple logistics distribution problem in which suppliers can collaborate with cross-product delivery. Participants will help model, implement and solve the problem using mixed-integer programming. In the second part of this session, these models will be modified to act as heuristic methods and obtain feasible solutions in shorter computational times.
All implementations will be made using Julia Programming Language and the JuMP package using the Juliabox web-based interface. No prior experience with these technologies is required to follow the session.

Alysson M. Costa is a Senior Lecturer in Operations Research at the School of Mathematics and Statistics – University of Melbourne. Alysson is interested in theory and applications of Optimisation. Throughout his career, he has worked extensively with mixed integer programming (modelling and solution methods) applied to problems in different areas such as environmental water management, disaster relief operations, educational timetabling, crop rotation, assembly line balancing and city logistics, among others.

He received his PhD in 2006 from HEC Montreal / University of Montreal - Canada. His thesis, titled "Models and algorithms for two network design problems", received the Cecil Graham doctoral dissertation award from the Canadian Applied and Industrial Mathematics Society. Before that, he received MSc. and B.Eng. Degrees in Electrical Engineering from the State University of Campinas - Brazil.

Pedro Castellucci is a PhD student (joint degree) at University of Sao Paulo/University of Melbourne. Currently, he is working with optimisation models and methods for distribution problems in the context of City Logistics. He graduated in Computer Engineering in 2011 from the University of Sao Paulo with an award from the Brazilian Society of Operations Research due to his undergraduate work on optimisation of assembly lines. After graduation, he worked as an IT consultant contributing in projects related to Computer Vision, Artificial Intelligence, Unmanned Aerial Vehicles and Network Programming. Most of his consulting activities were carried out in Brazil, but he has also developed solutions for a telecommunications company in California (USA). For his Master's degree, he developed a simulation tool for stochastic assembly lines. His main research interests are applications of Linear and Integer Programming and optimisation tools.

OPTIMISATION IN THE DARKNESS OF UNCERTAINTY: WHEN YOU DON'T KNOW WHAT YOU DON'T KNOW, AND WHAT YOU DO KNOW ISN'T MUCH!

Professor Kate Smith-Miles, The University of Melbourne

How do we find the optimal solution for a constrained multiobjective optimisation problem when we have no analytical expression for the objective functions, and very limited function evaluations within the huge search space due to the expense of measuring the objective functions? Calculus can't help you, and trial and error is not an option! This talk will describe a common practical optimisation problem found in many industrial settings with these challenges, and introduce some methods for expensive black-box optimisation. Finally, we will address the question of how best to evaluate the performance of such methods by generating new test instances with controllable characteristics.

Kate Smith-Miles is a Professor of Applied Mathematics in the School of Mathematics and Statistics at The University of Melbourne, and holds a five-year Laureate Fellowship from the Australian Research Council. She is also President of the Australian Mathematical Society, and a member of the Australian Research Council College of Experts from 2017-2019. Prior to joining The University of Melbourne in September 2017, she was Professor of Applied Mathematics at Monash University, where she was also Head of the School of Mathematical Sciences (2009-2014), and inaugural Director of the Monash Academy for Cross & Interdisciplinary Mathematical Applications (MAXIMA) from 2013-2017. She was also previously Head of the School of Engineering and Information Technology at Deakin University (2006-2009) with a Chair in Engineering. She obtained her first Professorship in Information Technology at Monash University, where she worked from 1996-2006. Professorships in three disciplines (mathematics, engineering, and information technology) have given her an interdisciplinary breadth reflected in much of her research.

Kate obtained a B.Sc(Hons) in Mathematics and a Ph.D. in Electrical Engineering, both from The University of Melbourne. Commencing her academic career in 1996, she has published 2 books on neural networks and data mining, and over 240 refereed journal and international conference papers in the areas of neural networks, optimisation, data mining, and various applied mathematics topics. She has supervised to completion 22 PhD students, and has been awarded over AUD$12 million in competitive grants, including 12 Australian Research Council grants and industry awards.

Kate was elected Fellow of the Institute of Engineers Australia (FIEAust) in 2006, and Fellow of the Australian Mathematical Society (FAustMS) in 2008. Awards include: the Australian Mathematical Society Medal in 2010 for distinguished research; the EO Tuck Medal from ANZIAM in 2017 for outstanding research and distinguished service; and the Monash University Vice-Chancellor's Award for Excellence in Postgraduate Supervision in 2012.

In addition to her academic activities, she regularly acts as a consultant to industry in the areas of optimisation, data mining, and intelligent systems. She also actively involved in mentoring, particularly with the aim of encouraging greater female participation in mathematics, and she is Chair the Advisory Board for the AMSI Choose Maths program.

POSTER ABSTRACTS

A TWO-STAGE STOCHASTIC PROGRAMING MODEL TO OPTIMIZE LOGISTICAL DECISIONS IN COLD SUPPLY CHAIN UNDER GOVERNMENT REGULATION

Mahla Babagolzadeh

Co-author: Dr Anup Shrestha, Associate Professor Babak Abbasi, Dr Shane Zhang, Professor Alice Woodhead

Increasing awareness of sustainability in supply chain management has prompted organizations and individuals to consider environmental impacts while optimizing supply chain management. The issues concerning environmental impacts is prominent in cold supply chains due to significant carbon emissions arising from storage and distribution of temperature-sensitive products. This research extends the classical supply chain optimization models, which focus on cost efficiency as a single key performance indicator (KPI), to include other sustainability-based KPIs.

More specifically, the impact of accounting for carbon emissions that arise from unique processes of the cold supply chain consisting of a supplier and multiple retailers in the presence of government regulations is investigated. To this end, we developed a two-stage stochastic programing model to determine replenishment policy and transportation schedules aiming to minimize operational and emissions costs considering demand uncertainty. Since the proposed model contains several nonlinear expressions, we apply linearization techniques to develop an equivalent linear mathematical model. A numerical experiment is used to validate the model and explore the trade-off between emissions and operational costs. Finally, several managerial insights on optimizing cold supply chains are offered through parameter analysis.

OPTIMISATION DESIGN FOR ENERGY-EFFICIENT DOWNLINK CLOUD RADIO ACCESS NETWORKS

Dr Minh Dao

Increasing data traffic and reducing the total network energy consumption are listed among of the top priorities of 5G wireless systems. Cloud radio access networks (C-RANs) have been considered as a promising solution to address these challenging objectives. In this work, we aim to maximise the ratio of network throughput and total power consumption of a downlink C-RAN, where the user association plays a key role in network resource allocation. A mixed-integer non-linear problem is formulated under practical constraints on routing, predefined minimum data rates, fronthaul capacity and maximum transmit power. By using convex and continuous relaxation techniques, an iterative algorithm is proposed with guaranteed convergence to a Fritz John solution of the formulated problem. Significantly, each iteration of the proposed algorithm solves only one simple convex program. Numerical examples with practical parameters confirm that the proposed joint optimisation design markedly improves the C-RAN's energy efficiency compared to benchmark schemes.

OPTIMISATION OF DISASTER WASTE MANAGEMENT SYSTEMS

Cheng Cheng

Co-authors: Professor Russell Thompson, Dr Alysson Costa, Dr Lihai Zhang

The four major stages of disaster management are mitigation, preparation, response, and recovery. Waste management is one of the core activities in the recovery stage and focuses on collecting, reducing or recycling, and final disposal of the remaining waste. The volume of waste generated from a single event can reach 5 to 15 times the annual waste normally produced by affected communities. The clearance, removal, and disposal of such large amounts of debris are costly and time-consuming operations. However, there has been little literature dedicated to the improvement of disaster waste management (DWM) procedures compared to other operations in disaster management. The main objective of this research is to develop an integrated framework to improve DWM. Two sets of models that focus on two topics have been developed, namely reliability analysis of a DWM system and the two-echelon DWM system optimisation. The framework is tested for its validity and capacity for an improved understanding of the challenges in disaster waste clean-up.

STOCHASTIC MINIZINC

David Hemmi

Combinatorial optimisation problems often contain uncertainty that has to be taken into account to produce realistic solutions. This uncertainty is usually captured in scenarios, which describe different potential sets of problem parameters based on random distributions or historical data. While efficient algorithmic techniques exist for specific problem classes such as linear programs, there are very few approaches that can handle general Constraint Programming formulations with uncertainty.

Stochastic MiniZinc is an extension to the Constraint Modelling language MiniZinc, that aims to enable operations research practitioners to study the impact of uncertainty on problems they typically solve using deterministic formulations.

RECONCILIATION OF BACK-CASTED TIME SERIES OF DIFFERENT AGGREGATION LEVELS USING CONSTRAINED OPTIMISATION

Dr Linh Huynh

Co-author: Steve Xu, Dr Kay Cao, Dr Oksana Honchar

Views expressed in this paper are those of the author(s) and do not necessarily represent those of the Australian Bureau of Statistics. Where quoted or used, they should be attributed clearly to the author. The Australian Bureau of Statistics (ABS) is going through a transformation period. As part of the transformation, changes to survey processes and estimation methods may result in changes to time series. Methods have been developed to measure statistical impacts that stem from changes for important time series. After statistical impacts have been detected, usually at highly aggregated level, back-casting can be used to adjust for the break in the series before and after method change. Reconciliation is then needed to distribute the impacts to underlying lower level series; while making sure that the lower level series still add up to the higher level series; and time movement pattern (growth rates) of the series are preserved. Using the ABS Labour Force Survey as a case study, analysis

has shown that Constrained Optimisation method would be a suitable tool for reconciling series at different levels of aggregation; with time movements preserved, while, at the same time, supporting the incorporation of information about relative impacts to lower level series.

CUSTOMIZED ASSORTMENT PLANNING FOR CHEMISTS USING INTERNAL AND EXTERNAL DATA: CASE OF OVER-THE-COUNTER (OTC) DRUGS

Dr Morteza Saberi

Co-authors: Dr Zahra saberi, Dr Bahare Hadad, Dr Omar Hussain, Professor Elizabeth Chang

Assortment planning is of importance for the retailers by which manage their customers' demand according to their needs. Given the competition in their sector, chemists too need assortment planning that requires a customized approach for maintaining their stores in two categories, namely, over-the-counter (OTC) drugs and prescription drugs. Our focus in this paper is planning on the assortment type of OTC drugs. Using customized factors such as specialist office closeness to the store, season, weather, store internal data and google trend data, we propose a customized AP to manage the demand of OTC drugs.

CUSTOMIZED ASSORTMENT FOR ONLINE RETAILERS CONSIDERING BASKET SHOPPING CONSUMER USING REINFORCEMENT LEARNING

Zahra Saberi

Co-authors: Dr Omar Hussain, Dr Morteza Saberi, Professor Elizabeth Chang

Customized assortment (CA) is a powerful approach to manage demand in e-tailing. CA enhances customer satisfaction as well as e-tailer profit by providing dynamic assortment to the customers. Various studies have been done to optimize the goal of CA by considering different aspects of the problem. However, none consider the fact that most customers in online shopping prefer to buy a basket of items which means they consider the whole utility of a basket and not just one specific item. However, incorporating this fact in CA is important but at the same time is complicated to solve. In this paper, we model the problem as a Markov decision framework and use Reinforcement Learning (RL) to solve the proposed model. RL enable us to tackle curse of modelling by using simulations techniques. To tackle the curse of dimensionality we propose a decomposition-aggregation RL technique. In the decomposition stage, we decompose the problem in to multi sub-problems for each product and solve by RL. State definition for each sub-problem is inventory level of the product as well as an aggregate inventory level of other products. Finally, in the aggregation stage, a total reward is computed by using all the sub problem outcome.

OPTIMISATION IN INDUSTRIAL APPLICATIONS: DISASTER MANAGEMENT AND SIGNAL PROCESSING

Dr Nadia Sukhorukova

Co-authors: Dr Julien Ugon, Dr Zahra Roshan Zamir, Dr Behrooz Bodaghi, Mr Aiden Fontes

In this poster, we present two large applications that are based on Optimisation. The first project is disaster management and shift pattern optimisation; and the second one is signal processing. Both projects are based approximation and optimisation (mainly, linear and convex). Some of the results

have been published in peer-reviewed optimisation and applied mathematics journals, while some others are the subject of our current research.

DEVELOPING A COMPREHENSIVE DISASTER EVACUATION PLANNING MODEL FOR URBAN AREAS IN AUSTRALIA

Maziar Yazdani

Co-authors: Assistant Professor Mohammad Mojtahedi, Professor Martin Loosemore

The impacts of devastating natural disasters have increased over the last decades due to abundant factors including unplanned urbanisation and population growth. Hundreds of thousands of deaths and billions of dollars of economic loss due to natural disasters highlight the importance of effective disaster operations management (DOM) for reducing the impacts and improving the response to such events. Recognizing the vulnerable area and grouping them is very important for decision-makers to prepare mitigation plans to reduce the disaster impact in vulnerable areas, and response to the post-disaster urgent relief needs through efficient emergency logistics distribution. This study proposes an approach for clustering the identified urban areas in a city into several groups, where the areas with relatively similar vulnerable characteristics are assigned to the same group, and relatively, their preparedness plans, mitigation plans, and post-disaster urgency attributes can be significantly different from those of any other area groups. This study presents an efficient hybrid method algorithm based on combining Metaheuristic algorithms and support vector machine(SVM) for the optimum clustering vulnerable urban areas.

CLUSTERING ANALYSIS OF VULNERABLE AREAS IN AUSTRALIA'S CITIES AGAINST DISASTERS

Maziar Yazdani

Co-authors: Assistant Professor Mohammad Mojtahedi, Professor Martin Loosemore

Due to an increasing number of disasters, coupling with population growth and the risks of well-unplanned urbanisation, demand for disaster operations management (DOM) has absorbed more attention during the past decade. Evacuation planning is an important component of DOM for protecting lives from disaster and increasing the resiliency of built environment. Although many evacuation studies have been conducted in the past, challenges of evacuating people from cities in response to disaster is still insufficiently explored in Australian urban regions. To fill this research gap, this study introduces a novel mathematical integrated model for evacuation planning in urban regions. Most of the evacuation plans are complex, and frequently characterised by their large-scale sizes and the need for obtaining high-quality solutions in short computing times. Thus, using metaheuristic algorithms to obtain the optimal plan are indispensable. This study also proposes a metaheuristic algorithm which benefit from different random-search strategies to solve the problem in a quicker and optimised way. However, uncertainty is character of a disaster planning, and proposing a hybrid metaheuristic and simulation method can allow decision makers to plan evacuations optimally and finally helping to deal with model uncertainty by integrating simulation into a metaheuristic-driven framework.

DAY 4: THURSDAY 21 JUNE 2018

Workshops

0915 - 0930	**National Plenary:** Optimal Control for Computing Carbon Prices **Professor Christopher Kellett** University of Newcastle
0930 - 1000	
1000 - 1030	Decision-making under severe uncertainty: from worst-case analysis to robust optimization Dr **Moshe Sniedovich**, The University of Melbourne
1030 - 1100	**MORNING TEA**
1100 - 1130	Recursive Evaluate and Cut **David Hemmi**, Monash University / Data61
1130 - 1200	A fixed point operator in discrete optimisation duality **Professor Andrew Eberhard**, RMIT
1200 - 1300	**LUNCH**
1300 - 1330	About Stability of Error Bounds **Associate Professor Alexander Kruger**, Federation University Australia
1330 - 1400	Curve clustering using Chebyshev and Least Squares approximation **Dr Nadia Sukhorukova**, Swinburne University of Technology and Federation University Australia
1400 - 1430	Reducing post-surgery recovery occupancy under uncertainty **Dr Belinda Spratt**, Queensland University of Technology
1430 - 1500	Mathematics in medicine: optimising image acquisition and cancer treatment in radiotherapy **Dr Michelle Dunbar**, The University of Sydney
1500 - 1530	**AFTERNOON TEA**
1530 - 1600	Augmented Benders' Decomposition for Synchromodal Logistics **Andrew Perryman**, Monash University
1600 - 1630	Efficient computation of cost allocations for the Vehicle Routing Problem **Dr Philip Kilby**, CSIRO Data61
1630 - 1700	An algorithm for the network flow problem with multi-transport modes and time window constraints **Chaojie (Jasmine) Guo**, The University of Melbourne

DAY 4 – Thursday 21 June

INVITED SPEAKER: OPTIMAL CONTROL FOR COMPUTING CARBON PRICES

Professor Christopher M Kellett, University of Newcastle

Many governments and international finance organisations use a carbon price in cost-benefit analyses, emissions trading schemes, quantification of energy subsidies, and modelling the impact of climate change on financial assets. The most commonly used value in this context is the social cost of carbon (SCC). Users of the social cost of carbon include the US, UK, German, and other governments, as well as organizations such as the World Bank, the International Monetary Fund, and Citigroup. Consequently, the social cost of carbon is a key factor driving worldwide investment decisions worth many trillions of dollars.

The social cost of carbon is derived using integrated assessment models that combine simplified models of the climate and the economy. One of three dominant models used in the calculation of the social cost of carbon is the Dynamic Integrated model of Climate and the Economy, or DICE. DICE is a relatively low order discrete-time dynamical system which, when coupled with an optimal control problem, can be used to compute estimates of the social cost of carbon. In this talk, I will briefly describe the DICE model and its associated optimal control problem. Subsequently, I will describe some of the interesting numerical techniques and questions that arise in computing estimates in the social cost of carbon.

DECISION-MAKING UNDER SEVERE UNCERTAINTY: FROM WORST-CASE ANALYSIS TO ROBUST OPTIMIZATION

Dr Moshe Sniedovich, The University of Melbourne

Worst-case analysis is an old, controversial tool for the treatment of uncertainty. In contrast, (modern) robust optimization is a relatively new, extremely popular, paradigm for decision-making under uncertainty in the framework of optimization problems. In this presentation we examine the relationship between these two approaches from the view point of Wald's famous maximin principle (circa 1940), recalling that this principle argues that decisions should be ranked according to their worst-case performance, hence an optimal decision is one whose worst-case performance is at least as good as the worst-case performance of any other decision. We draw a distinction between local and global worst-case analysis (hence local and global robustness), clarify the role of constraints in worst-case analysis and robust optimization, and discuss in detail the "conservatism" issue associated with the use of models based on a worst-case approach to uncertainty.

RECURSIVE EVALUATE AND CUT

David Hemmi, Monash University / Data61

Stochastic programming is concerned with decision making under uncertainty, seeking an optimal policy with respect to a set of possible future scenarios. We look at multistage decision problems where the uncertainty is revealed over time. First, decisions are made with respect to all possible

future scenarios. Secondly, after observing the random variables, a set of scenario specific decisions is taken. Our goal is to develop algorithms that can be used as a back-end solver for high-level modelling languages. We propose a scenario decomposition method to solve multistage stochastic combinatorial decision problems recursively. Our approach is applicable to general problem structures, utilizes standard solving technology and is highly parallelizable. We provide experimental results to show how it efficiently solves benchmarks with hundreds of scenarios.

A FIXED POINT OPERATOR IN DISCRETE OPTIMISATION DUALITY

Professor Andrew Eberhard, RMIT

I will discuss some duality structures that have appeared in discrete optimisation in conjunction with studies of discrete proximal point algorithm, augmented Lagrangian duality, supporting theory for the "Feasibility Pump" and more recently with regard to Stochastic Integer programming. A common theme appears involving a fixed point operator associated with the local minima of a regularised dual function. This enables the one to describe some MIP heuristics in terms of so continuous optimisation ideas.

ABOUT STABILITY OF ERROR BOUNDS

Associate Professor Alexander Kruger, Federation University Australia

Stability of local and global error bounds, including new concepts of (arbitrary, convex and linear) perturbations of the given function, will be discussed. The characterisations of error bounds for families of perturbations can be interpreted as estimates of the 'radius of error bounds'. The definitions and characterisations are illustrated by examples.

CURVE CLUSTERING USING CHEBYSHEV AND LEAST SQUARES APPROXIMATION

Dr Nadia Sukhorukova, Swinburne University of Technology and Federation University Australia

There have been a number of attempts to extend a well-known K-means method to curve clustering. This method is based on repeated recalculations of cluster prototypes (that is, approximations) when one or more curves are moving from one cluster to another. In this presentation I will talk about possible ways to accelerate the procedure. I will consider two types of problems: Least Squares and Chebyshev approximation. I will also mention other applications of approximation to curve clustering and signal processing.

REDUCING POST-SURGERY RECOVERY OCCUPANCY UNDER UNCERTAINTY

Dr Belinda Spratt, Queensland University of Technology

Co-author: Adjunct Professor Erhan Kozan

Operations Research approaches to surgical scheduling are becoming increasingly popular in both theory and practice. Often, these models neglect stochasticity in order to reduce the computational complexity of the problem. In this talk, two years of historical data are utilised to examine the occupancy of post-surgery recovery spaces as a function of the initial surgical case sequence. We show that the number of patients in the recovery space is well modelled by a Poisson binomial random variable. A mixed integer nonlinear programming model for the surgical case sequencing problem is presented that reduces the probability of exceeding the capacity in post-surgery recovery units. Given the complexity of the model, metaheuristic approaches are implemented to solve the surgical case sequencing problem. Preliminary results indicate that this approach can be used to level the demand for post-surgery recovery resources and improve the predictability of demand in downstream wards.

MATHEMATICS IN MEDICINE: OPTIMISING IMAGE ACQUISITION AND CANCER TREATMENT IN RADIOTHERAPY

Dr Michelle Dunbar, The University of Sydney

Effective radiotherapy is dependent on being able to (i) visualise the tumour clearly, and (ii) deliver the correct dose to the cancerous tissue, whilst sparing the healthy tissue as much as possible. In the presence of motion uncertainty, both of these tasks become increasingly difficult to perform accurately – increasing the likelihood of incorrect dose delivered to cancerous tissue and exposure of healthy tissue to unnecessary radiation, causing adverse effects.

In this presentation we outline our novel mathematical models for optimising pre-treatment imaging in radiation therapy. We focus on tumours located in the lung and thorax subject to respiratory motion, and discuss the performance of our models for real-world patient breathing data. In addition, we briefly outline our current research involving the development of mathematical models for joint respiratory and cardiac motion to enable imaging and treatment for tumours located in parts of the anatomy that are currently considered a “no-fly zone”. We present current challenges and ideas for future research.

Augmented Benders’ Decomposition for Synchromodal Logistics

Andrew Perryman, Monash University

Co-authors: Professor Andreas Ernst, Professor Mohan Krishnamoorthy

In Australian cities, deep-sea container ports are regularly located close to the city-center, with transportation to and from the port facilitated by trucks. In the aim of reducing the congestion associated with road transportation, state and federal governments have recently begun championing a modal switch to short-haul rail for these transportation tasks. In this talk we describe a metropolitan freight transportation problem arising from this domain that seeks to effectively leverage both modes of transport from a least-cost perspective. We propose a mathematical programming formulation and develop a modified Benders’ decomposition method for the problem. We mathematically

demonstrate that this method finds pareto-optimal cuts by solving an augmented version of the subproblem that exploits subproblem dual-degeneracy without destroying its underlying structure. Our modified Benders' routine is further augmented by a number of logic-based Benders' cuts that remain valid for arbitrarily complex road-transportation requirements. Computational results demonstrate the effectiveness of this routine over the performance of commercial solver implementations of the mathematical programming formulation.

EFFICIENT COMPUTATION OF COST ALLOCATIONS FOR THE VEHICLE ROUTING PROBLEM

Dr Philip Kilby, CSIRO Data61

Co-author: Dr Dan Popescu

In the Vehicle Routing Problem we aim to find efficient routes for a fleet of vehicles to serve customers situated at various locations. Given a solution, we may then wish to find a way to divide the overall service cost, in a way that is fair to all customers. This cost allocation problem is the focus of our paper.

This fair division problem turns out to be very challenging. An ideal solution is well defined, based on the Shapley Value of the Travelling Salesman Game. Unfortunately, this method has exponential computational complexity, which makes it practical only for small-scale scenarios, involving no more than 30 customers. In real life applications, scenarios involving a few hundred or even a few thousand customers are more typical.

We present a novel methodology to generate high-quality approximations to the Shapley Value, giving a fair division of transportation cost. It is based on a deeper geometric insight into distance sharing in an Euclidean context. We give explicit formulas for two such approximations, which have polynomial computational complexity. We present experimental results which demonstrate that our proposed methods outperform the other state of the art approximations found in the literature.

AN ALGORITHM FOR THE NETWORK FLOW PROBLEM WITH MULTI-TRANSPORT MODES AND TIME WINDOW CONSTRAINTS

Chaojie (Jasmine) Guo, The University of Melbourne

Co-author: Associate Professor Russell Thompson

With the spread concept of hyper-connected City Logistics which highlight the importance of consolidating transport facilities in urban city to improve the delivery efficiency and reduce the environment cost. Transportation network become more flexible and comprehensive with a lot of transit hubs and multi-transport modes (for example public facilities, private cars and traditional freight vehicles) connecting nodes. So far, works on solution approach for network flow are based on Tabu research. However, in a such a complex network with multi-transport modes and time window constraints, Tabu research will be not that efficient. Based on the work of Solomon (1987) who propose an insertion-heuristic for VRSPTW, we find a hub-insertion procedure to solve this network flow problem.

DAY 5: FRIDAY 22 JUNE 2018

Workshops

0915 - 0930	**Invited Speaker:** Tactical Network Planning for Food Aid Distribution in Kenya **Associate Professor Marie-Ève Rancourt** HEC Montréal
0930 - 1000	
1000 - 1030	Optimising the resilience of road networks under uncertainty **Arash Kaviani**, The University of Melbourne
1030 - 1100	**MORNING TEA**
1100 - 1130	Post-disaster Humanitarian Logistics **Pamela Cortez**, Universidade Estadual de Feira de Santana (Brazil) and The University of Melbourne
1130 - 1200	Optimal Control of a UAV in Search and Rescue Operations **Dr Yalçın Kaya**, University of South Australia
1200 - 1300	**LUNCH**
1300 - 1330	Douglas-Rachford Method: a View from Strongly Quasi-Nonexpansive Operators **Scott Lindstrom**, CARMA, The University of Newcastle
1330 - 1400	Sparsity optimization for a network of coupled oscillators **Associate Professor Regina Burachik**, University of South Australia
1400 - 1430	Quantifying expert judgement in an objective function for table-balancing **Dr Geoffrey Brent**, Australian Bureau of Statistics
1430 - 1500	On Numerical Methods for Spread Options **Mesias Alfeus**, University of Technology Sydney
1500 - 1530	**AFTERNOON TEA**
1530 - 1600	A comparison of nonlinear, second order cone and linear programming formulations for the optimal power flow problem **Jose Nicolas Melchor Gutierrez**, Sao Paulo State University & The University of Melbourne
1600 - 1630	Using column generation to solve an aircrew training timetabling problem **David Kirszenblat**, The University of Melbourne
1630 - 1700	Process Plant Layout Optimization: Equipment Allocation **Dr Gleb Belov**, Monash University

DAY 5 – Friday 22 June

INVITED SPEAKER: TACTICAL NETWORK PLANNING FOR FOOD AID DISTRIBUTION IN KENYA

Associate Professor Marie-Ève Rancourt, HEC Montréal

In Kenya, annual weather patterns cause recurrent shocks which make the population vulnerable to food insecurity. In some regions, seasonal droughts create regular food shortages that are mitigated through food aid. The objective of this real application is to design an effective last-mile food aid distribution network. It is based on a food aid distribution problem arising in the Garissa region of Kenya, but develops a methodology which is of general applicability. We present a location model to determine a set of distribution centers from which the food is directly distributed to the beneficiaries. Our model considers the welfare of all stakeholders involved in this regional response system: the World Food Programme, the Kenya Red Cross, and the beneficiaries. We describe how need assessment and population data where combined to determine the food distribution requirements. We also show how GIS data describing the road network was used to establish a set of potential distribution centers. In addition to the results obtained by solving our primary model, we present several sensitivity analyses and variants of the basic covering model to illustrate the trade-offs between the objectives of the different stakeholders. Finally, future research directions are presented and discussed.

OPTIMISING THE RESILIENCE OF ROAD NETWORKS UNDER UNCERTAINTY

Arash Kaviani, The University of Melbourne

The increase in the frequency and severity of natural disasters has motivated researchers and practitioners to propose various optimisation models within the concept of resilience in the transportation networks such as roadway systems. Many of these models aim to optimise the pre-disaster investment decisions to achieve road network resilience and are formulated as a Network Design Problems (NDP). Moreover, to incorporate various uncertainties that exist in the decisions around the human-made or natural disasters, Stochastic Programming (SP) has been vastly applied in the formulation of NDP in which uncertain variables are considered as random variables with a known probability distribution. Moreover, the alternative approach of Robust Optimisation (RO) has been utilised recently as a method to deal with uncertainties in an optimisation problem. This talk initially covers the latest applications of SP and RO in the context of NDP and presents our recent work in which we propose a hybrid stochastic-robust optimisation approach for dealing with the resilience of road networks.

POST-DISASTER HUMANITARIAN LOGISTICS

Pamela Cortez, Universidade Estadual de Feira de Santana, The University of Melbourne

Co-author: Dr Alysson Costa

This research is concerned with the delivery of relief items in the aftermath of sudden-onset natural disasters, such as fires and floods. These catastrophes present hard challenges for the humanitarian sector, unfolding very different conditions than those found in commercial logistics.

We propose a multi-commodity, multi-period, multi-trip facility location and routing problem that takes into account important objectives and constraints such as fairness and acceptable delay in meeting a request.

We decompose our model into two simpler problems: the first one deals with facility location and commodities pre-positioning, while the second deals with routing decisions. The first model locates temporary warehouses, defines the amount of supply to be stored in each facility and assigns relief items to meet the demands of each point of distribution with the objective of minimising unsatisfied demands. A further decomposition level is considered to efficiently solve the routing problem; we studied two strategies: decomposing by depot or by period. Results on the time decomposition model show the importance of coordination to reduce logistics costs.

OPTIMAL CONTROL OF A UAV IN SEARCH AND RESCUE OPERATIONS

Dr Yalçın Kaya, University of South Australia

We consider the problem of designing optimal trajectories of an uninhabited aerial vehicle (UAV) so that the connectivity with a set of moving ground nodes is never (or at least not for too long) lost, in search and rescue operations. Our scenario consists of two ground nodes and one UAV. We present three mathematical models to ensure effective communication amongst these dynamic nodes of the network. Our first model introduces a new objective function which is used to maximize the network connection level. The second model considers, under the presence of an obstacle between the ground nodes, a new objective representing the maximization of a so-called confidence level under the uncertainty of the knowledge about the positions of the ground nodes. Our third model represents multi-objective optimisation, by utilizing the two previous objectives. We illustrate these three models with various scenarios and numerical/graphical examples. Due to the nonsmoothness of our optimal control models, the problems are computationally challenging, with even this modest number of nodes. This is joint work with Regina Burachik from UniSA, and Kin-Ping Hui and Damien Phillips from DSTG.

DOUGLAS-RACHFORD METHOD: A VIEW FROM STRONGLY QUASI-NONEXPANSIVE OPERATORS

Scott Lindstrom, CARMA, The University of Newcastle

A frequent problem in optimization is that of finding a feasible point in the zero level sets of a finite number of functions. We discuss a method which is based on iterated over and under relaxed cutter

projection methods, of which the method of alternating projections and Douglas-Rachford are special cases. Notwithstanding the loss of firm nonexpansivity, useful convergence results may still be obtained by using another framework. We provide examples and share new insights.

SPARSITY OPTIMIZATION FOR A NETWORK OF COUPLED OSCILLATORS

Associate Professor Regina Burachik, University of South Australia

Co-authors: Dr C. Yalçin Kaya, Dr Alex Kalloniatis, Professor Subhrakanti Dey

We consider a graph with N nodes and adjacency matrix A. The dynamics, i.e., the phases, of the nodes are coupled via a network version of the Kuramoto model, defined in terms of A and the coupling strength $\sigma>0$ of the network. Our aim is to find the sparsest adjacency matrix A for which the phases of the nodes are synchronized. We formulate optimization problems that promote sparsity of A, using the ℓ_p-norm of the matrix A, with $p\in (0,1]$. Our first model is nondifferentiable and nonconvex for $p<1$. Our second model is an ℓ_1-relaxation of the first one. We solve the problem with the ℓ_1-relaxation for three cases, namely for 20-, 30- and 50-node networks with the node intrinsic natural frequencies and the phase initial conditions generated randomly. Our formulation of the problem and the numerical approach we devise achieve highly sparse solutions for the given networks. Our models are developed for finding (i) Directed sparse networks, (ii) undirected sparse networks, and (iii) undirected sparse networks in which the overall difference between the degrees is relatively small.

QUANTIFYING EXPERT JUDGEMENT IN AN OBJECTIVE FUNCTION FOR TABLE-BALANCING

Dr Geoffrey Brent, Australian Bureau of Statistics

The Australian Bureau of Statistics (ABS) has recently adopted quadratic optimisation methods for reconciling economic data in cases where different sources give inconsistent estimates. These methods must produce accurate estimates both at the aggregate level (e.g. GDP) and for fine divisions (e.g. individual industries and products). Consistency requirements include quadratic as well as linear constraints.

Designing the objective function for this application is challenging. Ideally, weighting would be based on probabilistic measures of source accuracy, but this information is often unavailable. Instead, we have used Lagrange-multiplier methods to allow subject-matter experts to specify the balancing objective, in terms of plausible adjustments for each cell. The objective function then reconciles these expectations to find a good compromise solution.

This approach allows for subject-matter expertise to be codified into balancing rules. By providing an intuitive link between balancing specifications and results, it makes specification and debugging easier. Graphical methods can be used to identify and interpret issues with the inputs, making it easier to correct these.

ON NUMERICAL METHODS FOR SPREAD OPTIONS

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Co-author: Professor Erik Schlogl

Spread options are multi-asset options whose payoffs depend on the difference of two underlying financial variables. In most cases, analytically closed form solutions for pricing such payoffs are not available, and the application of numerical pricing methods turns out to be non-trivial. We consider several such non-trivial cases and explore the performance of the highly efficient numerical technique of Hurd and Zhou (2010), comparing this with Monte Carlo simulation and the lower bound approximation formula of Caldana and Fusai (2013). We show that the former is in essence an application of the two–dimensional Parseval Identity.
As application examples, we price spread options in a model where asset prices are driven by a multivariate normal inverse Gaussian (NIG) process, in a threefactor stochastic volatility model, as well as in examples of models driven by other popular multivariate Lévy processes such as the variance Gamma process, and discuss the price sensitivity with respect to volatility. We also consider examples in the fixed–income market, specifically, on cross–currency interest rate spreads and on LIBOR/OIS spreads. In terms of FFT computation, we have used the FFTW library and we document appropriate usage of this library to reconcile it with the MATLAB ifft2 counterpart.

A COMPARISON OF NONLINEAR, SECOND ORDER CONE AND LINEAR PROGRAMMING FORMULATIONS FOR THE OPTIMAL POWER FLOW PROBLEM

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Co-authors: Professor Pierluigi Mancarella, Professor Rubén Augusto Romero Lazaro

The provision of electrical energy is a vital service in our society, so the continuity as well as the quality of this service are compulsory. To guarantee the aforementioned, first, the system operational state at any time must be determined and second, various hypothetical situations in the power system must be considered to guarantee the reliability under unexpected changes. The optimal power flow (OPF) problem addresses the foregoing. The linear direct current (DC) mathematical formulation has been used for more than 50 years to represent the OPF problem. However, the DC OPF is a mere approximation of the complete alternating current (AC) formulation and in some cases its solution could lead to unrealistic results. In this work, a comparison between the DC and AC OPF in steady state power systems is made. A second order cone (SOC) approximation and a nonlinear formulation are studied for the AC OPF problem. The formulations are implemented in the mathematical programming language AMPL and solved by the solvers Knitro and Cplex. The power flow simulations for the AC and DC formulations are made on the IEEE 300 bus system.

USING COLUMN GENERATION TO SOLVE AN AIRCREW TRAINING TIMETABLING PROBLEM

David Kirszenblat, The University of Melbourne

The Training Authority Aviation (TA-Avn) is an organisation within the Royal Australian Navy (RAN) responsible for managing aviation-specific training for all RAN personnel, who are to be employed in

an aviation-related job category. In a temporal sense, the bulk of aircrew training consists of a sequence of major, structured courses and a number of mandatory short courses for which the prerequisite requirements are less strict. Both short and long courses are run repeatedly throughout a year with a fixed number of repetitions and are subject to high and extremely variable course pass rates.

In this talk, we adopt a conventional integer linear programming technique, specifically, column generation. The problem of designing feasible schedules is formulated as a network flow problem that encompasses covering and prerequisite constraints. The problem is decomposed into a master and subproblem. The master problem is initialised with a set of dummy schedules to which we allocate the aircrew student population, whilst respecting class capacity limitations. The master problem then requests solutions from the subproblem that offer some promise of minimising the overall time spent in training. Experimental results are compared with those of an ILP approach that assigns feasible schedules to labelled students.

PROCESS PLANT LAYOUT OPTIMIZATION: EQUIPMENT ALLOCATION

Dr Gleb Belov, Monash University

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Designing the layout of a chemical plant is a complex and important task. Its main objective is to find a most economical spatial arrangement of the equipment and associated pipes that satisfies construction, operation, maintenance and safety constraints. The problem is so complex it is still solved manually, taking multiple engineers several years to complete. This paper provides two main contributions. First, the most comprehensive model ever reported in the literature for spatially arranging the equipment. And second, a Large Neighborhood Search framework that enables Constraint Programming and Mixed-Integer Programming solvers to explore much larger neighborhoods than in previous approaches, thus increasing its effectiveness. The model is part of a system being developed in collaboration with Woodside Energy Ltd. for their Liquefied Natural Gas plants. The results are so promising Woodside is actively exploring its commercialisation.