

MATHEMATICAL AND STATISTICAL DISCOVERIES THAT SOLVE REAL WORLD PROBLEMS

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ACEM \int

AUSTRALIAN RESEARCH COUNCIL CENTRE OF EXCELLENCE FOR
MATHEMATICAL AND STATISTICAL FRONTIERS

ANNUAL REPORT 2015



THE ARC CENTRE OF EXCELLENCE FOR MATHEMATICAL AND STATISTICAL FRONTIERS

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ACEMS would like to thank the Professional staff in the Centre for their support - Emily Duane, Kate Hall, Kathy Palmer and Tania Smith at The University of Melbourne; Claudia Deasy, Greg Lee, Tim Macuga and Andrew Stephenson at Queensland University of Technology; Claire Nitsch at The University of Queensland; Snezana Ilic at The University of Adelaide and Sarah King at University of Technology, Sydney.

CONTENTS

| | |
|-----------|--|
| 2 | ABOUT ACEMS |
| 3 | MISSION STATEMENT |
| 4 | DIRECTOR'S REPORT |
| 6 | IN MEMORIAM: PETER GAVIN HALL, FOUNDING DIRECTOR OF ACEMS |
| 8 | MODELS TO TELL US WHERE THE FISH ARE GOING, AND WHY POPULATIONS GO EXTINCT |
| 10 | ACEMS MANAGEMENT AND GOVERNANCE |
| 10 | Centre Management |
| 10 | Governance Advisory Board |
| 10 | Scientific Advisory Committee |
| 11 | ACEMS MEMBERSHIP |
| 11 | Professional Staff |
| 11 | Chief Investigators |
| 11 | Associate Investigators |
| 12 | Partner Investigators |
| 12 | Research Fellows |
| 12 | Students |
| 14 | Affiliate Members |
| 15 | MATRIX |
| 15 | Australia's New International Research Institute for Mathematics |
| 16 | SMART CREDIT LIMITS TO SAVE MONEY FOR CUSTOMERS AND BANKS |
| 18 | KEY PERFORMANCE INDICATORS |
| 20 | ACEMS Media Releases |
| 20 | ACEMS Projects on Television and Radio |
| 21 | Research Training, Workshops and Professional Education |
| 21 | Sponsorships |
| 22 | TAKING COALS TO NEWCASTLE |
| 24 | STUDENT AND EARLY CAREER RESEARCHER RECRUITMENT & COMPLETION |
| 25 | INTERNATIONAL, NATIONAL & REGIONAL LINKS & NETWORKS |
| 25 | Visitors |
| 26 | SAVING SEAGRASS SANCTUARIES |
| 28 | STAKEHOLDER ENGAGEMENT |
| 28 | The Trouble With Traffic – ACEMS and VicRoads Collaboration |
| 30 | Partner Organisations |
| 30 | Industry Engagement |
| 31 | OUTREACH |
| 31 | Public Lectures |
| 31 | School Visits |
| 32 | Other Public Activities |
| 33 | Website and Social Media Statistics |
| 34 | TRAFFIC MATRICES: MAXIMISING UNCERTAINTY TO DESIGN MORE RELIABLE DIGITAL NETWORKS |
| 36 | NATIONAL BENEFIT – STAFF RECOGNITION |
| 36 | Prizes, Awards and Other Prestige Measures of Centre Members |
| 38 | PUBLICATIONS |
| 38 | Books and Book Chapters |
| 39 | Refereed Journal Articles |
| 48 | Conference Papers and Proceedings |
| 50 | FINANCE |
| 50 | Grants |
| 52 | 2015 Financial Statement |

ABOUT ACEMS

The Australian Research Council (ARC) Centre of Excellence for Mathematical and Statistical Frontiers (ACEMS) brings together leading Australian applied and theoretical researchers in the fields of mathematics, statistics, mathematical physics and machine learning.

Today's world collects a massive amount of data in a variety of forms and via a multitude of sources daily. Many of the resulting data sets have the potential to make vital contributions to society, business and government, as well as impact on international developments, but are so large or complex that they are difficult to process and analyse using traditional tools.

The Centre brings together for the first time a critical mass of Australia's best researchers in mathematics, statistics, mathematical physics and machine learning, with partner researchers to engage in three research programs that combine innovative methods for the analysis of data with theoretical, methodological and computational foundations provided by advanced mathematical and statistical modelling. The Centre will focus on the impact of new insights for end users working in the Collaborative Domains of Healthy People, Sustainable Environments and Prosperous Societies.

The three research programs are:

- **Big Data Analytics** – which uses mathematical, statistical and machine learning tools to analyse data characterised by volume, variety, velocity and complexity
- **Big Models** – which develops new theories, methodologies and implementations that underpin predictive models required to interpret and utilise big data
- **New Insights** – which bridge the gap between theory and practice by providing solutions to problems driven by cross-organisational and cross-disciplinary collaboration, using big data and big models

The objective of the Centre is to unify the programs by emphasising:

- Globally innovative research and research leadership across the discipline spectrum;
- Integration and translation, bridging theory and practice so that the research programs are motivated by and inform the Collaborative Domains for real world impact; and

- Training the next generation of quantitative researchers integrating technical expertise, industry exposure and high-level cross-disciplinary and scientific communication skills.

The synergy of the Centre's compelling research programs, together with its strong collaborations, both domestically and internationally; its composition, management and governance arrangements; and research, training and translation strategy; mean that ACEMS will deliver real value for money as well as make a transformative contribution to Australian research in mathematics, statistics, mathematical physics and machine learning.



MISSION STATEMENT

**THE ARC CENTRE OF EXCELLENCE FOR MATHEMATICAL
& STATISTICAL FRONTIERS (ACEMS) WILL DELIVER
WORLD-LEADING RESEARCH IN MATHEMATICAL AND STATISTICAL
THEORY AND METHODS, AND WILL USE THESE TO ADDRESS
CHALLENGING SCIENTIFIC PROBLEMS IN THE REAL WORLD.**

DIRECTOR'S REPORT

Professor Peter Taylor, Director



ACEMS' Founding Director Peter Hall passed away on January 9, 2016, after suffering an illness that substantially incapacitated him for most of the time that ACEMS has existed.

We've included a full tribute to Peter elsewhere in this report. I'd like to reiterate here that, as well as being a statistician of the absolute highest calibre, he was a wonderfully kind and generous man, who was willing to give his time to any endeavour in the cause of the mathematical sciences. Those of us who were involved in the ACEMS application process will never forget the dedication that he brought to the task, at a time when his health must have already been starting to deteriorate.

I became Acting Director of ACEMS in June 2015 and then Director in late December 2015. In mid-2015, ACEMS Communications Officer Tim Macuga asked me to write a statement outlining my vision for the Centre to put on the website. I wrote the following:

The idea of trying to tailor the sort of research we do in mathematics and statistics to the environment of a Centre of Excellence isn't easy, but it's really important. We don't run a 'big-lab model' where the lab head comes in and tells everyone exactly what to do and they all go away and do it, reporting back at the team meeting every week. Mathematical and statistical research requires close collaboration throughout. What we have to do in ACEMS is develop the right sort of model to take advantage of the opportunities for collaboration, scaling up of activities and learning from our colleagues that the Centre provides, without stifling the way research in the mathematical sciences normally happens.

One big advantage of having a Centre of Excellence is that it creates opportunities for early-career

researchers to obtain postdoctoral positions. It also brings together a critical mass of students, who can all learn from each other and the members of the Centre more widely.

The ARC keeps asking us to make sure that we're more than just a bunch of people with our own projects. We have to build a reason for the Centre. We have to show things happen because of the Centre which would not have happened if we got our own individual grants. The goal is that cross collaboration is fostered, research gets done, and ideas get generated that wouldn't happen if we were only sitting in our own universities. I'm already starting to see signs of that.

Overall, I'm very excited about the opportunity to make a contribution to building our Centre; we are still in the initial stages and the goal is that we will all be proud of the outcome.

On re-reading that statement, I'm still happy with it. It sums up my high-level vision for what ACEMS should be trying to do. Across the fields of mathematical physics, stochastic modelling, theoretical and applied statistics, numerical mathematics and machine learning, our task is to foster collaboration across the Centre's nodes and at all points along the theoretical/practice dimension to deliver new analytical methods for big data, models for complex multicomponent systems and new insights into how these systems behave. During 2015, I think that we can claim to have made substantial progress along the path towards this vision.

Eighty-five members of ACEMS attended the Annual Retreat, held in Glenelg from 4–6 November. Among them were twelve Chief Investigators, two Partner Investigators, thirteen Postdoctoral Fellows, thirteen Associate Investigators, nine Professional Staff, thirty-two PhD Students and four guests, including the Chief Executive Officer of the Australian Research Council, Professor Aidan Byrne, and the Chair of the ACEMS Governance Advisory Board, Dr Ron Sandland.

During the Retreat, the ACEMS Professional Staff held their own "mini-retreat". They spent time getting to know each other's roles and responsibilities, and workshopped ways in which ACEMS can improve its communication and data collection processes.

Twenty technical papers were presented at the Retreat, discussing fundamental topics such as random matrix theory through statistical mechanics, stochastic processes, theoretical statistics and numerical modelling to applied statistics and machine learning. They represent just a snapshot of all the research that ACEMS members have been pursuing.

In this Annual Report, you will find five case studies highlighting a selection of some of the research that ACEMS members undertook in 2015:

- Phil Pollett and Ross McVinish from The University of Queensland node discuss how mathematical modelling of parasite load can help researchers understand fish migration patterns,
- PhD student Jonathan Budd and I discuss how credit card agencies can use data from individual customer purchases to determine the optimal way to set credit limits,
- Louise Ryan and PhD student Alan Malecki from the University of Technology, Sydney, show how modelling of dust loads caused by coal trains in the Hunter Valley can be used to help solve a local dispute,
- Paul Wu from Queensland University of Technology discusses how Bayesian Network analysis can be used to help manage seagrass sanctuaries, and
- Matt Roughan and Paul Tune from The University of Adelaide node explain the significance of traffic matrices for understanding the data flows in the Internet.

Thirty-two PhD Students spent the two days preceding the Retreat with ACEMS' Outreach Officer Andrew Stephenson at the Student Retreat in



Attendees at the 2015 ACEMS Annual Retreat.

McLaren Vale. As well as taking part in a number of 'team-building activities', each ACEMS PhD student who wasn't already scheduled to talk at the main Retreat presented his or her work at the Student Retreat, reflecting the priority that ACEMS places on its students honing their presentation skills. I found it particularly gratifying to see the students arriving at the main Retreat congregating in groups across the ACEMS nodes rather than just from their home institutions. Clearly the activities that Andrew put in place to help the students get to know each other worked very well.

More broadly, ACEMS has established a successful workshop program, taking on the organisation of nine workshops under its own auspices, as well as providing sponsorship for a further eleven meetings organised by members of the broader mathematical sciences community. It has sponsored a large number of visits by distinguished and early-career international researchers, as well as facilitating cross-node interaction, in particular with its Partner Organisations, VicRoads, the Australian Institute of Marine Science and the Australian Bureau of Statistics. In 2016 we plan to put more resources into encouraging such interaction, which is at the very core of what the Centre should be pursuing.

Other highlights are:

- ACEMS' role in the establishment of Australia's first single-venue mathematical research institute, MATRIX. ACEMS Chief Investigator Jan de Gier's energy and foresight in pushing this through has been a sight to behold. I'm convinced that his initiative, supported strongly by The University of Melbourne as well as ACEMS, will lead to a long-term legacy for the mathematical sciences community of this country that we can all be proud of. For the first time, Australian mathematical scientists will have something that almost all other developed countries already have: a dedicated venue to host workshops and extended research programs in the mathematical sciences, specifically with the intention of fostering collaborative activity.

- High-level awards for Kerrie Mengerson (an Australian Research Council Laureate Fellowship), Peter Bartlett (election as a Fellow of the Australian Academy of Science) and Peter Hall (election as a Fellow of the Australian Academy of Social Sciences).
- The 'Doing Maths like a Mathematician' outreach activity, conducted in Ballarat and Melbourne by Anthony Harradine on behalf of ACEMS with the assistance of a number of ACEMS Chief and Associate Investigators and PhD Students. Anthony's program is based on the principle that it is a good thing to present talented high school students and their teachers with open-ended mathematical problems, where the solution of one question leads immediately to the formulation of other, more advanced, questions of interest. It's exactly the type of thinking that research mathematicians use, and something which tends to get lost in the day to day effort of keeping up with the syllabus in a high school class.

During 'Doing Maths like a Mathematician', it was inspiring to see so many high school students experience that 'aha' moment when they suddenly gain 'new insight' into a problem. I'm convinced that we are going to see quite a few of the attendees enrolling in our mathematical science majors in three or four years' time. ACEMS has plans to extend 'Doing Maths like a Mathematician' to other states in 2016.

- The significant achievements of ACEMS PhD students Amy Cook, Xing Lee, Jonathan Budd, Ellen Muir and Peter Braunstains. Amy was a semi-finalist in the Hilti Corporation Big Data competition, Xing won the Tony Morton Award for research into infectious disease modelling, Jonathan won the Best Paper Award at the Edinburgh Credit Scoring and Credit Control Conference XIV, while Ellen and Peter received awards for the best student talk and an honourable mention respectively at the Fourth Australia-New Zealand Applied Probability Workshop.

- The 'ACEMS Advanced Sampling Exploration and Matlab Competition', put together by ACEMS Chief Investigator Dirk Kroese. This competition was designed for teams of ACEMS students to compete in finding the best route from the centre to the boundary of a circular region occupied by obstacles. Even though this might be regarded as an idealised problem, it can serve as a prototype for a large number of route-finding/shortest path problems. The only resource that the students had available was a computer routine that would tell them whether or not there was an obstacle at any given location that they chose to input. The quality of a solution was measured in terms of the number of times that this routine had to be called. The competition was won by a team led by Tim Hyndman and Kate Saunders (interestingly with an algorithm that they considered to be their 'B solution').

All in all, despite its difficult start, ACEMS started to build up momentum throughout 2015. This has left all ACEMS members with a considerable amount of energy to continue building into 2016. I expect to have even bigger and better things to report next year.

Peter Taylor

IN MEMORIAM:

PETER GAVIN HALL FOUNDING DIRECTOR OF ACEMS

20 November 1951 – 9 January 2016



**ACEMS Chief Investigator
Aurore Delaigle and
Distinguished Professor
Raymond J. Carroll pay
tribute to one of the most
influential statisticians of
our time.**

On 9 January 2016, in Melbourne, Australia, the statistics community lost one of its greatest statisticians. Peter Hall was born in Sydney, Australia, to William Hall and distinguished radio astronomer Ruby Payne-Scott. He earned his degrees from the University of Sydney, the Australian National University (ANU) and the University of Oxford, and he spent his career as an academic at the ANU (1978–2006), The University of Melbourne (1976–1978 and 2006–2016) and the University of California at Davis, where he had a fractional appointment since 2005. He married his wife Jeannie Hall, who held the high post of cabinet secretary for multiple Australian Prime Ministers, in 1977.

Peter was a wonderful person. He was gentle, generous, passionate, enthusiastic, optimistic and very supportive. He had a massive impact on hundreds of statisticians, both junior and senior, all over the world. As a colleague (AD) and a regular visitor (RJC), we were able to observe how Peter worked with younger people, helping them solve problems they thought they wanted to solve, and, more importantly, advancing their careers while doing so. It was fascinating, and exciting, to watch how Peter operated. He first sorted out the problem that his younger visitors actually wanted to solve, framed it in a concrete way, and then, in a burst of energy beyond what any of us can do, simply solved it. His lunches were famous for wide-ranging discussions, including, surprisingly, aviation, where he regularly read blogs about aviation design, for example, the Boeing 787 Dreamliner, and labour issues, for example, pilot complaints.

Peter was extremely prolific. His work was deep and founded on unbelievably creative and beautiful ideas. He wrote more than 600 papers, most of which appeared in the top statistics



or probability journals. As he was absolutely passionate about science and mathematics in general, the breadth of problems he tackled was very wide. He made extraordinary and enormously influential contributions to many areas of statistics, including the bootstrap, deconvolution and inverse problems, spatial statistics problems, functional data analysis, smoothing methods, fractals, classification and clustering, extreme-value statistics, martingale theory and ranking techniques.

The diversity of topics that Peter studied originated from his passion for science. He was literally fascinated by all sorts of problems, ranging from the most applied biological or physical question, to the most theoretical puzzle in number theory. Faced with a new challenge (something he particularly enjoyed), his typical approach was to gain insight by first exploring its fundamental theoretical properties. This is how he managed to unravel the most surprising and important characteristics of problems, and, from there, suggest highly innovative, ground-breaking and creative statistical methods. His constant search for understanding, and his sheer tenacity as a researcher, led him to develop some of the most difficult and most influential theory in modern statistics.

He received the most prestigious awards available throughout his career. Among other recognitions, he was a Fellow of the Royal Society of London, of the Australian Academy of Science and of the Australian Academy of Social Sciences, a Foreign Associate of the US National Academy of Sciences, and an Officer of the Order of Australia. He also had four honorary doctorates and numerous awards that include the Committee of Presidents of Statistical Societies Award (COPSS Award).

Despite his stature, Peter had a gentle and unassuming nature. Regardless of how important you were, he always managed to make you feel included through the sheer warmth of his personality. He was loved and admired by many around the world. He offered especially strong support to young scientists, and women in particular, and trained more than sixty young statisticians at the doctoral or postdoctoral level. Every visitor that we know of, left with a sense that they were in the presence of genius, but genius with a kind face and one whose goal was to support their careers, instead of his own.

Peter was also strongly committed to his profession more generally, and the amount of service and support he provided to mathematics and science throughout his life, both in Australia and internationally, was also quite extraordinary. Among many other things, he was President of the Institute of Mathematical Statistics, of the Bernoulli Society, and of the Australian Mathematical Society, and Secretary (Physical Sciences) of the Australian Academy of Science. He served on innumerable committees and advisory boards, and was editor and associate editor of many journals. He was extremely active in supporting Australian mathematics and statistics, regularly interacting with cabinet ministers about how to appreciate the key role of statistics and mathematics in the age of data deluge.

Outside academia, Peter had two great passions: steam trains and photography. He developed his love of trains as a young boy, fascinated by the impression of power and invincibility that they gave. It was his love of trains that got him interested in photography, which he saw as a way of recording steam trains, although later he developed a genuine passion for photography more generally. It was

Peter who introduced photography to his sister, the distinguished Australian artist Fiona Hall, of whom he was very proud and whose work he admired. In an interview of him to appear in *Statistical Science*, he said of her: "her eye for composition was just spectacular. I learned a lot just by watching her take photographs." Peter also had a passion for animals. He was particularly fond of cats, but he also had a special connection with sulphur-crested cockatoos, which he attracted by feeding them through his office window at the ANU. Amusingly, the cockatoos got their food in the early morning by knocking on Peter's window to get his attention.

Peter was someone really special. He was an extraordinary, kind, gentle and generous person, of the type most people do not even have the chance to meet once in their lifetime. He was an exceptional scientist who made many cutting-edge and influential contributions to statistics. He was an outstanding leader, one whose enthusiasm and passion for research has been a motivation and a great source of inspiration for many. His absence will leave a huge hole in the heart of many all over the world.

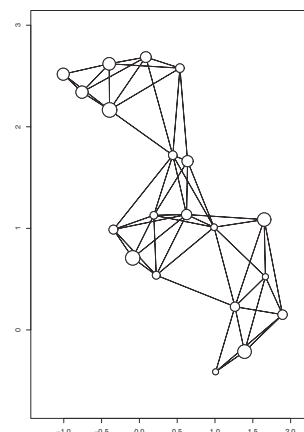
Aurore Delaigle and Ray Carroll

MODELS TO TELL US WHERE THE FISH ARE GOING AND WHY POPULATIONS GO EXTINCT

How much fish move around is critical information for fisheries managers. Different tracking techniques can be used but each has its weaknesses.



A representation of the general population structure used in the modelling (metapopulations, epidemics and parasites).



How much fish move around is critical information for fisheries managers – for example, they need to know if fish caught off Brisbane are a separate population to those caught off Cairns. Different tracking techniques, such as physical tags or genetic mapping, can be used but each method has its weaknesses.

A team of ACEMS mathematicians is using pre-existing data on Spanish mackerel, using their hitchhiking parasites to track the fish's movements and model the populations.

Since some parasites can live for a long time in their host, they can be used as living 'markers'. If particular parasites that are found only in specific areas turn up on a fish caught somewhere else, this parasitic collection helps tell the story of the fish's travels.

It's just one of the applications of the models that Dr Ross McVinish and Professor Phil Pollett are working on.

"We're looking at population models and trying to understand how individual characteristics affect the population as a whole," says Ross, a Research Fellow at the Centre. Both he and Phil, who is a Chief Investigator at the Centre, are based at The University of Queensland.

Another area of interest is how the spread of a disease can be limited by changes in a population's migration. For example, the rate of infection in a city is not only affected by things such as the quality of sanitation, but also by the population density. So an increase in the population might make it easier for the infection to spread. You want more individuals to go to the places of low infection, but how do you

balance this increasing population without also boosting the risk of the disease spreading further?

Ross says one of the biggest challenges is that when looking at the behaviour of systems made up of many individuals, the numerous differences between them (for example, their susceptibility to disease) can make it difficult to identify the important factors that will affect the whole population. It's an important consideration, since some differences in individuals can create 'super-spreaders' in epidemics.

So they're taking complex models and trying to develop models that are easier to apply and study in real settings.

Another example concerns how changes across connected sub-populations affect the survival of the whole species. When local populations (which are distinct, but part of a wider network) live on different patches of habitat, multiple things will determine how long they survive – such as how often they reproduce, how many are dying, and the availability of food. Fires, floods and human development are other important factors ecologists will look at when using these models for conservation. Together, these factors create a threshold for survival in that area.

They're investigating how the differences in these measurements affect the overall outcome for the population – whether the larger group lives or dies.

"Essentially we're trying to extract the crucial individual characteristics, separating those that will have an important effect on how the population evolves from those that are less influential," Ross says.

"We're looking for the key factors that determine the persistence or extinction of a particular species."

**Dr Ross McVinish and
Professor Phil Pollett,
The University of Queensland**

ACEMS MANAGEMENT AND GOVERNANCE

ACEMS is a collaborative research centre that links The University of Melbourne, Queensland University of Technology, The University of Queensland, The University of Adelaide, The University of New South Wales and the University of Technology, Sydney, funded by the Australian Research Council (ARC) Centre of Excellence program. Our Partner Organisations are: AT&T Labs, Australian Bureau of Statistics (ABS), the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), Mathematics of Information Technology and Complex Systems (MITACS), the Roads Corporation of Victoria (VicRoads), SAX Institute, and the Australian Institute of Marine Science (AIMS).

As the lead administering node, The University of Melbourne manages the grant and node contributions, and distributes funds in accordance with the signed agreements. These agreements cover ACEMS management, collaboration and policy arrangements.

ACEMS day to day management is overseen by the Executive Committee, which meets fortnightly. The ACEMS Governance Advisory Board and Scientific Advisory Committee meet twice annually.

Centre Management

The ACEMS Executive Committee is responsible for administration as it pertains to Centre policy, performance, financial matters, research output, research training and professional education of members, partnerships, national and international liaison, commercialisation and outreach.

The members of the Executive Committee are:

Professor Peter Hall, Director (out-going)

Professor Peter Taylor, Acting Director/Director (in-coming)

Professor Nigel Bean, Deputy Director, Outreach (in-coming)

Professor Jan de Gier, Deputy Director, Operations

Professor Kerrie Mengersen, Deputy Director, Stakeholder Engagement

Professor Louise Ryan, Deputy Director, Outreach (out-going)

Governance Advisory Board

The ACEMS Governance Advisory Board met in June 2015 at The University of Melbourne, School of Mathematics and Statistics. A second meeting was scheduled in December 2015 but was postponed until February 2016 due to the ill health of the Chief Operating Officer and then the passing of Professor Hall. The meetings focussed on change of leadership, collaborations, external engagement and recommendations made by the ACEMS Scientific Advisory Committee.

The Governance Advisory Board members are:

Dr Ron Sandland (Chair)*, Former Deputy Chief Executive of the CSIRO

Professor Mike Brooks, Deputy Vice-Chancellor (Research), The University of Adelaide

Professor Robert Calderbank, Director, Information Futures Initiative, Duke University

Dr Julian Caley, Leader, AIMS and Queensland University of Technology Collaboration, Australian Institute of Marine Science

Professor Peter Donnelly, Director, Wellcome Trust Centre for Human Genetics, Oxford University

Professor Martin Groetschel*, President, Zuse Institute Berlin

Professor Tony Guttmann*, Director, MASCOs, The University of Melbourne

Professor James McCluskey, Deputy Vice-Chancellor (Research), The University of Melbourne

Professor Anton Middelberg, Deputy Vice-Chancellor (Research), The University of Queensland

Mr Daniel Owens*, Grants Management Office, The University of New South Wales

Professor Arun Sharma, Deputy Vice-Chancellor (Research and Commercialisation), Queensland University of Technology

Ms Tania Smith (ex officio)*, Chief Operating Officer, ACEMS, The University of Melbourne

Professor Peter Taylor (ex officio)*, Director, ACEMS, The University of Melbourne

Professor Glenn Wightwick*, Deputy Vice-Chancellor (Research), University of Technology, Sydney

** Indicates the board members (or their proxy) who attended the 2015 meeting.*

Scientific Advisory Committee

The ACEMS Scientific Advisory Committee met in June and November 2015. Communicating research success stories — such as the five case studies presented in this report — was a key recommendation. Other recommendations included suggestions for additional workshops and initiatives, ideas on quantifying and maximising the benefits of the Annual Retreat, and improvements to the ACEMS website.

Professor Peter Taylor (Chair)*, Director, ACEMS, The University of Melbourne

Professor Louis Chen*, Distinguished Professor, National University of Singapore

Professor Montserrat Fuentes, Head of Statistics, North Carolina State University

Professor Bronwyn Harch, Assistant Dean (Research) Science and Engineering Faculty, Queensland University of Technology

Professor Iain Johnstone*, Professor of Statistics and Health Research and Policy (Biostatistics), Stanford University

Professor Michael Jordan, Pehong Chen Distinguished Professor, University of California, Berkeley

Professor Xihong Lin*, Professor of Biostatistics, Harvard University

Professor Terence Tao*, Professor of Mathematics, University of California, Los Angeles

** Indicates the committee members who attended at least one meeting in 2015.*

ACEMS MEMBERSHIP

Professional Staff

Tania Smith, Chief Operating Officer, The University of Melbourne

Claudia Deasy, Administration Officer, Queensland University of Technology

Emily Duane, Administration Officer, The University of Melbourne

Elizabeth Gurung Tamang, Administration Officer, University of Technology, Sydney

Kate Hall, Finance Officer, The University of Melbourne

Snezana Ilic, Administration Officer, The University of Adelaide

Lucia Kralova, Administration Officer, University of Technology, Sydney

Greg Lee, External Engagement Officer, Queensland University of Technology

Tim Macuga, Communications Officer, Queensland University of Technology

Claire Nitsch, Administration Officer, The University of Queensland

Kathy Palmer, Acting Administration Officer, The University of Melbourne

Andrew Stephenson, Outreach Officer, Queensland University of Technology

Chief Investigators

A Chief Investigator is a member named in Schedule A of the ARC Centre of Excellence Funding Agreement as Chief Investigator.

This person has direct responsibility to the ARC for delivering on ACEMS objectives. Usually, he or she will have overall intellectual responsibility for an ACEMS research project, leading research, providing effective supervision to students and mentoring as required.

Peter Bartlett, Queensland University of Technology

Nigel Bean, The University of Adelaide

Kevin Burrage, Queensland University of Technology

Jan de Gier, The University of Melbourne

Aurore Delaigle, The University of Melbourne

Peter Forrester, The University of Melbourne

Tim Garoni, Monash University

John Geweke, University of Technology, Sydney

Peter Hall, The University of Melbourne

Robert Kohn, The University of New South Wales

Dirk Kroese, The University of Queensland

Kerrie Mengersen, Queensland University of Technology

Anthony Pettitt, Queensland University of Technology

Philip Pollett, The University of Queensland

Matthew Roughan, The University of Adelaide

Louise Ryan, University of Technology, Sydney

Peter Taylor, The University of Melbourne

Ian Turner, Queensland University of Technology

Matthew Wand, University of Technology, Sydney

Associate Investigators

An Associate Investigator is a member nominated by a Chief Investigator and approved by the Executive Committee, who is employed at an Australian or overseas research institution. An Associate Investigator is not a Chief Investigator but does have significant engagement with ACEMS in some way. For example, this could be by engaging in a significant and ongoing research project in conjunction with an ACEMS Chief Investigator or by being a joint supervisor of an ACEMS student. Associate Investigators are appointed for renewable two-year terms.

Yasin Abbasi-Yadkori, Queensland University of Technology

George Athanasopoulos, Monash University

Andrew Barbour, The University of Melbourne

Adrian Barnett, Queensland University of Technology

Andrea Bedini, The University of Melbourne

Andrew Black, The University of Adelaide

Rhys Bowden, The University of Melbourne

James Brown, University of Technology, Sydney

Pamela Burrage, Queensland University of Technology

Christopher Carter, The University of New South Wales

Jinyuan Chang, The University of Melbourne

Nathan Clisby, The University of Melbourne

Aaron Darling, University of Technology, Sydney

Pierre del Moral, The University of New South Wales

Giuseppe de Martino, Queensland University of Technology

Alex Dokumentov, Monash University

Chris Drovandi, Queensland University of Technology

Yanan Fan, The University of New South Wales

Troy Farrell, Queensland University of Technology

Davide Ferrari, The University of Melbourne

Victor Gabillon, Queensland University of Technology

Peter Grace, Queensland University of Technology

Nick Graves, Queensland University of Technology

Peter Green, University of Technology, Sydney

Tony Guttman, The University of Melbourne

Sophie Hautphenne, The University of Melbourne

Markus Hegland, Australian National University

Robert Hyndman, Monash University

Iwan Jensen, The University of Melbourne

Paul Keeler, The Weierstrass Institute, Berlin

Bonsoo Koo, Monash University

Gael Martin, Monash University

James McGree, Queensland University of Technology

Lewis Mitchell, The University of Adelaide

Tim Moroney, Queensland University of Technology

Yoni Nazarathy, The University of Queensland

Giang Nguyen, The University of Adelaide

John Ormerod, The University of Sydney

Anastasios Panagiotelis, Monash University
Graeme Pettet, Queensland University of Technology
Tung Pham, The University of Melbourne
Christian Robert, Queensland University of Technology
Leonardo Rojas-Nandayapa, The University of Queensland
Joshua Ross, The University of Adelaide
Nathan Ross, The University of Melbourne
Benjamin Rubinstein, The University of Melbourne
Scott Sisson, The University of New South Wales
Steven Stern, Queensland University of Technology
Laleh Tafakori, The University of Melbourne
Thomas Taimre, The University of Queensland
Peter Timms, Queensland University of Technology
Minh Ngoc Tran, The University of Sydney
Ole Warnaar, The University of Queensland
Alan Welsh, Australian National University
Michael Wheeler, The University of Melbourne
Gentry White, Queensland University of Technology
Nicole White, Queensland University of Technology
Bob Williamson, Australian National University / NICTA
Sally Wood, The University of Sydney
Paul Wu, Queensland University of Technology
Hong-Bo Xie, Queensland University of Technology
Qiangian Yang, Queensland University of Technology
Nan Ye, Queensland University of Technology
Joseph Young, Queensland University of Technology
Wenxin Zhou, The University of Melbourne

Partner Investigators

A Partner Investigator is a member employed at a Partner Organisation, who is the main contact for that organisation. The person may collaborate with an ACEMS Chief Investigator, act as the main contact for access to in-kind contributions, and contribute to strategic decisions as required.

Jeremy Burdan, VicRoads
Julian Caley, AIMS
Timothy Churches, Sax Institute
Daniel Elazar, Australian Bureau of Statistics
Zihui Ge, AT&T Labs
Arvind Gupta, MITACS
Fiona Langdon, MITACS
John Machin, Australian Bureau of Statistics
Veronica Podhorodecki, VicRoads
John Taylor, CSIRO
Walter Willinger, AT&T Labs

Research Fellows

A Research Fellow is employed by ACEMS to work directly on an ACEMS research project. The person is responsible for contributing to research, helping with mentoring students and with other activities as directed by their supervisor.

Craig Anderson, University of Technology, Sydney
Tomasz Bednarz, Queensland University of Technology
Praveen Choppala, The University of New South Wales
Nicole Cusimano, Queensland University of Technology
Yuguang Fan, The University of Melbourne
Caley Finn, The University of Melbourne
Alexandr Garbali, The University of Melbourne
Jesper Ispen, The University of Melbourne
Benoit Liquet, Queensland University of Technology
Anthony Mays, The University of Melbourne
Ross McVinish, The University of Queensland
Christopher Oates, University of Technology, Sydney
Bin Peng, University of Technology, Sydney
Juan Perez Bernal, The University of Melbourne
Erin Peterson, Queensland University of Technology
Anita Ponsaing, The University of Melbourne
Steven Psaltis, Queensland University of Technology

Marcehl Scharth, The University of New South Wales
Silvio Tarca, The University of Adelaide
Paul Tune, The University of Adelaide
Slava Vaisman, The University of Queensland
Joanna Wang, University of Technology, Sydney
Stephen Wright, University of Technology, Sydney
Huaxin Xu, University of Technology, Sydney
Lele Zhang, Monash University

Students

A Student is a member who belongs in at least one of the following categories:

1. Is supervised by an ACEMS Chief Investigator;
2. Is a recipient of an ACEMS top-up scholarship;
3. Is supervised by an ACEMS Associate Investigator or Research Fellow in a project that forms part of ACEMS activities.

Fadhah Alanazi, Queensland University of Technology
Wahid Allihaihi, Queensland University of Technology
Azam Asanjarani, The University of Queensland
Eka Baker, The University of Adelaide
Jannah Baker, Queensland University of Technology
Peter Ballard, The University of Adelaide
Denise Beaudequin, Queensland University of Technology
Peter Braunsteins, The University of Melbourne
Elizabeth Brown, Queensland University of Technology
Jonathan Budd, The University of Melbourne
David Campbell, The University of Queensland
Marcela Cespedes, Queensland University of Technology
Nathaniel Chand, The University of Queensland
Zeying Chen, The University of Melbourne
Timothy Churches, University of Technology, Sydney
Eamon Conway, Queensland University of Technology

| | | |
|---|---|--|
| Amy Cook , Queensland University of Technology | Tim Hyndman , The University of Melbourne | Tui Nolan , Queensland University of Technology |
| Susanna Cramb , Queensland University of Technology | Sarah James , The University of Adelaide | Eric Parsonage , The University of Adelaide |
| Stephen Crotty , The University of Adelaide | Scott Jones , Queensland University of Technology | Brendan Patch , The University of Queensland |
| Nicole Cusimano , Queensland University of Technology | Lachlan Kang , The University of Adelaide | Martin Peron , Queensland University of Technology |
| Kale Davies , The University of Adelaide | Daryl Kempthorne , Queensland University of Technology | Ramethaa Pirathiban , Queensland University of Technology |
| Matthew DeMaere , University of Technology, Sydney | Daniel Kennedy , Queensland University of Technology | David Price , The University of Adelaide |
| Qibin Duan , The University of Queensland | Ibrahim Khairy , Queensland University of Technology | Leah Price , Queensland University of Technology |
| Earl Duncan , Queensland University of Technology | Sang Li Kim , University of Technology, Sydney | Shanlin Qin , Queensland University of Technology |
| Debajit Dutta , The University of Melbourne | Julia Kuhn , The University of Queensland | Dinesha Ranathunga , The University of Adelaide |
| Megan Farquhar , Queensland University of Technology | Ashwani Kumar , The University of Melbourne | Nicholas Read , The University of Melbourne |
| Charisse Farr , Queensland University of Technology | Patrick Laub , The University of Queensland | Nicholas Rebuli , The University of Adelaide |
| John Feenstra , The University of Adelaide | Thu Huong Le , Queensland University of Technology | Tristan Reddan , Queensland University of Technology |
| Libo Feng , Queensland University of Technology | Alexander Lee , The University of Melbourne | Adam Redman , Queensland University of Technology |
| Benjamin Fitzpatrick , Queensland University of Technology | Jarod Lee , University of Technology, Sydney | Jessie Roberts , Queensland University of Technology |
| John Foxcroft , The University of Melbourne | Yuen Yi Lee , University of Technology, Sydney | Guilherme Rodrigues , The University of New South Wales |
| Puwasaala Gamakumara , Monash University | Xing Lee , Queensland University of Technology | Thais Rodrigues , The University of New South Wales |
| Yani Geng , The University of Melbourne | Shaoke Lei , The University of Melbourne | Adam Rohrlach , The University of Adelaide |
| John Gilbertson , The University of Melbourne | James Lewis , Queensland University of Technology | Adam Rosenow , The University of Melbourne |
| Morgan Grant , The University of Queensland | Jaslene Lin , The University of New South Wales | Robert Salomone , The University of Queensland |
| Jens Grimm , Monash University | Michael Lydeamore , The University of Melbourne | Kate Saunders , The University of Melbourne |
| David Gunawan , The University of New South Wales | Alan Malecki , University of Technology, Sydney | Sarini Sarini , Queensland University of Technology |
| Shovanur Haque , Queensland University of Technology | Jiadong Mao , The University of Melbourne | Rohan Shah , The University of Queensland |
| Catriona Hargrave , Queensland University of Technology | Scott Mason , The University of Melbourne | Shrupa Shah , The University of Melbourne |
| Patrick Hassard , Queensland University of Technology | Peter Mathews , The University of Adelaide | Aminath Shausan , The University of Queensland |
| Hala Hejazi , Queensland University of Technology | Lisa Mayo , Queensland University of Technology | Somayeh Shiri , Monash University |
| Wilko Henecka , The University of Adelaide | James McBroom , Queensland University of Technology | Noon Silk , The University of Melbourne |
| Brock Hermans , The University of Adelaide | Michelle McGrath , Queensland University of Technology | Alex Simmons , Queensland University of Technology |
| Peter Hickey , The University of Melbourne | Marianne Menictas , University of Technology, Sydney | Andrew Smith , Queensland University of Technology |
| Liam Hodgkinson , The University of Queensland | Matthew Moores , Queensland University of Technology | Rachael Anne Smith , Queensland University of Technology |
| Jeff Ching-Fu Hsieh , Queensland University of Technology | Ellen Muir , The University of Melbourne | Simon Smith , The University of Adelaide |
| Wei Huang , The University of Melbourne | Aparna Nickkawade , The University of Queensland | Dimity Stephen , Queensland University of Technology |
| Md Hamidul Huque , The University of Adelaide | | Ria Szeredi , The University of Melbourne |
| Hon Hwang , The University of Adelaide | | Mingmei Teo , The University of Adelaide |

Aleysha Thomas, Queensland University of Technology
Nicholas Tierney, Queensland University of Technology
Jason Tran, The University of Melbourne
Phoebe Truswell, Queensland University of Technology
Zoe van Havre, Queensland University of Technology
Julie Vercelloni, Queensland University of Technology
Kelly Victor, Queensland University of Technology
Nho Vo, Queensland University of Technology
Alexander Volodin, Queensland University of Technology
James Walker, The University of Adelaide
Erli Wang, The University of Queensland
Jason Whyte, The University of Melbourne
Henecka Wilko, The University of Adelaide
Michael Woolgar, Queensland University of Technology
Jianyun Wu, Queensland University of Technology
Wangyue Xie, The University of Queensland
Dong Xu, Queensland University of Technology
Alice Yao, The University of Queensland
Xin Zhang, The University of New South Wales
Huanjun Zhu, Monash University
Wanchuang Zhu, The University of New South Wales

Souhaib Taieb, Université Libre de Bruxelles, Belgium
Simon Yin, University of Technology, Sydney

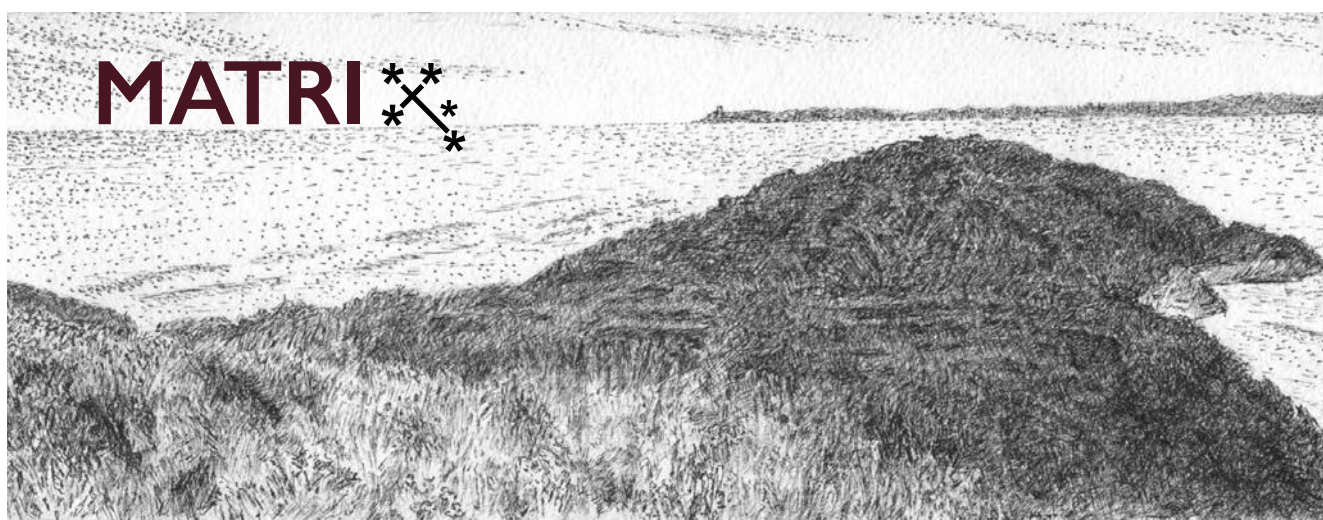
Affiliate Members

An Affiliate Member is a person engaged in ACEMS outreach activities, or who contributes to ACEMS via other non-research activities.

Ken Anthony, AIMS
Mike Callan, Monash University
Mary Coupland, University of Technology, Sydney
Susanna Cramb, Queensland University of Technology
Joseph Grotowski, The University of Queensland
Bronwyn Harch, Queensland University of Technology
Colin O'Hare, Monash University
Michael Pitt, The University of Warwick
Martin Sevier, The University of Melbourne
Mervyn Silvapulle, Monash University

MATRIX

AUSTRALIA'S NEW INTERNATIONAL RESEARCH INSTITUTE FOR MATHEMATICS



A fixed venue research institute in the mathematical sciences has long been the shared desire of many Australian mathematical scientists. Yet, despite several attempts over many years, Australia has remained one of the very few developed countries without such an institute. In 2014 the momentum generated by the formation of ACEMS provided a rare and narrow window of opportunity. After substantial lobbying, The University of Melbourne's School of Mathematics and Statistics and Faculty of Science decided in 2015 to match a contribution from ACEMS of \$100K per annum for three years and increase it four-fold to provide \$400K per annum for three years to establish a research institute, with activities organised at a fixed venue in Victoria. The ACEMS contribution is comprised of \$50K per annum from central ACEMS funds, with the remainder coming from the Melbourne node allocation. These amounts were agreed to by the full executive and put to all Chief Investigators who unanimously voted in favour.

The name of the new research institute is MATRIX. Research institutes around the world each have a

different operating model, determined by the local context. After consultation with several colleagues it was concluded that during the Institute's early years, 2–6 week duration for programs was the most relevant in the Australian context. We expect around 20 residents present at any one time during a research program, but not necessarily the same 20 people each week. We also expect that MATRIX programs will usually contain a focus week in which a conference or embedded workshop may be held with a larger number of participants, and that programs of more than three weeks would include advanced-level short courses or a postgraduate lecture series.

MATRIX' first call for activities in 2016 closed in late 2015. Programs may cover all areas in the mathematical sciences. In 2016 these programs will take place at The University of Melbourne's Creswick campus, located in the heart of Victoria's gold country and close to the popular getaways of Hepburn Springs, Daylesford and Ballarat.

Programs submitted to MATRIX will be approved by the scientific committee of MATRIX whose

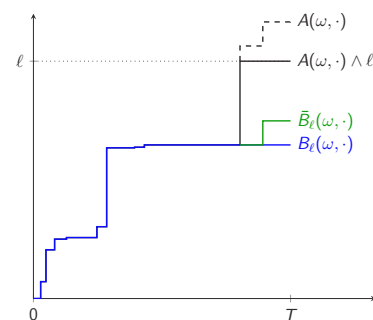
members are selected to cover a wide range of expertise. The 2015 committee members are: Jan de Gier (UoM, Chair), Gary Froyland (UNSW), Liza Levine (Michigan), Kerrie Mengersen (QUT), Arun Ram (UoM), Joshua Ross (Adelaide), Terry Tao (UCLA), and Ole Warnaar (UQ).

MATRIX has an Advisory Board chaired by Tony Guttman (UoM). The 2015 members of the board are: Hélène Barcelo (MSRI), Peter Bouwknegt (ANU), Karen Day (UoM), Jan de Gier (UoM), Iain Johnstone (Stanford), Nalini Joshi (Sydney), Aleks Owczarek (UoM), Cheryl Praeger (UWA), Geoff Prince (AMSI), Brigitte Smith (GBS Venture Partners), Peter Taylor (UoM), Kari Vilonen (UoM), and Ruth Williams (UCSD).

SMART CREDIT LIMITS TO SAVE MONEY FOR CUSTOMERS AND BANKS

The credit limit you're not using on your card is costing your bank money, and that's increasing the cost for all customers' cards.

The true process lies between Budd and Taylor's model and the newspaper vendor model.



The credit limit you're not using on your card is costing your bank money, and that's increasing the cost for all customers' cards.

Jonathan Budd and his supervisor Professor Peter Taylor have developed a way of minimising this, using data on customer spending behaviour. Jonathan left a 'big four' bank to pursue his PhD at The University of Melbourne and ACEMS, drawing on his experience to address a real-world problem.

Their model can create personalised estimates of credit 'need' from month-to-month, which could allow banks to manage their clients individually – especially transactors, who pay off their credit card balance in full each month.

Jonathan lives in London where he collaborates remotely with his supervisor Peter Taylor, tidying up another chapter in his PhD on revolvers – those customers who make only the minimum monthly repayments. In 2015 he travelled to Edinburgh where he presented the work at the Credit Scoring and Credit Control XIV Conference.

He's hoping that in the near-future, the skills and knowledge gained from his research will give him a competitive edge for a career back in banking. His time at the Centre has made a significant contribution to his skill development as a young researcher.

Jonathan says the inspiration for the model came from his previous banking role. During a meeting his colleagues bemoaned the inability to tailor credit limits to different customers on a more personal basis. Now he hopes this model will help – and be taken back from academia so it can be applied in retail banking.

"Banks are very sophisticated users of maths and stats in their trading rooms. But retail banking is much more conservative. There's a whole number of ways that we can make retail banking better for the banks and customers by smart analysis of the information banks hold," he says.

"It's a shame that all the attention goes to markets when there are problems in retail banking that involve lots of data and not-so-obvious solutions. Ultimately it's human behaviour, which is fascinating."

The model is based on the fact that the credit you don't use each month still costs the bank money. Regulators require them to reserve a proportion of the capital, to cover the possibility that you'll make a big purchase tomorrow and then not pay the borrowed money back.

"For example, if you have a \$10,000 limit and you're only spending \$1,000, it's costing the bank. Not a lot, but it adds up and reduces overall profit. Banks try to recuperate that cost through interest charges and fees, which makes a credit card an expensive way to borrow money," Jonathan says.

It's a variation of the classical newspaper vendor challenge. The vendor buys a set number of papers in the morning and has paid for them all, regardless of how many they sell. So how many should they buy? Should they plan to run out and lose some sales, or should they buy more than they expect to sell? It's a problem of allocating resources in an uncertain environment.

"Our model will allow banks to decrease that cost; it's an optimisation procedure, based on an individual's purchasing and payment behaviour."

Jonathan says that in Australia, credit limits tend to be set quite high.

"In November 2015, the Reserve Bank of Australia reported that purchases were only 18 per cent of total card limits, meaning most people aren't using their full credit each month," he says.

"There's an inefficiency in the system – because often people spend much less than their actual limits."

This is one way of applying the available data, but there are many other ways it could be used, which Jonathan says he's keen to explore.

**Jonathan Budd and
Professor Peter Taylor,
The University of Melbourne**

MEDIA



3

KPI

34

achieved



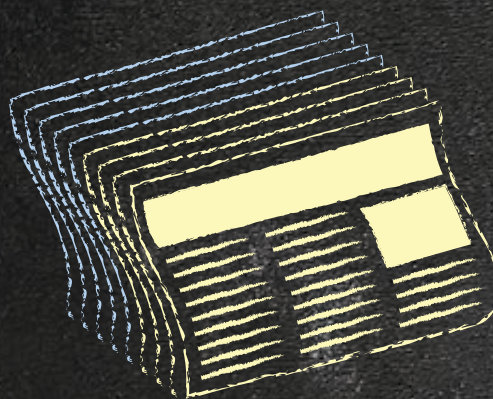
SPONSORSHIP

KEY PERFORMANCE INDICATORS

ACEMS and its members have been published in print and electronic media on 34 occasions, well exceeding our KPI requirement of three articles to be released on Centre activities.

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6. Mengersen, K. IT Wire: QUT Research helping to shape the airports of the future, www.itwire.com/it-industry-news/development/67392-qut-research-helping-to-shape-the-airports-of-the-future, 20 March 2015
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TV & RADIO



5
KPI

9
achieved

MEDIA RELEASES

WORKSHOPS



2
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14
achieved

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ACEMS IN THE MEDIA

34

print & electronic

9

media releases

4

tv & radio

27

ACEMS youtube

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ACEMS Media Releases

The ARC has specified that ACEMS issue five media releases about the Centre's achievements in 2015. We have exceeded this requirement with the following nine releases:

1. Macuga, T. *Statistics Provide the Final Proof in Royal Mystery*, media release, 1 April 2015
2. Macuga, T. *ACEMS Leader Awarded Australian Laureate Fellowship*, media release, 14 June 2015
3. Macuga, T. *ACEMS Node at QUT Welcomes QLD Chief Scientist*, media release, 16 July 2015
4. Macuga, T. *ACEMS Student Wins Award for 'Best Paper' at European Conference*, media release, 10 September 2015
5. Macuga, T. *ACEMS Director Elected as Fellow of Australian Academy of Social Sciences*, media release, 23 September 2015
6. Macuga, T. *ACEMS Visitor Uses Statistical Modelling to Rank the Best Test Cricket Batsmen Ever*, media release, 19 October 2015
7. Macuga, T. *ACEMS Helps with Establishment of New International Institute for Maths at Melbourne University*, 20 October 2015
8. Macuga, T. *ACEMS Associate Investigators Awarded Early Career Research Awards by ARC*, media release, 30 October 2015
9. Macuga, T. *ACEMS Deputy Director Honoured by Modelling and Simulation Society*, media release, 16 December 2015

ACEMS Projects on Television and Radio

The following appearances on television and radio by ACEMS members have enhanced the public awareness of the Centre over the past year.

1. Unmanned Aerial Pilot Program for Koala Surveillance, ABC News, ABC National, 26 February 2015
2. Research on Airports of the Future, Channel 7 News, Australia, 19 March 2015
3. The Changing Face of Melbourne, Channel 7 News, Australia, 15 September 2015
4. Scientists utilise 'Avatar-style' Virtual Reality to Help Threatened Species by Preserving Best Habitat, ABC News, ABC National, 11 October 2015

To visit ACEMS YouTube channel go to:

<https://www.youtube.com/channel/UCfImumslclK4VFVik1NMClA>

or put ACEMS in the YouTube search bar



Research Training, Workshops and Professional Education

ACEMS has implemented a number of initiatives that enhance the experiences of our research students and members, including training and professional education. The ARC has set the KPI for hosting national and international workshops in 2015 at two, which ACEMS has exceeded. The workshops we have held during 2015 are listed below.

1. Chief Investigator Retreat, Coolangatta – January
2. Tomohiro Sasamoto Workshop Series, The University of Melbourne – February
3. Statistical Modelling and Analysis of Big Data Workshop, Queensland University of Technology – February
4. Bayesian Statistics for the Big Data Age, Queensland University of Technology – May
5. ACEMS/AIMS Workshop on the Great Barrier Reef, Queensland – May
6. International Workshop on Monte Carlo Methods for Spatial Stochastic Systems, The University of Queensland – July
7. ACEMS Node Retreat, Queensland University of Technology – July
8. Stochastic Processes and Special Functions Workshop, The University of Melbourne – August
9. ACEMS Short Course on INLA, Queensland University of Technology – August
10. Collaborative Workshop, The University of Queensland – September

11. Hadoop for Statisticians, University of Technology, Sydney – October
12. Julia for Statisticians, University of Technology, Sydney – November
13. ACEMS Student Retreat, McLaren Vale – November
14. ACEMS Annual Retreat, Glenelg – November

Sponsorships

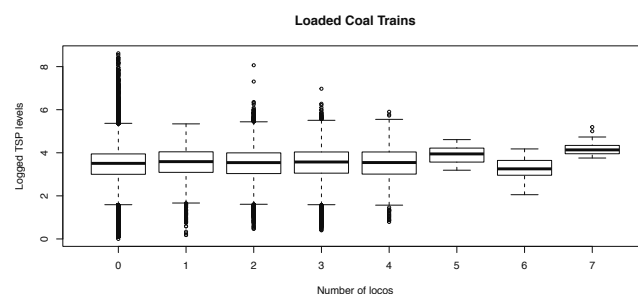
The following is a list of events that ACEMS has sponsored in 2015; an investment of \$15,500:

1. South Pacific Continuous Optimization Meeting, Newcastle, February – \$1,000
2. Tony Guttman Lecture Series, Newcastle, February – \$1,000
3. SSAI NSW Branch Lancaster Lecture, Sydney, March – \$500
4. The Fourth Australia New Zealand Applied Probability Workshop (ANZAPW), Barossa Valley, April – \$2,000
5. The 40th Annual IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) 2015, Brisbane, April – \$1,000
6. International Biometrics Society Conference, Hobart, August – \$1,000
7. ANZAMP Conference, Newcastle, September – \$1,000
8. Analysis and Visualizations of Large Complex Data with Tessera, Sydney, October – \$1,000
9. Stochastic Modelling meets Phylogenetics Workshop, Hobart, November – \$1,000
10. SM² meeting, Melbourne, November – \$1,000
11. Bayes on the Beach Conference, Surfers Paradise, December – \$5,000

TAKING COALS TO NEWCASTLE

*Coal trains in the Hunter Valley
have been kicking up a cloud of
dust and controversy.*

An example of logged Total Suspended Particulates (TSP) according to number of locomotives by passing train type.



Coal trains in the Hunter Valley have been kicking up a cloud of dust and controversy.

Now, good statistical design and experimentation has revealed the surprising source of the dust.

For a number of years, residents near the rail line that delivers coal to export via Newcastle's busy port have complained of coal dust, which they say escapes uncovered coal wagons to pollute homes and endanger health.

A proposal to cover the coal wagons was considered, but the cost would be high. What's more, there was evidence that much of the local dust wasn't originating from loaded coal trains at all.

Coal dust tends to be of a particular size: around ten thousandths of a millimetre (i.e. 10 microns) in diameter. However much of the dust on surrounding streets was found to be much finer (meaning it's also more hazardous to health), and likely sourced from engine exhaust.

A 2012 study of airborne dust before and after passing trains was inconclusive.

The challenges involved in analysis of the data were varied: there were large extremes and some gaps in the data; there were often a number of trains of different types all passing at once; the weather was a significant factor; as was the time of day and day of the week.

So the NSW Environment Protection Authority brought in ACEMS, who correlated air-pollution data collected beside the rails near a busy junction in Metford (a town on the outskirts of

Newcastle) against information on passing trains and weather conditions.

Professor Louise Ryan from the University of Technology, Sydney, her PhD student Alan Malecki, and other Centre analysts used an advanced version of linear regression analysis – the so-called generalised additive model. This allows statisticians to build a complex model of interdependent factors, and then fine-tune that model to minimise the variance between modelled data and measured data.

The analysis confirmed that:

- There was around a 10 per cent increase in airborne dust with passing coal trains.
- The increase was about the same, whether wagons were full of coal, or empty.
- Freight trains caused the same increase in dust as coal trains!

They found that the shorter passenger trains that also passed on the same lines only increased dust by approximately two per cent. If it had rained the day before, the amount of dust of all particle sizes was reduced.

A theory had been proposed that the fine particles found in airborne dust could arise from the diesels pulling the wagons, rather than from escaping coal dust. But analysis found no correlation between the number of diesel locomotives and the amount of fine-particle dust.

One of the suggestions from the new analysis was that the measured increase in airborne pollution as trains passed was most likely being caused

by vibrations and turbulence from the trains' passing throwing up dust from the tracks and the surrounding land.

This explained why empty coal wagons, full coal wagons, and freight wagons all increased airborne dust by the same amount. Meanwhile, the shorter, lighter passenger trains threw up much less dust.

It also explained why airborne dust of all particle sizes increased as the long, heavy trains passed, not just 10-micron coal dust. This included the finest particles, which are the most damaging to health.

Which certainly posed a further challenge for policymakers and train operators. But with this knowledge, they could make decisions with a firm understanding of the mechanisms behind the pollution, and thus what might work best.

Professor Louise Ryan and Alan Malecki, University of Technology, Sydney

STUDENT AND EARLY CAREER RESEARCHER RECRUITMENT & COMPLETION

A total of 74 PhD students and 28 Early Career researchers were members of ACEMS in 2015.



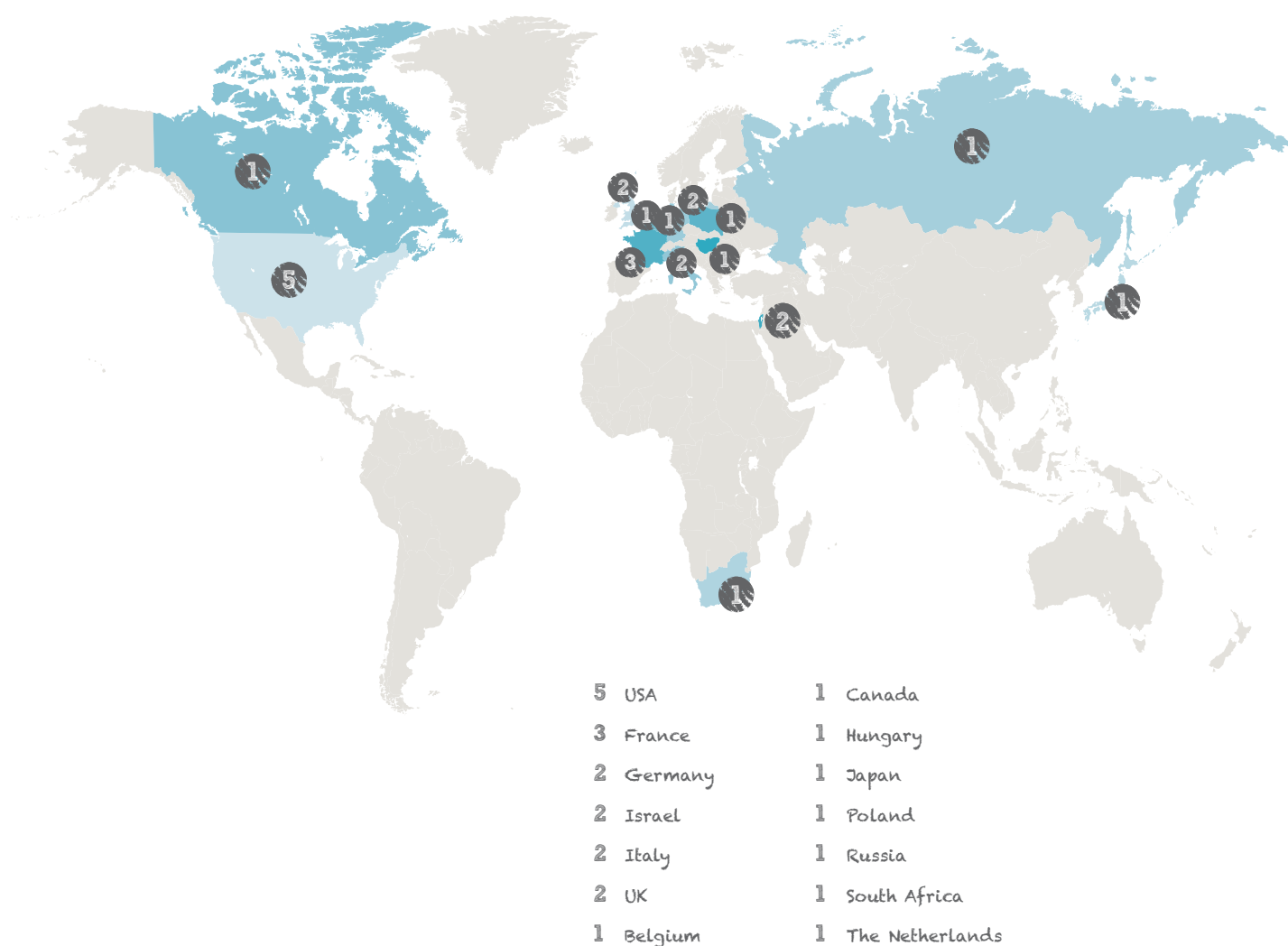
ACEMS Scholarship recipients in 2015 were:

1. Peter Braunsteins, The University of Melbourne
2. Zeying Chen, The University of Melbourne
3. Qibin Duan, The University of Queensland
4. Puwasala Gamakumara, Monash University
5. Liam Hodgkinson, The University of Queensland
6. Tim Hyndman, The University of Melbourne
7. Daniel Kennedy, Queensland University of Technology
8. Patrick Laub, The University of Queensland
9. Huan Lin, The University of New South Wales
10. Brendan Patch, The University of Queensland
11. Leah Price, Queensland University of Technology
12. Adam (Ben) Rohrlach, The University of Adelaide
13. James Walker, The University of Adelaide
14. Erli Wang, The University of Queensland

INTERNATIONAL, NATIONAL & REGIONAL LINKS & NETWORKS

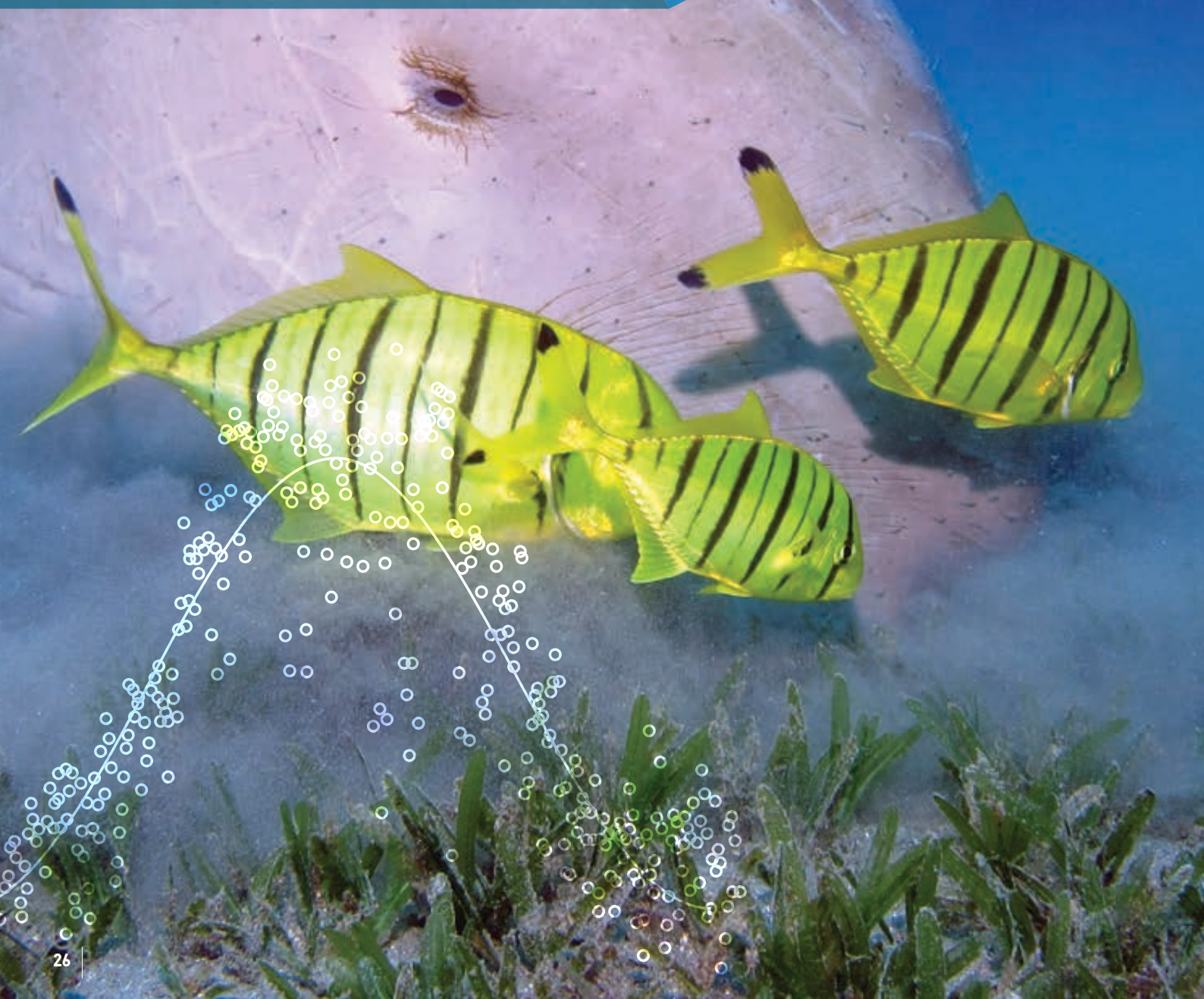
Visitors

Visitors arrived to ACEMS nodes from the following countries:

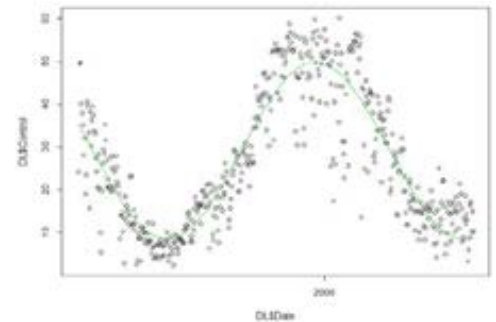


SAVING SEAGRASS SANCTUARIES

Seagrass communities are one of the most productive ecosystems, yet they have been disappearing at an average rate of 110 km² per year since 1980.



An example of how light intensity follows a seasonal sinusoidal pattern, showing the substantial natural variability without taking dredging into account.



Seagrass communities are one of the most productive ecosystems, providing food, nursery grounds and habitats for many animals – from dugongs, turtles and birds, to fish, prawns, tiny crabs and invertebrates. With their networks of underground roots, many species of seagrass stabilise the ground they cover, as well as acting as carbon stores and supporting fisheries. But globally seagrass has been disappearing at an average rate of 110 km² per year since 1980, and some of their biggest threats include dredging, coastal developments, and agricultural and urban runoff.

To see how seagrass sanctuaries can be given a fighting chance, researchers have been using an extension of an existing modelling technique (Bayesian Networks) and putting it to relatively new use for species of tropical and temperate seagrass meadows. They found that using 'environmental windows' (time restrictions on when dredging activities can occur) can greatly reduce the loss of seagrasses and improve their recovery time under certain conditions.

Dr Paul Wu, an Associate Investigator at ACEMS who is based at the Queensland University of Technology, has collaborated with colleagues at the Australian Institute of Marine Science, the Western Australian Marine Science Institution, Edith Cowan University and the University of Western Australia.

"Our partners have decades of knowledge from diving, so we are getting the information from them and combining it with data into a framework that is useful for management," Paul says.

The team hopes their work will help inform dredging management, and new port development and maintenance. They are looking to apply the modelling approach to other complex systems such as coral reefs.

Bayesian Networks have become popular in ecological modelling, as they allow data to be combined with expert knowledge. But they give a 'snapshot in time' and don't allow for feedback loops, which are an important part of ecosystems. Paul says that to model systems like seagrass communities, they needed an approach that can account for changes in the past causing flow-on effects on the system in the future.

The Dynamic Bayesian Networks applied by Paul and his colleagues allow cumulative effects to be built into the model – so the fact that seagrass habitats may transition into a different, degraded environment with new characteristics can be included in any predictions.

The approach has been used in the field of genetics, to model how genes are regulated, but less-so in ecosystem support, particularly for seagrasses.

"It's an interesting problem: the ocean is such a complex and diverse environment, so there are lots of gaps in our knowledge of it. It's tricky to get a comprehensive picture of what could happen under different conditions," says Paul.

In the case of seagrasses, there are many features of different meadows to consider, including the density of plant growth, how many shoots there are, how quickly the plants are growing, the amount

of sediment in the water and how much light it blocks – some of which are impacted by natural occurrences such as storms.

"In a real-world application like this, with all these complex variables and processes, modelling is really helpful in that it helps managers to better understand the impact of decisions," Paul says.

The knowledge is being shared both ways between the biologists out in the field, doing experiments covering fields of seagrass with tarps, and those sifting through statistics.

"This combination of expertise allows us to predict information that would take years to gather in the field. This model is our current best understanding of nature – it allows us to test that, ask what we can learn about the system, and make predictions on things like extinction."

Dr Paul Wu, Queensland University of Technology

STAKEHOLDER ENGAGEMENT

THE TROUBLE WITH TRAFFIC – ACEMS AND VICROADS COLLABORATION



An urban transport network model, grounded in statistical mechanics and developed by experts from The University of Melbourne, Monash University and the Roads Corporation of Victoria (VicRoads), is pioneering the predictive testing of potential modifications to the traffic network system.

According to the International Energy Agency, there will be 1.7 billion cars on the world's roads by 2035 – roughly double the current number. Such a significant rise in road traffic is expected to take a heavy toll on levels of urban congestion. The problem is particularly pressing in light of the fact that the world's population is increasingly concentrated within cities and megacities. Indeed, according to the UN, by 2030 three out of every five people will live in an urban environment.

If urban planners are to successfully manage road traffic in the upcoming years, then effective models are needed to identify and pinpoint solutions for the predominant causes of congestion. Although there are a number of microsimulation packages already available on the market, their usefulness is

hampered by two major limitations. Firstly, they are time-consuming to set up, as each scenario requires a large amount of input data that is both extremely detailed and accurate. Secondly, they can only simulate relatively small traffic networks – larger networks, such as arterial road networks in a city, cannot be accurately modelled.

Clearly what is required for this heavy-duty simulation – as a matter of increasing urgency – is a novel type of model that has the computational power required to deal with large-scale traffic networks. This is where ACEMS, together with Monash University and VicRoads, comes in. Experts from each entity are collaborating on a project to build just such a model. At the heart of this algorithmic alliance are three statistical mechanics researchers: Dr Tim Garoni, Professor Jan de Gier and Dr Lele (Joyce) Zhang.

Stochastic Cellular Automata

Developing a traffic model based on statistical mechanics is an approach that has been applied

successfully to freeway traffic. Within such a system, cars are modelled as moving and interacting particles. Applying these mathematical physics techniques to network traffic is in itself a fairly innovative approach, as most other models currently available have been developed from techniques based on branches of applied mathematics or engineering. Even more innovative is the model's pioneering use of stochastic cellular automata for the study of the impact of realistic traffic lights on urban traffic networks.

The resulting model, named Cellular Automata Simulator for Arterial Roads (CEASAR), is both easy to implement – as it requires only the most essential basic information, such as traffic signal data – and simple to update in the event of a changing scenario, such as the introduction of new bicycle lanes or a sudden road closure.

“This approach, treating the network as an interacting particle system, allows us to use advanced techniques developed in fundamental research, and thus provides a tool capable of



simulating traffic through large road networks, which is computationally fast and requires only minimal input data and calibration,” de Gier explains.

Real-World Uses

The CEASAR model can be used to apply realistic traffic signal systems, improving its accuracy and therefore its ability to derive real-world benefits. For example, CEASAR includes an accurate model of the Sydney Coordinated Adaptive Traffic System (SCATS). SCATS is based on a control system used in many cities around the world, in which traffic signal parameters such as green times and cycle lengths respond to current levels of congestion.

In a recent study performed with CEASAR, the researchers studied the effects of different adaptive signal systems on an arterial network’s macroscopic fundamental diagram (MFD). An MFD plots information relating to flow versus density within a road network, and enables the effective comparison of traffic flow under different conditions. CEASAR has the ability to simulate various network performance metrics, such as MFDs, in combination with operating on a citywide scale in a way that incorporates real life traffic signal systems and includes diverse modes of transport. This breadth and flexibility is what makes the model so useful to urban planners and transport policy makers. The research team behind CEASAR is one of just a handful of groups worldwide who have achieved such a high level of functionality.

Making a Difference in Melbourne

To date, the CEASAR team has produced a number of interesting findings, which have led to the publication of three peer-reviewed papers as well as multiple technical reports. Under the ARC Linkage Project ‘Modelling Large Urban Transport Networks Using Stochastic Cellular Automata’, between 2012–2014, researchers used the model to study the Melbourne road traffic network, undertaking the following key studies:

- The effect of temporary traffic incidents on network performance and of using real-time data to divert traffic away from the incident
- The impact of different levels of kerbside parking on network performance
- A preliminary comparison of absolute versus conditional tram priority
- Analysis of the impact of allowing cyclists to use bus lanes
- Refining the SCATS model to enable the comparison of a variety of alternative SCATS implementations
- A study of the effect of increasing SCATS’ maximum cycle length
- Examination of the impact of several clearway policies on tram routes
- Examination of the consequences of relocating a number of tram stops and detectors

The insights generated by this research have already been used to inform a number of policy decisions and, by continuing to work closely with local government, the CEASAR team hopes to further utilise their model for the predictive testing of the impact of potential road network modifications. Additionally, the group is also working in collaboration with Dr Andrea Bedini at The University of Melbourne to develop their model’s online visualisation tool (use Google Chrome to visit <http://ceasar.acems.org.au>). The team also plans to carry out theoretical research on the generic behaviour of road traffic networks over the upcoming years – work that is likely to bring about significant practical applications in the future.

Traffic Modelling Objectives

The key objectives of this research are to:

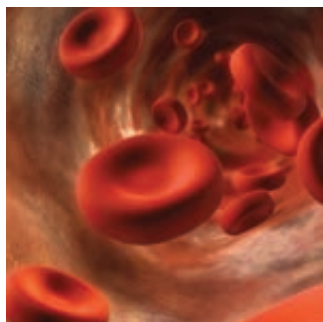
- Improve understanding of traffic, both public and private transport, in order to combat increasing road traffic and urban congestion;
- Develop models of large urban transport networks using stochastic cellular automata for use as a predictive tool for urban planners; and
- Use mesoscopic models to evaluate network-wide responses to a range of parameter values, such as turning rates and input/output volumes.

Partner

Victoria’s Department of Economic Development

Funding

Roads Corporation of Victoria (VicRoads) and ACEMS



Partner Organisations



Industry Engagement

The following is a list of organisations where projects and opportunities have been established and leads followed in 2015. Each opportunity remains open.

- Australian Agricultural Company
- Surf Life Saving Australia
- Australian Red Cross Blood Service
- Bendigo Health
- Bill and Melinda Gates Foundation
- Caterpillar Australia
- Defence Science and Technology Group (DST Group)
- Hawthorn Football Club*
- IBM Research
- Johnson and Johnson / Janssen Pharmaceutical
- Open Data Institute Australia (ODIA)
- Parramatta City Council
- Pricewaterhouse Coopers (PwC) Australia
- Booking.com

** indicates lead commenced in 2014. Contact has been maintained.*

OUTREACH

Public Lectures

The following public lectures included ACEMS participation in National Science Week:

1. Scott, S. *Multi-Armed Bandit Experiments in the Online Service Economy*, Google Australia, talk at Queensland University of Technology, February.
2. Menendez, P. *Statistical Methods to Study the Effect of the 2014 Lockout Laws in Sydney*, NSW Bureau of Crime Statistics and Research, talk at University of Technology, Sydney, June.
3. Scott, M. *The Environmental Data Deluge – Sinking or Swimming*, University of Glasgow, talk at Queensland University of Technology, June.
4. Tracy, C. *Integrable Probability and the Role of Painleve Functions*, University of California, Davis, ACEMS Colloquium at The University of Melbourne, August.
5. Saunders, K. and Taylor, P. *How do we calculate the probability of an extreme event?* The University of Melbourne, talk for National Science Week, August.
6. Mengersen, K. *Now that we have it, what do we do with it? How Maths and Stats can save us from drowning in big data*, Queensland University of Technology, talk for National Science Week, August.
7. Ryan, L. *The Impact of Coal Dust in the Hunter Valley*, University of Technology, Sydney, talk for National Science Week, August.
8. Mengersen, K. *The power and promise of immersive virtual environments*, Queensland University of Technology, part of World Statistics Day 2015, October.

School Visits

ACEMS members Andrew Stephenson and Steven Psaltis visited schools in Cairns during the week of 12–16 October as part of a pilot program to demonstrate key mathematical concepts in a fun and interactive way. They attended:

- Bentley Park College (including Year 7 Maths Challenge Day)
- Maths and Early Careers Network Meeting
- Cairns State High School
- Trinity Bay State High School
- St Mary's Catholic College

Andrew and Steven ran 22 workshops for 440 students and one professional development workshop for 15 teachers. It is hoped that the success of this pilot will result in a rollout to other states in coming years.



ACEMS Outreach Officer Andrew Stephenson working with students in Cairns as part of an ACEMS outreach project to show students how learning about maths can be fun.

The “maths grid” play area at Brunswick South West Primary School, helping teachers find new and creative ways to teach mathematics to their students, by getting students out of the classroom, and onto a play area where they will be more actively engaged in learning.



Other Public Activities

1. Rollout of the Brunswick South West Primary School mathematical playground equipment and a suite of activities for teachers to run with the children. The activities have been designed to be interactive and to highlight different mathematics topics. The mathematical topics covered by the current suite of activities introduce students to binary numbers, graph theory, topology, knot theory, probability and cryptography. More activities are planned for development in the future.
2. With the assistance of high school maths teacher Anthony Harradine, The University of Melbourne node ran an event called *Doing Maths like a Mathematician*, which is designed

to promote maths and problem solving skills to school students and teachers. Places were initially limited to 30, with schools being invited to send a team of three students and a teacher. It was intended to run the event only once but interest was so great that the project quickly expanded to five events in October and November, with a total reach of 48 schools and 192 participants across Melbourne and regional Victoria. There are plans to repeat the event next year in Melbourne, and a strong desire to expand the programme to ACEMS’ other host cities.

3. Associate Investigator Steven Stern conducted a training course at the Australian Bureau of Statistics, Canberra on Applied Resampling Methods – October.

4. *The Laborastory*: In Melbourne, Anita Ponsaing gave a presentation on Ada Lovelace, Charles Babbage and the Analytical Engine (26 July), and Anthony Mays gave a talk on the work and life of Voltaire and Émilie du Châtelet (16 May).
5. Anthony Mays presented the *Mathematics of Juggling* show during The University of Melbourne Science Festival – 17–21 August.
6. Laleh Tafakori supervised an ACEMS Vacation Scholarship Student.
7. Shrupa Shah developed the Random Variables Applet in Geogebra as part of the Conceptual Learning with Interactive Applets for the Undergraduate Mathematics and Statistics Initiative of the School of Mathematics and Statistics at The University of Melbourne.



ACEMS “Doing Maths Like a Mathematician”.



ACEMS MULTIMEDIA



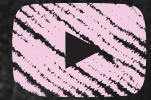
website
hits - 15,000
users - 9,500
page views - 41,000



facebook
followers - 147



twitter
followers - 120



youtube
views - 2060

Website and Social Media Statistics

The ACEMS website underwent a major redevelopment in the second half of 2015 with a complete refresh of its look and feel. The update has contributed to a growth in website traffic, with website hits at 15,000 sessions, with 9,500+ users and 41,000+ page views from 1 January to 21 December.

The ACEMS Facebook page continues in 2015 and has been growing at a slow but steady pace. It currently has 147 followers.

The ACEMS Twitter account was established in October and currently has more than 120 followers. ACEMS will work on developing strategies to increase its use and follower numbers.

A YouTube channel was established in mid-2015 and there are currently 35 subscribers with 2,000+ views of videos at the following events:

- ACEMS in Melbourne
- ACEMS School Project
- Statistical Modelling and Analysis of Big Data Workshop Presentations (10)
- Australia New Zealand Applied Probability Workshop (3)
- ACEMS & AIMS Workshop on Great Barrier Reef (2)
- Workshop on Monte Carlo Methods for Spatial Stochastic Systems (7)
- ACEMS Queensland University of Technology Node Retreat (2)
- National Science Week 2015, Kerrie Mengersen Lecture
- World Statistics Day Kerrie Mengersen AMSI Lecture
- ACEMS Doing Maths Like a Mathematician

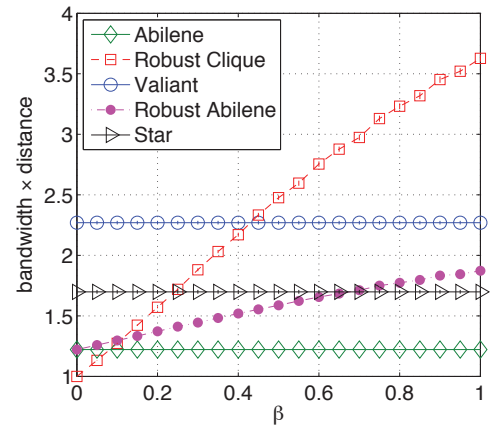


TRAFFIC MATRICES: MAXIMISING UNCERTAINTY TO DESIGN MORE RELIABLE DIGITAL NETWORKS

We've all cursed an inefficient digital network, but no-one wants to pay for a network that's vastly over-engineered for the traffic it will have to carry.



Network design tests based on an average of performance over 168 Abilene traffic matrices relative to the optimal design.



We have all cursed an inefficient digital network, whether it's delays streaming the latest Game of Thrones episode or a dangerous mobile phone overload during bushfire season. But no-one wants to pay for a 'gold plated' digital network that is vastly over-engineered for the traffic it will have to carry.

The secret to designing and testing a digital network to find the happy medium lies in mathematical tools called 'traffic matrices'.

When designing a digital network from scratch, network engineers need to make some assumptions about the type of traffic that the network will end up carrying. How heavy will traffic be between each element of the network? How much will traffic fluctuate? Where are the hotspots? Where are the bottlenecks? They need to know how their network will fare in response to various situations: a spike in traffic along one route; the failure of a key gateway; or a number of other different faults.

Network designers test their network's response to hundreds or even thousands of different scenarios. They use those results to make decisions such as the capacity required for individual components, how large a 'spike' to allow for before performance is affected, whether to replace expensive underground fibre-optic cables, or where to put a new data centre.

All these decisions carry cost implications. You could always build a network with no bottlenecks, over-engineering each component – think of it as the equivalent of building six-lane highways between every back-country town and sleepy outer suburb in Australia. Such over-engineering is

wasteful and expensive.

To test their new network's response to every feasible set of digital traffic conditions, and help with those myriad investment decisions, engineers use a traffic matrix. This is a model of all the digital traffic within the network, representing the data that travels between each component, including hotspots and bottlenecks – every digital factor that a 'real' network might face.

One or two such models aren't sufficient. To reliably predict a new network's response, engineers need to use – at least – hundreds of different matrices modelling different traffic conditions.

The matrices need to be built from scratch for each network. Using customised software, engineers generate the matrices they need by using a set of random variables and then iteratively correcting them towards the structure they need – 'growing' the matrix a little like growing a crystal.

Engineers need to know that the set of traffic matrices they create will cover every possible and probable digital scenario for the network being tested, which is particularly difficult when the network doesn't yet exist.

The standard approach when modelling any system is to measure first, then create a model that fits the measurements. But this is not possible for a brand new network, or for digital traffic conditions that could change radically – such as happened when Facebook or Netflix came along to cause a 'step change' in digital use.

The answer is to throw out the typical modelling

approach, and use a system called maximum uncertainty, or maximum entropy.

"Maximum uncertainty might sound like a strange way to develop a system that is as robust as possible," says Professor Matthew Roughan, who specialises in traffic matrices. "But it's a very powerful technique."

Matthew, working with Dr Paul Tune at The University of Adelaide, has found that the secret to designing traffic matrices is to apply the philosophy of maximum uncertainty, which minimises the number of assumptions within the system.

Such a set of matrices avoids inadvertent assumptions such as where bottlenecks will appear, or the size of the largest digital traffic spikes.

Engineers can be confident that any network that can cope with uncertainty-maximised traffic matrices will be best set to cope with the real world without needing to resort to expensive, 'gold-plated' over-engineering.

Professor Matthew Roughan
and Dr Paul Tune,
The University of Adelaide

NATIONAL BENEFIT — STAFF RECOGNITION

Prizes, Awards and Other Prestige Measures of Centre Members

1. Professor Jan de Gier was appointed an Associate Member of Commission C# (Commission on Statistical Physics) of the International Union of Pure and Applied Physics for the period of 2016–2018.
2. Postgraduate student, Xing Lee, won the inaugural Tony Morton Award, presented to an international student for his research into the statistical modelling of healthcare associated infection transmissions.
3. Professor Peter Bartlett was elected as a Fellow of the Australian Academy of Science.
4. Professor Louise Ryan received a Harvard University Graduate School of Arts and Sciences Centennial Medal.
5. The ARC awarded Professor Kerrie Mengersen an Australian Laureate Fellowship.
6. Student Jonathan Budd and Professor Peter Taylor won the award for “Best Paper” at the Credit Scoring and Credit Control Conference in Edinburgh, Scotland, UK.
7. Professor Peter Hall was elected as a Fellow of the Academy of Social Sciences in Australia.
8. Dr Chris Drovandi received an ARC Discovery Early Career Research Award (DECRA).
9. Dr Michael Wheeler from The University of Melbourne received an ARC Discovery Early Career Research Award (DECRA).
10. Professor Kerrie Mengersen was awarded a Biennial Medal by the Modelling and Simulation Society of Australia and New Zealand (MSSANZ).
11. Dr Troy Farrell was awarded the E.O. Tuck Medal for outstanding research and distinguished service to the field of applied mathematics.
12. Dr Tomasz Bednarz received the Merit iAward 2015. He also became an Adjunct Senior Associate Professor at the University of Sydney, Design Lab and an Adjunct Senior Lecturer at the University of South Australia, School of Information Technology and Mathematical Sciences.
13. Dr Christopher Oates was awarded an ARC Research Fellowship and a ViCBiostat Visiting Fellowship in 2015.
14. Ms Yuen Yi Lee was awarded the Harvard Post-Doctoral Fellowship 2015 and a Google Zurich Scholarship.
15. Professor Nick Graves won the Coloplast Biatain Literary Award 2015 presented by the Australian Wound Management Association.
16. Student Daniel Kennedy was awarded third prize for his poster presentation at the 2015 B3 Symposium.
17. Nick Tierney won the Sessional Teaching and Reflection Showcase at Queensland University of Technology (QUT) on 7 August 2015 and the QUT Vice Chancellors Performance Award for Innovation in Teaching on 11 December 2015.
18. Dr Victor Gabillion received the Accessit PhD Award 2015.



ACEMS Chief Investigator Peter Bartlett (QUT), pictured on the left, with Academy President Andrew Holmes (right), was named a Fellow of the Australian Academy of Science in May 2015.



ACEMS Deputy Director Kerrie Mengersen, with ARC CEO Aidan Byrne, was one of 15 people to be selected as ARC Laureate Fellows in 2015.

Image Courtesy: The Australian Research Council. Photo by: Norman Plant Photography.



ACEMS PhD Student Jonathan Budd (The University of Melbourne) won the award for best paper at the Credit Scoring and Credit Control Conference in Edinburgh, Scotland. Jonathan worked with ACEMS Director Peter Taylor on the paper.

19. Ms Dimity Stephen received an Australian Postgraduate Award Scholarship and won the Health Faculty 3-minute Thesis competition at QUT.
20. Amy Cook was a semi-finalist in the 2015 Hilti Big Data Analytics Competition.
21. Ben Fitzpatrick was awarded the Cooperative Research Centre for Spatial Information Student Excellence Award 2015.
22. Iwan Jensen was awarded 300,000 CPU hours by the National Computational Merit Allocation Scheme, valued at \$12,000.
23. Ellen Muir was awarded the prize for the Best Student Talk at the Australia New Zealand Applied Probability Workshop on 4 July 2015.
24. Peter Braunsteins was awarded an Honourable Mention in the Best Student Talk competition at the Australia New Zealand Applied Probability Workshop.
25. PhD students Kate Saunders, Tim Hyndman and Peter Braunsteins won the ACEMS Advanced Sampling Exploration and Matlab Competition.

PUBLICATIONS



Books and Book Chapters

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4. Jarrad, F., Low-Choy, S. and Mengersen, K. (Eds.) (2015) *Biosecurity Surveillance: Quantitative Approaches*. CAB International, Wallingford, Oxfordshire, UK.
5. Johnson, S., Mengersen, K., Ormsby, M. and Whittle, P. (2015) Using Bayesian networks to model surveillance in complex plant and animal health systems. In Jarrad, F., Low-Choy, S. and Mengersen, K. (Eds.) *Biosecurity Surveillance: Quantitative Approaches*. CAB International, Wallingford, Oxfordshire, 278—295.
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8. Mengersen, K., McGree, J.M. and Schmid C.H. (2015) Systematic Review and Meta-analysis Using N-of-1 Trials. In Nikles, J. and Mitchell, G. (Eds.) *The Essential Guide to N-of-1 Trials in Health*. Springer, Netherlands, 211—231.
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10. Murray, J., Whittle, P., Jarrad, F., Barrett, S., Stoklosa, R. and Mengersen, K. (2015) Design of a surveillance system for non-indigenous species on Barrow Island: plants case study. In Jarrad, F., Low-Choy, S. and Mengersen, K. (Eds.) *Biosecurity Surveillance: Quantitative Approaches*. CAB International, Wallingford, Oxfordshire, 203—216.
11. Quinlan, M., Stanaway, M. and Mengersen, K. (2015) Biosecurity surveillance in agriculture and environment: a review. In Jarrad, F., Low-Choy, S. and Mengersen, K. (Eds.) *Biosecurity Surveillance: Quantitative Approaches*. CAB International, Wallingford, Oxfordshire, 9—42.
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Refereed Journal Articles

In 2015, 261 articles by Centre members were published in scholarly refereed journals.

ACEMS had a KPI of 90 citations in 2015. A total of 86 individual ACEMS journal publications were cited in 2015, with various articles cited multiple times, resulting in 179 citations achieved.

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31. Shah, R., Hirsch, C., Kroese, D.P. and Schmidt, V. (2015) Rare event probability estimation for connectivity of large random graphs. *Proceedings – Winter Simulation Conference*.
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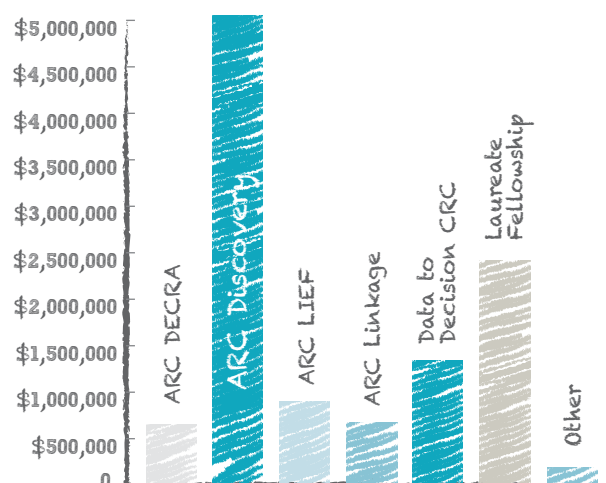
FINANCE

Grants

The following is a list of active grants in 2015.

| Grant Type | Grant ID | Investigator/s | Total Value of Grant (\$) |
|---|-------------|---|---------------------------|
| ARC Discovery Early Career Researcher Award | DE150101044 | Hautphenne, S. | 315,000 |
| ARC Discovery Early Career Researcher Award | DE130100291 | Nazarathy, Y. | 374,595 |
| ARC Discovery Early Career Researcher Award | DE130101670 | Ormerod, J. | 370,410 |
| ARC Discovery Early Career Researcher Award | DE130100819 | Rojas-Nandayapa, L. | 281,600 |
| ARC Discovery Early Career Researcher Award | DE150101842 | Yang, Q. | 345,000 |
| ARC Discovery Project | DP150103588 | Barbour, A. | 310,700 |
| ARC Discovery Project | DP150101459 | Barbour, A., Pollett, P. and Ross, N. | 591,800 |
| ARC Discovery Project | DP150100828 | Burrage, K. | 355,100 |
| ARC Discovery Project | DP140102201 | DeGier, J. | 340,000 |
| ARC Discovery Project | DP140100125 | Delaigle, A. | 415,000 |
| ARC Discovery Project | DP140102613 | Forrester, P. | 390,000 |
| ARC Discovery Project | DP140100559 | Garoni, T. | 300,000 |
| ARC Discovery Project | DP130103356 | Geweke, J. | 800,000 |
| ARC Discovery Project | DP140101110 | Guttmann, A. and Clisby, N. | 370,000 |
| ARC Discovery Project | DP150102345 | Hegland, M. | 225,900 |
| ARC Discovery Project | DP130101738 | Hegland, M. | 330,000 |
| ARC Discovery Project | DP140103220 | Hyndman, R. and Panagiotelis, A. | 335,000 |
| ARC Discovery Project | DP140101110 | Jensen, I., Clisby, N. and Guttmann, A. | 370,000 |
| ARC Discovery Project | DP150104630 | Kohn, R. and Carter, C. | 333,581 |
| ARC Discovery Project | DP150104292 | Koo, B. and Anderson, H. | 262,400 |
| ARC Discovery Project | DP140101956 | Kroese, D. | 280,000 |
| ARC Discovery Project | DP150101728 | Martin, G. and Robert, C. | 277,000 |
| ARC Discovery Project | DP140103564 | Mengersen, K. | 351,000 |
| ARC Discovery Project | DP130100156 | Nazarathy, Y. | 300,000 |
| ARC Discovery Project | DP140102319 | Ross, J. | 343,000 |
| ARC Discovery Project | DP150103710 | Rubinstein, B. | 216,000 |
| ARC Discovery Project | DP130102066 | Timms, P. | 360,000 |
| ARC Discovery Project | DP150101485 | Timms, P. | 458,600 |
| ARC Discovery Project | DP150103675 | Turner, I. and Burrage, K. | 347,100 |
| ARC Discovery Project | DP110101234 | Warnaar, O. | 715,000 |

ACEMS members attracted \$11,270,385
in additional support in 2015.



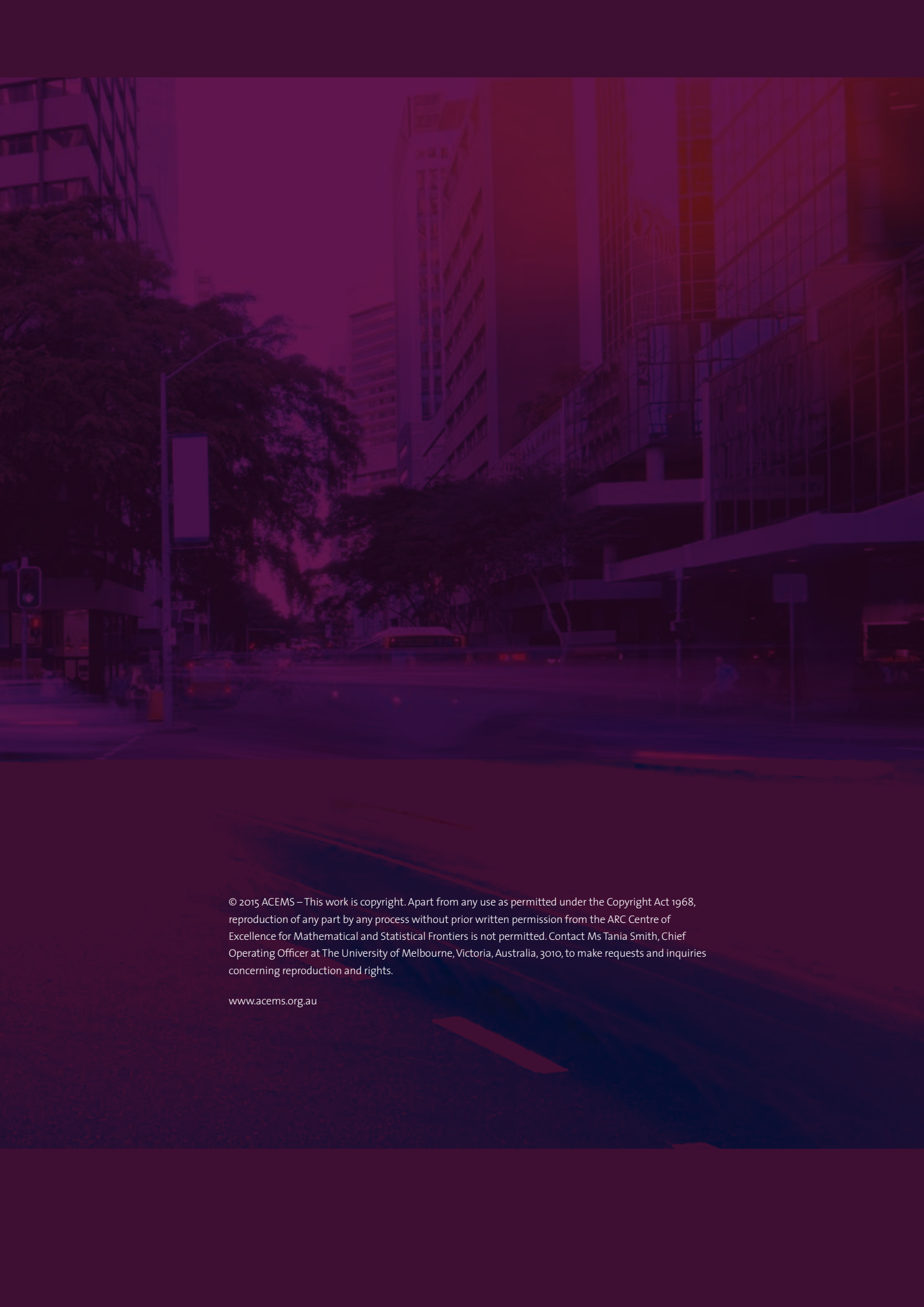
| Grant Type | Grant ID | Investigator/s | Total Value of Grant (\$) |
|--|-------------|---|---------------------------|
| ARC Discovery Project | DP140101186 | Warnaar, O. | 340,000 |
| ARC Discovery Project | DP140101259 | Welsh, A. | 351,000 |
| ARC Discovery Project | DP150104595 | Williamson, R. | 426,700 |
| ARC Future Fellowship | FT130100972 | Clisby, N. | 583,999 |
| ARC Future Fellowship | FT130100098 | Delaigle, A. | 736,416 |
| ARC Future Fellowship | FT140100408 | Nguyen, G. | 607,289 |
| ARC Future Fellowship | FT130100254 | Ross, J. | 619,381 |
| ARC Laureate Fellowship | FL110100281 | Barlett, P. | 2,777,066 |
| ARC Laureate Fellowship | FL110100003 | Hall, P. | 1,814,346 |
| ARC Laureate Fellowship | FL150100150 | Mengersen, K. | 2,413,112 |
| ARC Laureate Fellowship | FL130100039 | Taylor, P. | 2,750,000 |
| ARC Linkage Infrastructure, Equipment and Facilities | LE140100061 | Burrage, K., Mengersen, K. and Turner, I. | 1,000,000 |
| ARC Linkage Infrastructure, Equipment and Facilities | LE150100031 | Darling, A. | 630,000 |
| ARC Linkage Infrastructure, Equipment and Facilities | LE150100030 | Roughan, M. | 270,000 |
| ARC Linkage Project | LP140100923 | Mengersen, K. | 525,000 |
| ARC Linkage Project | LP140100282 | Mengersen, K. | 660,000 |
| ARC Linkage Project | LP150100539 | Nguyen, G. | 184,000 |
| ARC Linkage Project | LP140100489 | Roughan, M. | 194,873 |
| ARC Linkage Project | LP140100152 | Taylor, P. | 410,000 |
| ARC Linkage Project | LP150100046 | Timms, P. | 488,235 |
| ARC Linkage Project | LP140100315 | Timms, P. | 509,100 |
| AustMS Lift Off Fellowship | | Finn, C. | 3,072 |
| Data to Decisions CRC | | Bean, N. | 668,377 |
| Data to Decisions CRC | | Bean, N. | 661,262 |
| ECARD/VCRF Travel Fellowship | | Xie, H. | 7,000 |
| EPA Victoria Rivermap Project | | Petersen, E. | 40,000 |
| Heart Foundation Vanguard Grant University | | Barnett, A. | 69,000 |
| NVIDIA Academic Hardware Grant | | Psaltis, S. | 3,958 |
| QUT VC's Performance Award | | Barnett, A. | 3,000 |
| Science and Engineering HDR Publication Rewards Initiative | | Vo, B. | 1,000 |
| Stream Health Model Project | | Petersen, E. | 50,000 |

2015 Financial Statement

| ACEMS FINANCIAL REPORT 1 JANUARY – 31 DECEMBER 2015 | | | | |
|---|-----------------------|---|--|---|
| | 2015 Reporting Period | | 2016 Reporting Period (Estimated Budget) | |
| Carry Forward | \$3,154,820 | | \$3,579,165 | |
| Other Funds | \$2,996,205 | ARC Income | \$2,857,142 | ARC Income |
| | | Node Contributions | | Node Contributions* |
| | \$377,013 | UoM | \$366,731 | UoM |
| | \$476,006 | QUT | \$315,354 | QUT |
| | \$98,110 | UA | \$101,214 | UA |
| | \$59,251 | UNSW | \$61,428 | UNSW |
| | \$100,479 | UQ | \$101,214 | UQ |
| | \$147,636 | UTS | \$149,975 | UTS |
| | \$75,000 | External Income – VicRoads | \$135,000 | External Income |
| Total Income | \$7,484,520 | | \$7,667,223 | |
| Expenditure | \$1,816,017 | Salaries | \$2,500,544 | Salaries |
| | \$15,875 | Equipment | \$50,000 | Equipment |
| | \$317,124 | Travel, Conferences & Accommodation | \$600,000 | Travel, Conferences & Accommodation |
| | \$37,907 | Consultants, Materials & Provisions | \$235,000 | Consultants, Materials & Provisions |
| | \$93,867 | Node Scholarships | \$150,000 | Node Scholarships |
| | \$45,936 | HDR PhD Stipend Top Ups | \$200,000 | HDR PhD Stipend Top Ups |
| | \$96,965 | Marketing, Outreach & Sponsorships | \$450,000 | Marketing, Outreach & Sponsorships |
| | \$53,092 | Other | \$150,000 | Other |
| | \$1,428,572 | 6mth carry forward to final year due to July 2014 start | \$1,428,572 | 6mth carry forward to final year due to July 2014 start |
| Total Expenditure | \$3,905,355 | | \$5,764,116 | |
| Carry Forward | \$3,579,165 | | \$1,903,107 | |

*Due to the July 2014 start of ACEMS the node contributions are half year 2015 and half year 2016.

| IN-KIND REPORT JANUARY – DECEMBER 2015 | |
|--|--------------------|
| The University of Melbourne | \$1,083,110 |
| Queensland University of Technology | \$1,221,869 |
| The University of Adelaide | \$403,313 |
| The University of New South Wales | \$338,616 |
| The University of Queensland | \$600,616 |
| University of Technology, Sydney | \$787,351 |
| AT&T Labs | \$7,559 |
| Australian Bureau of Statistics (ABS) | \$45,354 |
| Commonwealth Scientific and Industrial Research Organisation (CSIRO) | \$6,803 |
| Mathematics of Information Technology and Complex Systems (MITACS) | \$3,780 |
| Roads Corporation of Victoria (VicRoads) | \$83,149 |
| Australian Institute of Marine Science (AIMS) | \$8,315 |
| SAX Institute | \$7,559 |
| Total | \$4,597,394 |



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