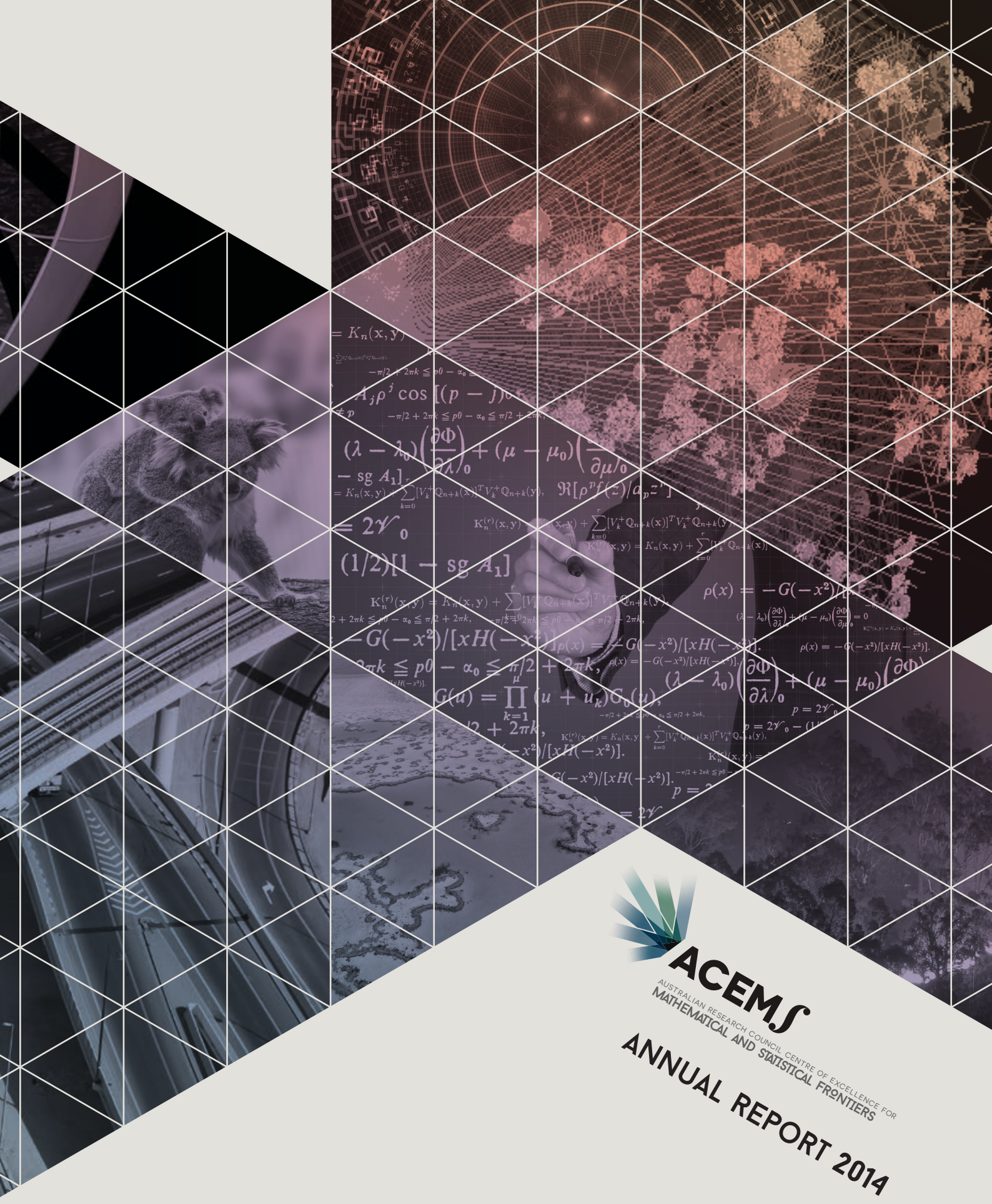
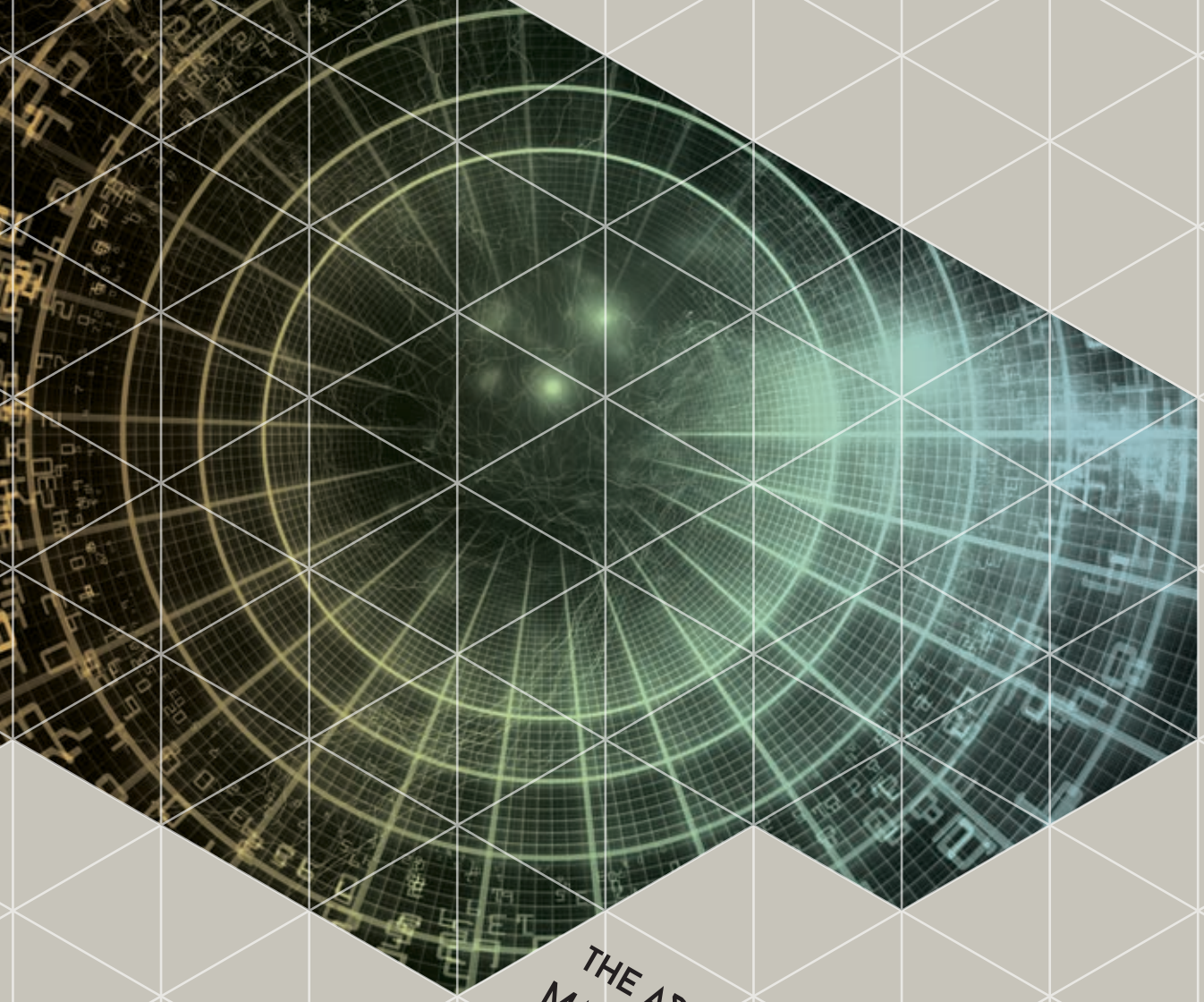


ACEMS

AUSTRALIAN RESEARCH COUNCIL CENTRE OF EXCELLENCE FOR MATHEMATICAL AND STATISTICAL FRONTIERS

ANNUAL REPORT 2014

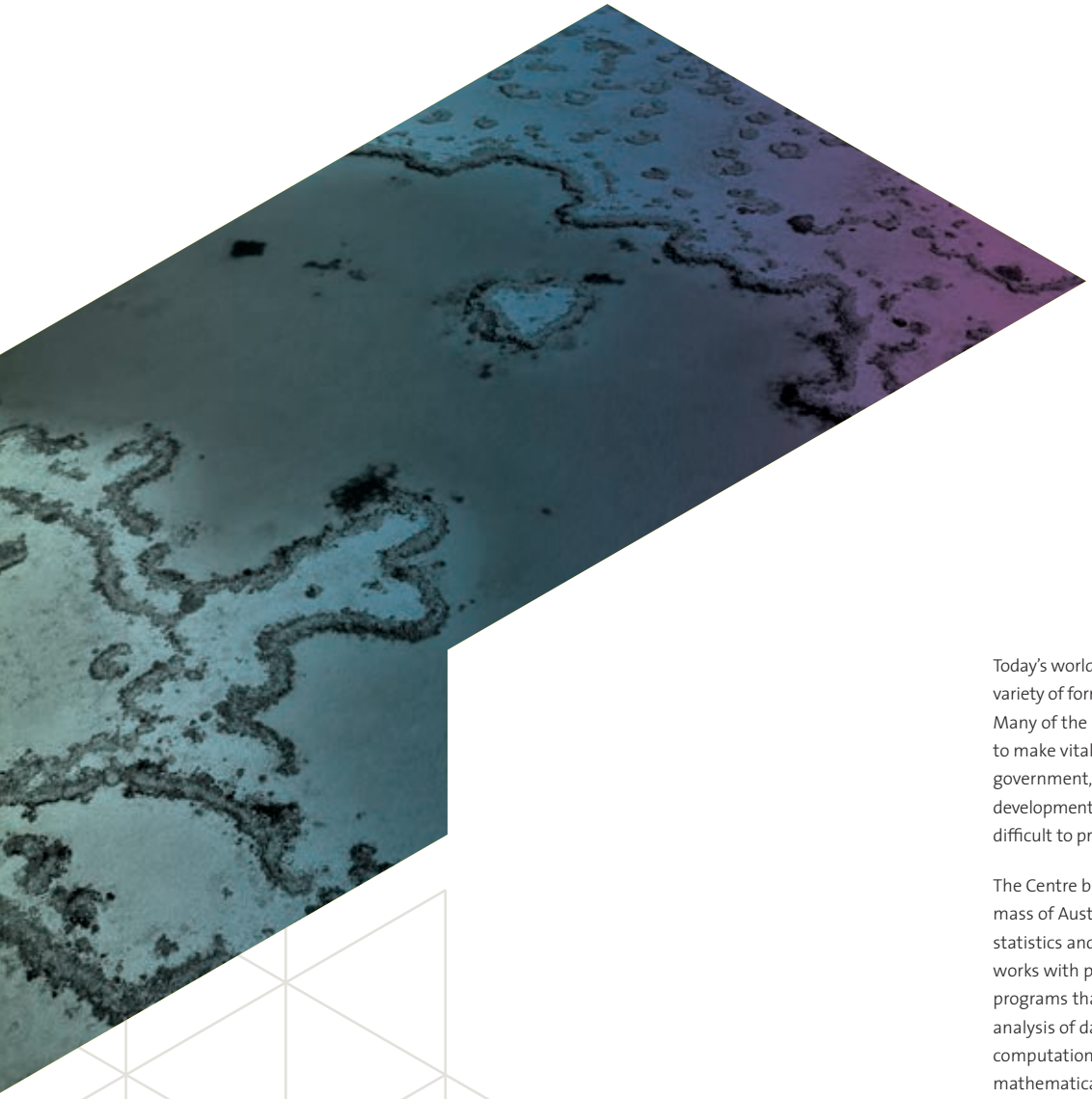


THE ARC CENTRE OF EXCELLENCE FOR MATHEMATICAL AND STATISTICAL FRONTIERS

ACEMS would like to acknowledge the support of the Australian Research Council. We would also like to acknowledge the financial and in-kind support provided by our collaborators – 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. We are also grateful for the financial and/or in-kind support received from AT & T Labs, Australian Bureau of Statistics, Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Australian Institute of Marine Science, Mathematics of Information Technology and Complex Systems, Monash University, SAX Institute and VicRoads.

ACEMS would like to thank the School of Mathematics and Statistics at The University of Melbourne, Tania Smith, Emily Duane, Kathy Palmer and Kate Hall at The University of Melbourne, Claudia Deasy at Queensland University of Technology and Claire Nitsch of The University of Queensland for their support.

CONTENTS



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 and machine learning. This unique group works with partner researchers to engage in research programs that combine new methods for the analysis of data with theoretical, methodological and computational foundations provided by advanced mathematical and statistical modelling. New insights developed by the Centre will have impact for end users working in collaborative domains of healthy people, sustainable environments and prosperous societies.

The objectives of ACEMS are:

- Research excellence on a global scale and research leadership across the discipline;
- Integration and translation, bridging theory and practice, so that research programs are motivated by and inform the collaborative domains for real world impact; and
- Training the next generation of quantitative researchers through the integration of technical expertise, industry exposure and high-level cross-disciplinary scientific communication skills.

The Centre's compelling research programs, its strong international and national collaborations, and excellent research training and translation, together with robust management and governance arrangements will ensure tangible returns on investment, and a transformative contribution to Australian research in mathematics, statistics and machine learning.

MISSION STATEMENT

DIRECTOR'S REPORT

After the exciting award announcement by the Australian Research Council (ARC) shortly before Christmas 2013, the new ARC Centre of Excellence for Mathematical and Statistical Frontiers (ACEMS) commenced on 1 July 2014. The Centre is very fortunate to be generously supported by the ARC, our participating universities and collaborating organisations. This support is gratefully acknowledged elsewhere in this report.

On 19 September 2014 Senator Scott Ryan officially launched the Centre at the University of Melbourne. Other speakers at the launch were Professor Brian Yates from the ARC and Professor Liz Sonenberg, Pro Vice-Chancellor (Research Collaboration and Infrastructure) at the University of Melbourne. We were thrilled to have so many distinguished guests to celebrate the birth of what will be a productive collaboration between our various nodes. The official proceedings ended with a student string quartet showcasing Kevin Volan's piece 'The Ramanujan Notebook'.

A second launch was held on 9 October 2014 at Queensland University of Technology (QUT). The keynote speaker at this event was Professor Arun Sharma, Deputy Vice-Chancellor (Research and Commercialisation) of QUT, who spoke of the depth and breadth of the contribution of mathematics and statistics to society. Further presentations were made by three of ACEMS' Chief Investigators, as well as Partner Investigators Julian Caley (from the Australian Institute for Marine Science), and Daniel Elazar (from the Australian Bureau of Statistics).

The executive team has willingly taken up the task to develop our Centre policy, expand our research program and engage with our partners and the wider community.

The ACEMS Governance Advisory Board met on 19 September 2014, chaired by the highly experienced Ron Sandland. We are honoured to be working with esteemed Professors and Deputy Vice-Chancellors (Research) from universities around the world to support the Centre's governance activities and provide their collective wisdom regarding our ongoing activities. Their combined expertise, support and effort will ensure that ACEMS reaches its agreed outcomes. Thank you all.

It is worth acknowledging that ACEMS began as an amalgamation of two proposals, one with an emphasis on applied statistics and big data analytics; and one focussing on strategic and theoretical research of mathematical and statistical models. Remarkably, it is this very combination of applied and theoretical research, brought together in the collaborative environment of an ARC Centre of Excellence, that has evolved to become a vehicle through which the innovation of mathematical and statistical methodologies will deliver new insights with impact in real world applications.

The executive team has willingly taken up the task to develop our Centre policy, expand our research program and engage with our partners and the wider community. Our eighteen Chief Investigators and partners have enthusiastically initiated research projects, commenced recruitment of research associates and organised a range of workshops. During the second half of 2014, workshops on Stochastic Systems at The University of Queensland, Computational Algorithms and Big Data Analytics at The University of New South Wales and Traffic Modelling at The University of Melbourne were of particular note.

During our first six months, ACEMS Chief Investigators established jointly funded post-doctoral research with the Centre's industry partners. Particularly worthy of mention are the collaborations established by Chief Investigator Louise Ryan with the Sax Institute and the Australian Red Cross Blood Service; and Associate Investigator Tim Garoni with VicRoads. Further industry partnerships continue to grow, with Kerrie Mengersen cementing collaborations with e-Bay and Google, among others.

In terms of achievements, John Geweke finalised the upcoming new release of a Matlab implementation of the SABL algorithm, which is a framework for Bayesian inference and for M-optimisation. Additionally, research fellows Andrea Bedini and Joyce Zhang developed the online CEASAR visual implementation tool for traffic modelling. Kerrie Mengersen also published on biodiversity modelling in collaboration with Partner Investigator Julian Caley from the Australian Institute of Marine Science (AIMS).

Phil Pollett and Dirk Kroese initiated their research on population models and random environments, while Peter Bartlett and Matt Wand focused on data analysis and variational message passing on large graphs. Nigel Bean and Matthew Roughan published on network topology synthesis, while Jan de Gier and Peter Taylor disseminated important results on queuing models relevant to health care systems. Peter Hall obtained further important theoretical results on feature selection and parameter estimation, Anthony Pettitt on marginal likelihood estimation and Peter Forrester on determinantal point processes. Robert Kohn's work on methodology for claim models relevant to insurance, and Kevin Burrage's work in computational biology further illustrates the depth and breadth of ACEMS' research.

ACEMS has managed to recruit extremely competent, hard-working and enthusiastic office staff at all our nodes, and with the recent addition of media and outreach officers, as well as an industry and stakeholder officer, we have an excellent support team to expand our research, outreach and translation programs.

I would also like to extend warm and personal gratitude to our COO Tania Smith who has put in every effort to make the Centre run smoothly and collaboratively.

All in all the Centre has made a very promising start, and I anticipate a large number of high quality and original journal articles from our collaborative work in 2015. ACEMS will be continuing its efforts to achieve breakthroughs in research in mathematics, statistics and machine learning that have the potential to improve the lives of Australians and the global community.

On behalf of Director Peter Hall who was on leave at the time of this writing,

Jan de Gier
Deputy Director ACEMS

ACEMS RESEARCH PROJECTS

Big Data, Big Models and New Insights

Lead Chief Investigators
Aurore Delaigle and Peter Hall

Analysis of Functional Data

The goal of this project is to develop novel statistical techniques for the analysis of non-standard data and problems. This involves naturally curved functional data – for example: growth curves of children, annual rainfall, or temperature curves. Curved functional data arise in a variety of fields, such as bio-security, face recognition, health studies and weather modelling. The team seeks to develop new tools to solve problems that have received little attention so far. Planned initiatives include:

1. Developing improved methods of classifying and clustering poorly aligned functional data. Currently, when functional data does not align perfectly, a common technique is to register the curves prior to analysis. However, such an approach is not straightforward, since by aligning the curves we run the risk of losing what makes the distinction between the various classes possible.
2. Developing techniques to estimate the correlation between several parts of the brain over time. This initiative originates from collaboration with a researcher from the School of Engineering at the University of Melbourne. The eventual goal is to construct a brain network that evolves with time.
3. Investigating effective ways to analyse streaming functional data. The goal is to determine how to update estimators, classifiers and other functional data when it arises in patches.

Lead Chief Investigator
Peter Bartlett

Large-Scale Decision Problems and Data Analysis on Graphs

Many large-scale decision problems that arise in a variety of areas (including biological science, social network analysis, retail recommender systems, web information retrieval, physical sciences, law-enforcement, and telecommunications) involve data viewed in a graph, with edges representing information about relationships. These data present several key challenges to big data analysis, because they are often heterogeneous, sparsely populated, and of variable quality. This project aims to develop design and analysis techniques for large-scale decision methods, with an emphasis on data in the form of large graphs. Key issues include combining information from many sources, despite their heterogeneity and variable quality; and adapting the complexity of predictions to local properties of data (for instance, in a metric defined by a graph).

The research project will involve:

1. Probabilistic and game-theoretic formulations of decision problems (such as regression, classification and ranking problems).
2. The design of methods for graphical data based on optimisation of criteria involving discrete smoothness functionals.
3. The development of algorithms appropriate for large-scale and potentially distributed problems (through convex optimisation and linear algebraic methods).
4. The analysis of the performance of these algorithms (particularly the development of optimal estimation rates for smoothness classes appropriate to the graphical setting and understanding the computational and statistical trade-offs in large scale cases).

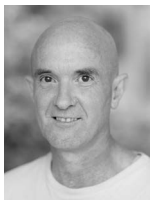
We anticipate that issues of model selection will emerge as a common thread in the key challenges of integrating information from multiple sources and adapting to local conditions.

Lead Chief Investigator
Dirk Kroese

Efficient Learning for Autonomous Systems

The movement, control, and planning of robotic and autonomous systems often involves statistical sampling on complex search spaces. For example, in robotic motion planning the idea is to build up a "probabilistic road map", via Monte Carlo sampling on a high-dimensional space of parameters. Often this is an ad hoc process. This project seeks to better understand how sampling and learning is best carried out for a variety of autonomic systems.

Lead Chief Investigator
Peter Forrester



Random Matrices and Big Data Sets

This project has two main focusses within the field of random matrix theory.

The first relates to Odlyzko's data set for the Riemann zeros and can be used to test aspects of the so called Montgomery-Odlyzko law, which asserts that after scaling so the mean spacing is unity, the large Riemann zeros have the same statistics as the bulk eigenvalues of a large Hermitian random matrix.

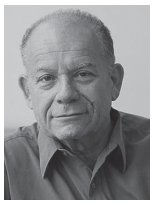
Aspects to be tested include:

a. The thinning of the data set by deleting each zero at random with some fixed probability; and
b. Correction terms to the random matrix prediction.

In relation to the first of these, random matrix predictions – given in terms of Painleve transcendents – predict that the corresponding probability density will exhibit oscillations. In relation to the second, earlier work of Keating and Snaith, and Bogomolny and collaborators predicts that the first correction term is well described by that coming from the circular ensemble of random unitary matrices. On the random matrix side, it should be possible to characterise the latter by a nonlinear equation of Painleve type.

The second area of focus relates to the aspects of random matrix theory relevant to multivariate statistics and numerical linear algebra, in particular signal detection in the case of low rank covariance, and the form of correction terms to leading order asymptotic behaviour.

Lead Chief Investigator
Robert Kohn



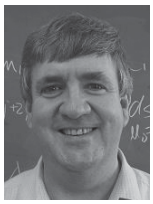
Bayesian Estimation of Big Data and Big Models

The primary purpose of the research is to develop Bayesian or quasi-Bayesian methods for handling Big Data and Big Models data using a number of approaches.

The initial approach will be fully Bayesian and involves randomly sub-sampling the data at each iteration using Markov chain Monte Carlo (MCMC). Our second approach is also fully Bayesian and based on simulated annealing. The third approach will involve Approximate Bayesian Computation. We base our fourth approach on variational Bayes methods. Our fifth approach is approximate and based on stochastic approximation methods.

A secondary rationale for the research is to apply the methodology to a number of challenging data sets, and in particular, to apply it to panel data consisting of a large number of individuals playing games on apps, where we have a large number of observations for each individual.

Lead Chief Investigator
Philip Pollett



Modelling and Calibration of Data Intensive Systems

A characteristic feature of data intensive systems such as the brain, social networks, communications networks, and climate and ecosystems, is the massively large numbers of interacting agents with various types of contact structures. A new set of mathematical tools is required to gain sufficient insight into the time evolution of these systems for monitoring and control.

One area that would benefit significantly from the development of such tools, and which is of major importance to Australia is understanding the spread of invasive diseases and pests. This would benefit both health service provision, and the management of native and commercial animal populations.

Whilst mathematical models have been used widely to gain insight into population dynamics, they have not been able to accurately account for local population dynamics, individual variation, spatial structure, and differing migration patterns. Nor do these models account simultaneously for behaviour emerging at differing scales in time and in space. Capturing these features represent a major challenge. Models for the spread of infection through population networks are emerging, and, stimulated by the HIV pandemic, much effort has been devoted to modelling epidemic spread in heterogeneous environments and at different time scales. However, the present model sets cannot deal with host-parasite infections and demographically structured ecological networks. It is the nature and the type of the data that requires models for which there is no limit on the number types of individual.

With this comes the challenge of calibrating these new models to data.

Suitable inferential methods that necessarily avoid evaluating the likelihood are Approximate Bayesian Computation and Indirect Inference (which, in the present context, would use a space-scaled diffusion approximation as a reference model). However, these methods rely heavily on the ability to simulate the model efficiently, and simulating large state-space models can be computationally demanding. Recently developed simulation methods show particular promise, especially the tau-leaping algorithm, which exploits time multi-scaling; it was initially proposed as a non-exact but computationally efficient means of simulating chemical reactions, but appears to be particularly suited to population process models. Another approach is to replace "fast" variables with the trajectories of their limiting deterministic counterparts.

Lead Chief Investigator
Matt Wand

Statistical Theory for Expectation Propagation and Variational Message Passing on Factor Graphs

Expectation propagation (EP) and variational message passing (VMP) are two protocols for performing approximate inference in Bayesian hierarchical models. They have the advantage of scaling up well to large models and sample sizes (`big models', `big data'), as well as high velocity data. These two so-called inference engines are the basis of the software framework Infer.NET

The factor graph representation of EP and VMP is not well known, especially in the field of statistics, and may well be restricted to some mid-2000s in-house technical reports by Infer.NET head developers T. Minka and J.M. Winn. However, it provides an attractive means by which to accommodate a large array of models, particularly those involving exponential family distributions.

The statistical accuracy of VMP and, especially, EP has received minimal attention. The folklore is that EP, whilst harder to implement, achieves a `higher order' level of accuracy compared with VMP. D.M. Titteringon (University of Glasgow) has written a small amount on this topic, focussing on a very simple finite mixture model. An in-progress paper by P.G. Hall, A. Huang, J.T. Ormerod and M.P. Wand derived path-breaking statistical theory for EP in a specific case. Hall and Wand are ACEMS chief investigators and Ormerod is an ACEMS associate investigator.

In late 2014, proposer Wand and PhD student, A.S.I. Kim, completed, and submitted for publication, a paper titled, "The Explicit form of Expectation Propagation for a Simple Statistical Model", that provides details on the factor graph approach version of EP and VMP for a specific simple example, where the data are a univariate random sample and the parameters are scalar.

Subsequent work will investigate vector parameter extensions such as regression.

Lead Chief Investigator
Dirk Kroese

Random Processes in Random Environments

Random walks in random environments (RWREs) are well-known models for motion in disordered media, such as transport of water through porous rocks, or charge transport in semiconducting materials.

The theoretical behaviour of multi-dimensional RWREs is poorly understood, both from a theoretical and computational point of view. Even for one-dimensional random walks, the evaluation of various system characteristics such as the drift of the random walk has received little attention. The goal of this proposal is to significantly advance the state of the art for RWREs by analysing the behaviour of the general class of quasi-birth-and-death (QBD) processes in multi-dimensional random environments. Such processes are natural generalisations of one-dimensional RWREs and it is expected that their analysis would bear resemblance to one-dimensional case, which is well understood.

Lead Chief Investigators
Peter Taylor, Matthew Roughan and Nigel Bean

Modelling and Control of Stochastic Networks of Resource Allocation Facilities

We consider many systems that are of significance to society as 'networks of resource allocation facilities'. They consist of processing facilities, each of which has a finite set of resources. The managers of such systems have the problem of putting in place procedures that ensure that they operate efficiently. Typically, they wish the system to stay close to an operating point where they provide fair and timely access to resources, and system resources are not wasted. In general, they might describe the operating point with reference to optimising some agreed function of system-wide utility that trades off wastage with timely processing of workload.

Information is gathered about the real-time operation of such systems via a number of mechanisms, however in most cases such information is observed imperfectly and, frequently observation incurs a cost. Current approaches for control of such systems often involve either:

- A static configuration without any real control;
- Ad hoc solutions that may appear to work, but often are not studied carefully enough to verify that is true in all situations; or
- Linearised controllers, which are known to oscillate, at least in some cases.

This project seeks to answer:

1. How we define suitable transient and stationary measures of system performance, 'optimal performance' and the policies that achieve it;
2. How we decide on optimal placement of sensors and observation regimes, cost-effective methods for analysing sensor data in real-time, protection from undesirable user behaviour; and
3. The role of price signalling mechanisms.

Lead Chief Investigator
Ian Turner

Data Assimilation using Large-Scale Bayesian Computation for Simulating Multiphase Transport in Heterogeneous Porous Media

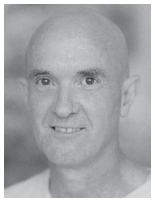
The aim of the project is to develop a computationally efficient modelling approach for simulating multiphase transport in heterogeneous porous media using homogenisation methods and large-scale Bayesian computations for estimating key model parameters from observed data. Applying the model will predict the gas composition in a coal seam gas field; simulate groundwater flows in coastal aquifer systems and dry fibrous media; and investigate anomalous diffusion in biological tissue.

Our modelling framework offers additional insights over experimental measurements alone because, once calibrated, we can perform cost-effective numerical simulations to investigate the evolution of different transport phenomena under a wide range of external conditions. This insight will prove invaluable for designing new industrial technologies and optimising current operations.

In order to calibrate and validate our models, we will seek permission from our industrial collaborators for the use of their measured 'large and noisy' experimental datasets for the chosen application areas. Due to the computational complexity of the underlying computational algorithms, the use of advanced computing infrastructure will be mandatory.

We plan to use a combination of parallel processing and GPU technology to implement our algorithms on the HPC system at QUT, with a particular focus on Krylov subspace methods (Strickland et al, 2011). The complexity of these algorithms necessitates careful design and planning to ensure an efficient overall solution. We will also develop specialised visualisation software for the large, complex datasets generated from the chosen industrial applications. An important contribution will be the generation of a suite of visualisation procedures that highlight the spatial and temporal trends of the different flow fields, and reveal structure in the data with multiple inputs from different sources.

Lead Chief Investigators
Jan de Gier, Peter Forrester and
Tim Garoni



Theory and Applications of Interacting Particle Systems

Fundamental models of interacting particles, such as those occurring in mathematical physics, statistical mechanics and queuing theory, are widely studied to understand non-equilibrium behaviour in physical systems consisting of large numbers of particles and to study large classes of transport phenomena, scheduling mechanisms and interface growth. This project combines theoretical approaches with computational and statistical analysis.

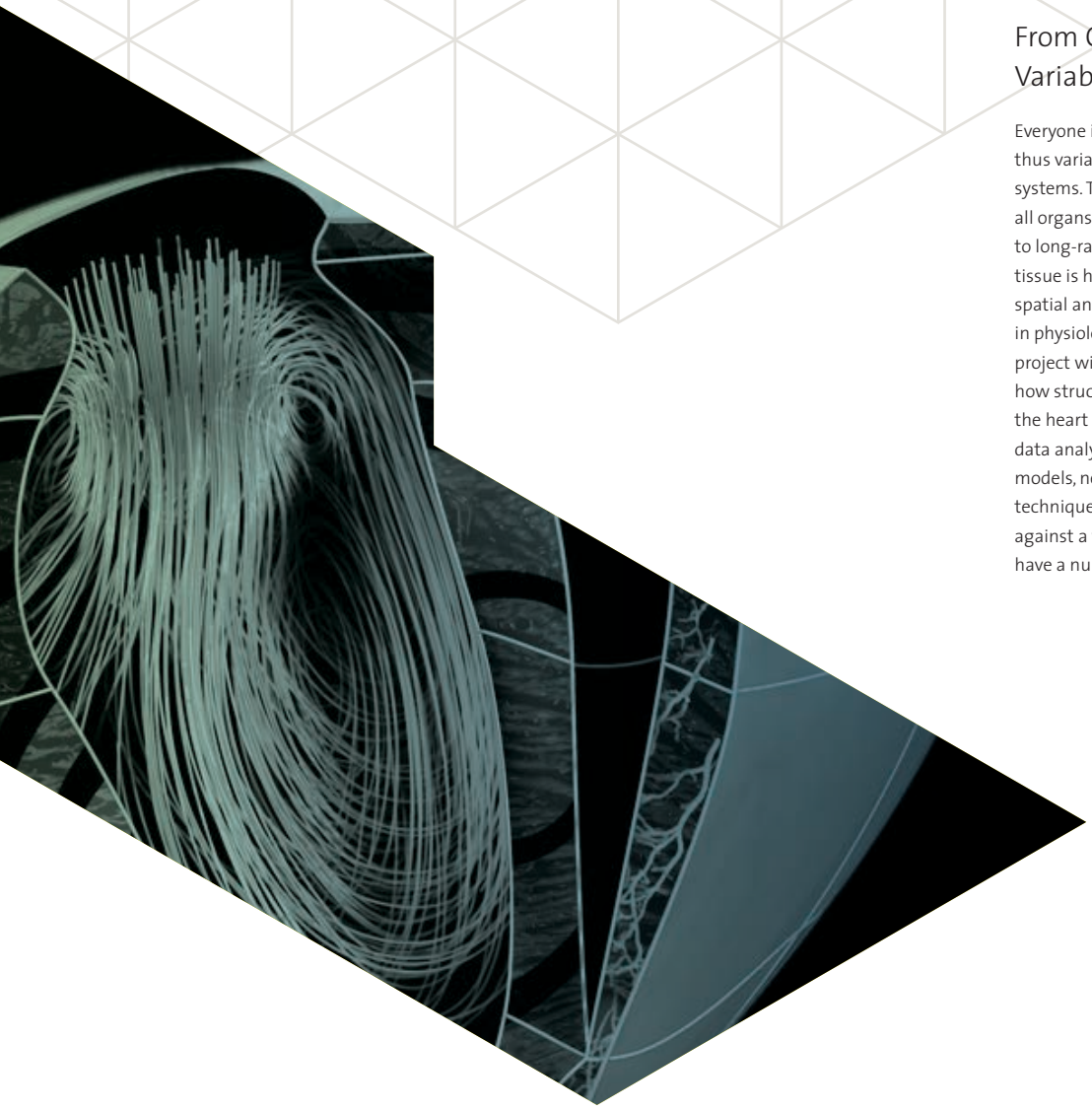
The theoretical part of the project will aim to derive exact analytical expressions for properties encoding emerging behaviour from microscopic principles. Such properties include important stationary and dynamical properties of model systems such as exclusion processes and queuing systems. Tools to use and further develop lie in the realm of random matrix theory, stochastic calculus, queuing theory, integrable probability, and include matrix product states.

The applied part of this project will involve computer simulations of large networks of interacting agents to model urban traffic on networks. This part of the project will also involve validation and calibration of simulated data to real world data provided by industry partner VicRoads.

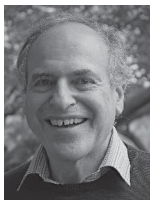
Lead Chief Investigator
Kevin Burrage

From Cells to Organs: Exploring Variability in Physiological Systems

Everyone is different, and every heart is different and thus variability is a common feature of all physiological systems. This variability manifests itself at all levels in all organs of living organisms: from ionic mechanisms to long-range electrical activity. In addition, biological tissue is heterogeneous at a variety of different spatial and temporal scales and one of the key issues in physiology is how structure affects function. This project will explore such variability and the issue of how structure affects function in both the brain and the heart using state–of-the-art modelling, simulation, data analytics and visualisation approaches. New models, new simulations and new data analytics techniques will be developed that are calibrated against a variety of experimental data. The project will have a number of components.



Lead Chief Investigator
Tony Pettitt



Bayesian Methods for Big Data Sets and Intractable Likelihoods; Scalable Methods and Approaches

There are many situations where analytically or computationally intractable likelihoods are encountered in a wide range of applications from stochastic models in genetics and biology through to spatial and temporal models in image analysis. Some of the current approaches are analytic based on pseudo likelihoods or quasi likelihoods. Some are numerically based on optimisation such as EM algorithm-like methods or variational Bayes. Other methods are computer intensive based on Monte Carlo such as Markov chain Monte Carlo (MCMC), Sequential Monte Carlo (SMC), Approximate Bayesian Computation (ABC) or indirect inference.

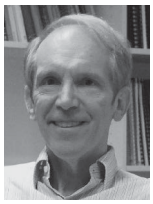
For the computer intensive approaches, parallel computing approaches are providing platforms to make computationally intensive Monte Carlo approaches feasible for large data sets. Sequential Monte Carlo provides an embarrassingly parallel approach. Network or graphical data provides an example where there are computationally tractable models to simulate from but exact likelihood methods are intractable. Here, there is a need for approximate likelihood approximations based on summary statistics whose computation is scalable and the application of these approximations in Bayesian methods.

Investigations will include the following:

- For ABC use of SMC and approaches based on making sampling and approximate likelihood proposals more efficient.
- Scalable Matrix algebra methods using Gaussian process approximations.
- Use of indirect inference or approximating models and estimation of functions relating parameters to mean values of statistics.
- Algorithm implementation in parallel computational environments.

Some of the specific applications and motivating examples include stochastic models of population dynamics from disease modelling and systems biology; spatial analysis and image analysis; network or graphical data; neurology with investigations involving upper and lower motor neurons, neuropathies and disease.

Lead Chief Investigator
John Geweke



Sequentially Adaptive Bayesian Learning

The sequentially adaptive Bayesian learning (SABL) algorithm is a framework for integration (in particular, and with emphasis on, Bayesian inference) and for optimisation (in particular, and with emphasis on, M-estimation). A generalisation of existing sequential Monte Carlo methods also incorporates ideas and procedures from sequential Monte Carlo, evolutionary algorithms, simulated annealing, and MCMC. There are quite a few specific variants of the algorithm: some well-established; others more recently developed by this project; and more to come in the near future. The project also includes a variety of statistical models and provides a platform on which others can incorporate other models easily.

Lead Chief Investigator
Kerrie Mengersen

Bayesian Approaches to Modelling and Analysis of Big Data

Bayesian methods for modelling and analysis of data are now well established. However, as with many statistical methods, their applicability in the context 'big data' is still being explored. This project will consider four questions that relate to 'scalable Bayes', that is, Bayesian models and computational methods that scale up to big data problems.

1. Bayesian Models for Data Integration: Development of a general framework for integrated analysis of data of different type from different sources. This includes observational data, sound and other sensor data, image data, genetic data, streaming data, online and other digital data. The envisaged framework will comprise a hierarchical combination of different parametric and nonparametric approaches.
2. Bayesian Models for Large Observational Studies: Development of approaches to describe and analyse large-scale observational studies such as those found online. These approaches will include, among other things, new experimental designs and the use of propensity scores.
3. Computational Algorithms: Pursuit of computational methods for Bayesian analysis that scale up to high dimensions. These will include Approximate Bayesian Computation and sequential Monte Carlo.
4. Visualisation of Bayesian Model Outputs: New ways to visualise the results of Bayesian analyses.

The methods developed as part of 1-4 above will be applied to the three collaborative domains:

1. Healthy People: To interface with the Systems Medicine project led by Kevin Burrage.
2. Sustainable Environments: In collaboration with partner organisation AIMS, the aim will be to develop multi-scale mathematical and statistical models and fast computational algorithms that utilise survey data; streaming data obtained from environmental sensors; and remotely sensed data at different spatial and temporal scales; to understand better the environmental impacts and trends in biodiversity on the Great Barrier Reef.
3. Prosperous Societies: Undertaken in collaboration with colleagues at Google and e-Bay Research Labs, and the Australian Bureau of Statistics.

Lead Chief Investigators
Louise Ryan, Scott Sisson, Alan Malecki and
NSW Department of Environmental Protection

Symbolic Data Analysis for the Analysis of Complex Environmental Data

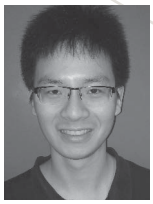
In late 2013, the NSW Environmental Protection Authority asked Professor Louise Ryan to assist with the analysis of data on air pollution levels associated with locomotive traffic in the Hunter Valley region of NSW. The project was of critical importance to EPA since Hunter Valley citizens were concerned about potential health effects of increased levels of coal dust exposures due to heavy traffic of coal trains in the area. A previous analysis reported by an environmental consulting company had been criticised as having a number of flaws in its statistical design and analysis. The EPA contracted Professor Ryan to undertake some additional data analysis after conducting her own review of this report. The dataset in question turned out to be challenging, in part due to its size but also due to its complex correlation structure and the complexity of the context being measured. The team had explored the usefulness of aggregation as a tool for simplifying the analysis and as expected, aggregation reduced the amount of serial correlation and generally made the analysis more manageable. However, this was at a loss of statistical power and efficiency.

In this project, the investigators will explore the use of Symbolic Data Analysis (SDA) to facilitate the analysis of this complex time series. SDA is a recently developed data analysis tool where inputs involve tables of data, rather than standard rows of data. It is a natural concept to generalise the relatively simplistic approach of simply summarising the data by aggregated means. It should be much more efficient since the inputted data tabulations also include measures of variability. Expected outcomes include papers to be published in the statistical and data mining literature as well as communications to the NSW EPA.

Lead Chief Investigators
Louise Ryan, Matthew Roughan, James Brown, Tim Churches, Jarod Lee, Daniel Elazar and John Machin







New Frontiers in Data linkage

Modern day information technology enables health researchers to enrich study designs and provides the ability to create innovative study populations using record linkage technologies that pull data from multiple sources. For example, the Sax Institute's "45 and Up" study involves a cohort of over 250,000 people who have responded to baseline and longitudinal surveys on health behaviours and risk factors, but then also given permission for their data to be linked with a variety of other databases, including Medicare, hospital records data, and the Pharmaceutical Benefits Scheme (PBS). This results in a rich longitudinal study that would have been prohibitively expensive to run using standard methods. Similarly, linkage of hospital records, census data and other surveys results in rich study populations to use to explore geographical and temporal variation in disease incidence and outcomes. Such studies play an essential role in terms of informing policy decisions and advancing scientific knowledge.

This project addresses a set of interesting statistical and analytical questions that arise in the design and analysis of studies involving record linkage. One such issue concerns the question of how to incorporate information about linkage uncertainty into data analysis and reporting. Typically, there will be varying degrees of uncertainty in constructing a linked database. For example, a subject's name may be misspelled in one database, or their birthday may have numbers transposed in another. Linkage methods generally identify a set of possible linkages and then designate the most likely ones as the true links and analysis proceeds accordingly. Research in a number of areas is needed, including new methods for efficiently characterising links between multiple different relevant databases and incorporating linkage uncertainty into analysis through missing data technologies. The team will work with collaborators from ABS on the development of such methods, as well as exploring new methods that exploit the concept of statistical sufficiency to fit statistical models without requiring unit record data.

ACEMS MANAGEMENT AND GOVERNANCE

ACEMS is a collaborative research program between 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 under the Australian Research Council (ARC) Centre of Excellence program. Our Partner Investigators are A T & T Labs, Australian Bureau of Statistics, the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), Mathematics of Information Technology and Complex Systems, VicRoads, SAX Institute and The Australian Institute of Marine Science.

As 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.

All collaborating organisations are represented within the ACEMS boards. The Scientific Advisory Committee and a General Advisory Board are established and meet twice annually.

Centre Management

The ACEMS Executive Committee and are 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 Executive Committee are:

Professor Peter Hall, Director

A/Professor Jan de Gier, Deputy Director, Operations

Professor Kerrie Mengersen, Deputy Director, Stakeholder Engagement

Professor Louise Ryan, Deputy Director, Outreach

General Advisory Board

The ACEMS General Advisory Board met in November 2014 at the University of Melbourne, School of Mathematics and Statistics. The meeting focussed on an introduction to the ACEMS research and operations and offered recommendations made by the ACEMS Scientific Advisory Committee.

The General Advisory Board members are:

Professor Ron Sandland (Chair), Chair of Steering Committee, Australian National Data Service, Australia

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

Professor Robert Calderbank, Director, Information Futures Initiative, Duke University, United States of America

Dr Julian Caley, **Leader**, AIMS Quantitative Unit and QUT Collaboration, Australian Institute of Marine Science, Australia

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

Professor Martin Groetschel, President Zuse Institute, Berlin, Germany

Professor Tony Guttmann, Director, MASCOS, The University of Melbourne, Australia

Professor Peter Hall (ex officio), Director, ACEMS, The University of Melbourne, Australia

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

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

Mr Daniel Owens, Director, Grant Management Office, University of New South Wales, Australia

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

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

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

Scientific Advisory Committee

Professor Peter Hall, ACEMS Director, The University of Melbourne

Professor Bronwyn Harch, Assistant Dean, AD Research, Queensland University of Technology

Professor Iain Johnstone, Professor of Statistics & Health Research and Policy (biostatistics), Stanford University

Professor Louis Chen, Distinguished Professor, National University of Singapore

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

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

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

Professor Xihong Lin, Professor of Biostatistics, Harvard University

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

Kate Hall, Finance Officer, The University of Melbourne

Claire Nitsch, Administration Officer, The University of Queensland

Kathy Palmer, Administration Officer, The University of Melbourne

Researchers

Chief Investigators

Professor Peter Bartlett, Queensland University of Technology

Professor Nigel Bean, The University of Adelaide

Professor Kevin Burrage, Queensland University of Technology

Associate Professor Jan de Gier, The University of Melbourne

Professor Aurore Delaigle, The University of Melbourne

Professor Peter Forrester, The University of Melbourne

Professor John Geweke, University of Technology Sydney

Professor Peter Hall, The University of Melbourne

Professor Robert Kohn, University of New South Wales

Professor Dirk Kroese, The University of Queensland

Professor Kerrie Mengersen, Queensland University of Technology

Professor Anthony Pettitt, Queensland University of Technology

Professor Philip Pollett, The University of Queensland

Professor Matthew Roughan, The University of Adelaide

Professor Louise Ryan, University of Technology Sydney

Professor Peter Taylor, The University of Melbourne

Professor Ian Turner, Queensland University of Technology

Professor Matt Wand, University of Technology Sydney

Associate Investigators

Associate Professor Adrian Barnett, Queensland University of Technology

Professor James Brown, University of Technology Sydney

Dr Pamela Burrage, Queensland University of Technology

Associate Professor Chris Carter, University of New South Wales

Professor Ian Charles, University of Technology Sydney

Associate Professor Aaron Darling, University of Technology Sydney

Dr Yanan Fan, University of New South Wales

Dr Tim Garoni, Monash University

Professor Peter Grace, Queensland University of Technology

Professor Nick Graves, Queensland University of Technology

Professor Peter Green, University of Technology Sydney

Professor Anthony Guttmann, The University of Melbourne

Professor Markus Hegland, Australian National University

Professor Rob Hyndman, Monash University

Dr John Ormerod, University of Sydney

Professor Graeme Pettet, Queensland University of Technology

Associate Professor Scott Sisson, University of New South Wales

Adjunct Professor Peter Timms, Queensland University of Technology

Dr Joseph Young, Queensland University of Technology

Professor Alan Welsh, Australian National University

Professor Ole Warnaar, The University of Queensland

Professor Bob Williamson, National Information and Communications Technology Research Centre of Excellence

Partner Investigators

Dr Julian Caley, The Australian Institute of Marine Science

Dr Timothy Churches, Sax Institute

Mr Daniel Elazar, Australian Bureau of Statistics

Professor Arvind Gupta, Mathematics of Information Technology and Complex Systems, Canada

Dr Bronwyn Harch, Commonwealth Scientific and Industrial Research Organisation

Dr Siu-Ming Tam, Australian Bureau of Statistics

Mr Keith Weegberg, VicRoads

Dr Walter Willinger, AT&T Labs-Research

THE UNIVERSITY OF MELBOURNE

ADMINISTERING NODE

- Queensland University of Technology
- The University of Adelaide
- The University of New South Wales
- The University of Queensland
- University of Technology, Sydney

ORGANISATIONAL CHART AS OF JULY 2014

Conferences and Academic Visits

Professor Peter Bartlett

- Invited presentation at the ASC-IMS 2014 Conference, Sydney, Australia, July 2014
- Distinguished Seminar Series Speaker UCLA, California, USA, November 2014
- Keynote Speaker at the 12th Australasian Data Mining Conference, Queensland, Australia, November 2014
- Semi plenary Speaker at the Foundations of Computational Mathematics 2014, Montevideo, Uruguay, December 2104

Professor Nigel Bean

- Invited speaker at the Connections and Continuity: Mathematics from School to University Conference, Canberra, Australia, December 2014

Professor Kevin Burrage

- Plenary presentation at IASTED, Botswana, September 2014
- Plenary Speaker at the Department of Mathematics, Agricultural University, Nanjing, China, September 2014
- Plenary presentation at ICNAAM 2014, Rhodos, Crete, Greece, September 2014
- Invited Seminar at the Department of Mathematics, University of Crete, Crete, Greece, September 2014
- Plenary Speaker at the Department of Mathematics, Chinese Academy of Science, Beijing, China, October 2014
- Invited Seminar at the Department of Mathematics, University of Leeds, UK, October 2014
- Attended workshop at Dagstuhl, Multiscale Spatial Computational Systems Biology, Germany, November 2014

Associate Professor Jan de Gier

- Organiser of the Traffic Modelling Workshop, Melbourne, Australia, July 2014

KEY PERFORMANCE INDICATORS

- Invited Speaker at the Biarri Applied mathematics Conference, RMIT, Melbourne, Australia, November 2014
- Invited Speaker at Intergrable Systems 2014, The University of Sydney, Australia, December 2014
- Contributing Talk at the 8th Australian-New Zealand Mathematics Convention, Melbourne Australia, December 2014

Professor Aurore Delaigle

- Invited speaker at the 3rd IMS-Asia Pacific Rim Meeting, Taipei, Taiwan, July 2014
- Invited speaker at the Institute of Mathematical Statistics and Australian Statistical Conference, Australia Technology Park, Sydney, Australia, July 2014
- Invited speaker at the Joint Statistical Meeting, Boston, USA, August 2014
- Attended the Statistics Seminar, Research School of Finance, Actuarial Studies and Applied Statistics, RMIT, Australia, September 2014
- Attended the East Meets West Seminar, University of Melbourne, Australia, October 2014

Professor Peter Forrester

- Attended the Probability Theory and Random Matrix Theory Seminar, MUMS, Melbourne, Australia, August 2014

Professor John Geweke

- Invited speaker at the International Symposium on Forecasting (International Institute of Forecasters), Rotterdam, The Netherlands, July 2014
- Invited speaker at the Australian Statistical Conference in conjunction with the Institute of Mathematical Statistics Annual Meeting, Sydney, Australia, July 2014
- Invited speaker at the Seminar, Board of Governors, Federal Reserve System, Washington DC, USA, October 2014
- Invited speaker at the Infometrics Institute Fifth Year Anniversary Meeting, American University, Washington DC, USA, November 2014
- Invited speaker at the Seminar, University of Iowa Department of Economics, Iowa City, Iowa, USA, November 2014

Professor Peter Hall

- Attended the ASC/IMS Conference, Sydney, Australia, July 2014

Professor Robert Kohn

- Attended the Topic Contributed Session - Joint Statistical Meetings, Boston, USA, August 2014
- Invited speaker at the ECRM 7th International Conference of the ERCIM WG on Computational and Methodological Statistics, Pisa, Italy, December 2014

Professor Dirk Kroese

- Attended the Monte Carlo Methods for Big Data and Big Models, The University of Queensland, Australia
- Attended Reuven Rubinstein and the Pursuit of Black Swans, The University of Queensland, Australia
- Attended the Mathematical and Statistical Frontiers of Big Data Workshop, The University of Queensland, Australia
- Keynote Speaker at the 10th International Workshop on Rare Event Simulation, Amsterdam, Netherlands, August 2014
- Invited speaker at the Big Data Day @ UQ, The University of Queensland, Australia, November 2014
- Keynote Speaker the Shanghai International Conference on Data Science and Advanced Analytics, Shanghai, China, November 2014

Professor Kerrie Mengersen

- Attended the Australian Statistical Conference 2014, Sydney, Australia, July 2014
- Attended the International Society for Bayesian Analysis World Meeting, ISBA 2014, Cancun, Mexico, July 2014
- Attended the 2014 Joint Statistical Meetings, Boston, USA, August 2014Attended the Western Australia Marine Science Institution Workshop # 2 Bayesian Statistics, University of Western Australia, Australia, September 2014
- Master of Ceremonies, ACEMS Launch, Queensland University of Technology, Australia, October 2014
- Attended the AIMS workshop on the government draft Long-term Sustainability Plan for the Great Barrier Reef World Heritage Area, Queensland, Australia, October 2014
- Keynote Speaker at the ICSM 2014, Surabaya, Indonesia, November 2014
- Workshop Instructor at the ICSM 2014, Surabaya, Indonesia, November 2014
- Conference convenor of Bayes on the Beach, Surfers Paradise, Queensland, Australia, November 2014
- Attended the CRC for Spatial Information Annual Conference, Perth, Western Australia, November 2014
- Invited speaker at the Makassar ISOS 2014, Makassar, Indonesia, November 2014
- Workshop instructor at the Canadian Society of Mathematics Winter Meeting 2014, Canada, November 2014
- Keynote Speaker at the Canadian Society of Mathematics Winter Meeting 2014, Canada, November 2014
- Invited speaker at Computational Techniques and Applications Conference 2014, Australian National University, Australia, December 2014

Dr Bin Peng

- Attended the Australian Statistical Conference in conjunction with the Institute of Mathematical Statistics Annual Meeting, Sydney, Australia, July 2014

Professor Anthony Pettitt

- Attended the Bayes on the Beach, Gold Coast, Australia, November 2014

Professor Phil Pollett

- Attended the 34th International Symposium on Forecasting Rotterdam, The Netherlands, July 2014
- Invited Speaker at ASC-IMS Meeting, Sydney, Australia, July 2014
- Keynote Speaker at the Symposium Erik van Doorn, University of Twente, The Netherlands, September 2014

Professor Matt Roughan

- Keynote Speaker at Next Generation Networking, Multi-Service, United Kingdom, July 2014
- Attended the AusNOG Australian Network Operators Group, Sydney, Australia, September 2014

Professor Louise Ryan

- Invited speaker at the Department of Mathematics and Statistics, University of New South Wales, Australia, August 2014
- Invited speaker at Joint Statistical Meetings, Boston, USA, August 2014
- Invited speaker at MRC Conference on Biostatistics, Leiden University, The Netherlands, September 2014
- Invited speaker at Sydney University, Sydney, Australia, October 2014
- Keynote Speaker at Bayes on the Beach, Surfers Paradise, Queensland, Australia, November 2014
- Tutorial at Bayes on the Beach, Surfers Paradise, Queensland, Australia, November 2014

Professor Scott Sisson

- Attended the ACEMS Big Data Day @ UQ, Brisbane, Australia, November 2014

Professor Peter Taylor

- Contributed talk at the American Statistical Society - Institute of Mathematical Statistics Conference, Sydney, Australia, July 2014
- Master of Ceremonies at the ACEMS Launch, The University of Melbourne, Australia, September 2014
- Invited Address at the Statistics Seminar, Research School of Finance, Actuarial Studies and Applied Statistics, Australian National University, Canberra, Australia, October 2014
- Keynote and Invited Address at the Australasian Symposium on Service Research & Innovation, University of Canberra, Australia, November 2014
- Keynote and Invited Address at the School of Information and Randomness 2014, Puerto Varas, Chile, December 2014

Professor Ian Turner

- Attended, NICTA Queensland Research Laboratory Technology Showcase, Parliament House, Queensland, Australia, August 2014
- Invited speaker at Computational Techniques and Applications Conference (CTAC) 2014, Australian National University Canberra, Australia, December 2014

Professor Matt Wand

- Invited speaker at the School of Mathematical Sciences, The University of Adelaide, Seminar Series, Adelaide, Australia, November 2014

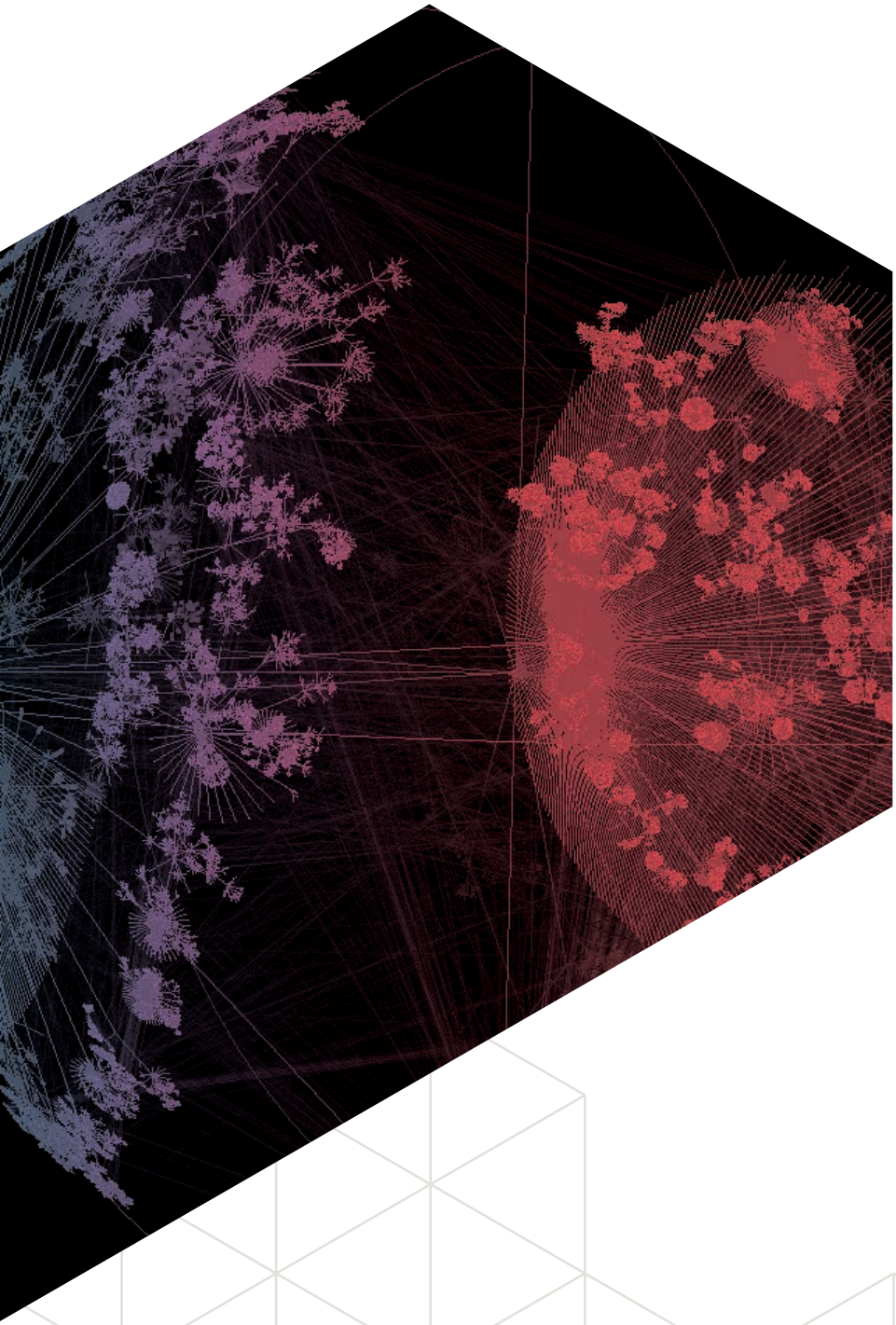
Dr Huaxin Xu

- Attended the Australian Statistical Conference in conjunction with the Institute of Mathematical Statistics Annual Meeting, Sydney, Australia, July 2014

Other Presentations

Ms Tania Smith

- Invited Speaker at the Tall Poppies Campaign Victorian Winners Program Day, The University of Melbourne, Australia, October 2014
- Guest judge at the Growing Tall Poppies Alumni Conference, Australian Synchrotron, Clayton, Australia, December 2014



ACEMS SPONSORED EVENTS

ACEMS sponsored the following events in 2014:

- ABC In Sydney, The University of New South Wales, Australia, 3-4 July 2014
- International Engagement Dinner Australian Statistical Conference in conjunction with the Institute of Mathematical Statistics Annual Meeting, Tech Park, Sydney, 7 July 2014
- Bayes on the Beach 2014, Mantra Legends Hotel on Surfers Paradise, Gold Coast, Australia, 10-12 November 2014
- Effective use of Visualisation in the Mathematical Sciences (EViMS2), Mathematical Sciences Institute, Australian National University, 21 November 2014
- Canberra Physics Summer School, Australian National University, 23-28 November 2014
- Fractal Conference and Visualization Conference, Mathematical Sciences Institute, Australian National University, 23-28 November 2014
- The Statistical Society of Australia, J B Douglas Programme, New South Wales, Australia, 25 November 2014
- Frontiers in Physics, 23rd Annual Canberra Physics Summer School, Australian National University, Canberra, Australia, 1-5 December 2014
- ANZAMP Tony Guttmann Prize for Best Student Talk, University of Melbourne, Australia, 8-12 December 2014

ACEMS conducted the following interdisciplinary workshops and events in 2014:

- Big Models – 'Stochastic Systems', St Leo's College, The University of Queensland, 28 April 2014
- Computational Algorithms, University of New South Wales, 2 June 2014
- Big Data Analytics, University of New South Wales, 3 June 2014
- Traffic Modelling, University College, The University of Melbourne, 29 July 2014
- ACEMS Launch, The University of Melbourne, 19 September 2014
- ACEMS Launch, Queensland University of Technology, 9 October 2014

ACEMS CONFERENCE, WORKSHOPS AND EVENTS

LINKAGES, COLLABORATIONS AND VISITORS

A key activity of the Centre is the engagement of industrial partners. These relationships provide the opportunity for potential partners to leverage the Centre's extensive research capability through its multiple research nodes. ACEMS actively seeks and encourages the support and assistance of industry and government-sponsored projects in strategic design and the establishment of research priorities.

The Centre has invested in proactively building collaborative research partnerships through the appointment of an Industry Engagement officer whose role is to identify, screen and facilitate industry and government research collaboration opportunities. ACEMS also offers a formal Partner Investigator Program.

Throughout 2014, the Centre actively engaged with various organisations to establish collaborative or partner research opportunities:

Collaborations and Partnerships

Title: Healthy Environments
Chief Investigator: Professor Kerrie Mengersen
Collaborating organisation: Hunter Industrial Medical (HIM)

This partnership is focussed on utilising new statistical methods to better predict outcomes for employees and workplaces. For example, identifying subgroups of workers that may have adverse health outcomes as a result of workplace exposure. The data for this research comes from existing information collected during compulsory medical examinations and health checks.

Title: Healthy Waterways
Chief Investigator: Professor Kerrie Mengersen
Collaborating organisation: Healthy Waterways

Healthy Waterways is an independent, not-for-profit organisation working to protect and improve South East Queensland waterways. Together with members from government, industry and the community it seeks to achieve healthy waterways for a healthy economy.

This project examines the analysis of water quality data to identify trends and factors affecting water quality using network models that take into account social and physical variables.

Title: CEASAR: Cellular Automata Simulator for Arterial Roads
Chief Investigator: Professor Jan De Gier
Collaborating organisations: VicRoads and Monash University

CEASAR is a joint project between VicRoads, Monash University and The University of Melbourne. It is a network traffic simulator, which incorporates realistic traffic signal systems such as the Sydney Coordinated Adaptive Traffic System (SCATS). Traffic on the links of a network is simulated using the cellular automata approach of Nagel and Schreckenberg.

Title: Planning needs of the Australian Health System
Chief Investigator: Professor Nigel Bean and Professor Peter Taylor
Collaborating organisation: Cumberland.AU

Professor Nigel Bean and Professor Peter Taylor are founding members of the member of Cumberland. AU a collaboration that is being established to address the research, development and planning needs of the Australian health system. A relationship has been established with the Cumberland Initiative in the United Kingdom, which aims to transform the quality and cost of the National Health Service care delivery through simulation, modelling and systems thinking.

Title: Co-funded Post-doc
Chief Investigator: Professor Louise Ryan
Collaborating organisation: Australian Red Cross Blood Service

The Australian Red Cross Blood Service is co-funding post-doctoral candidate Stephen Wright to be engaged in variety of activities, including collaboration with the SAX Institute to do data linkage for the 45 and Up Study. Professor Ryan is also assisting the service with the analysis of a clinical trial for a vein viewer technology. This appointment is for three years.

Title: Co-funded Post-doc
Chief Investigator: Professor Louise Ryan
Collaborating organisation: SAX Institute

Post-doctoral candidate Joanna Wang has been appointed to the SAX Institute for three years on a 60 percent basis to work on the 45 and Up Study, developing methods for evidence based policy-making. Professor Ryan is also supervising Dr Tim Churches, PhD student (full time with SAX) in the area of causal inference within the SAX Institute.

Title: Leverage more from administrative data
Chief Investigator: Professor Louise Ryan
Collaborating organisation: Australian Bureau of Statistics

The ABS is working with Professor Ryan, Professor James Brown (UTS), Jarrod Lee (PhD student) for the development of methods to combine data from multiple sources to protect individual confidentiality.

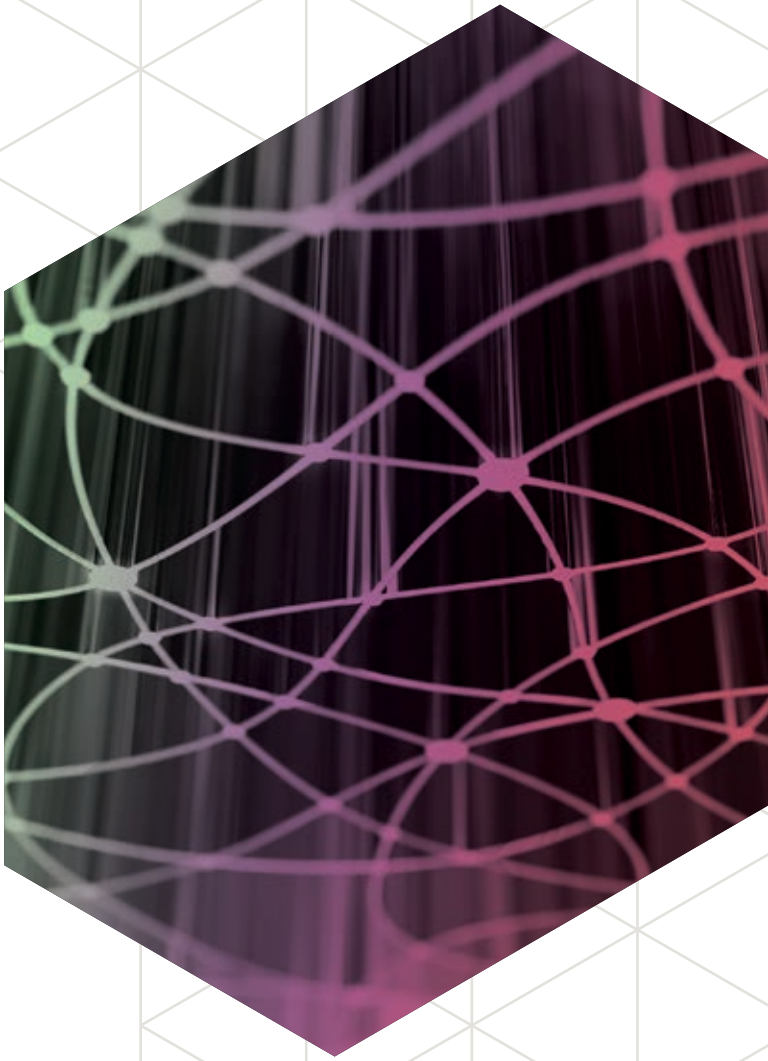
Visitors and Developing Collaborations

ACEMS has had 32 visitors to its nodes in the second half of 2014, which has far exceeded expectations as well as our key performance indicator requirement. Following is a summary of the visitations and resultant collaborations that have commenced or are under development with various people and groups from around the globe.

- Professor Ofer Biham from Hebrew University, Israel visited Associate Professor Jan de Gier at The University of Melbourne in September to discuss collaborations and deliver a talk on statistical physics of deterministic and stochastic reaction networks and applications to chemistry and biology.
- Dr Randal Bush, Dr Cristel Pelsser and Dr Ilias Pallikarakis from the IIJ, Japan were visiting researchers at The University of Adelaide in September where they worked with Professor Matt Roughan on the Boarder Gateway Protocol Security.
- Dr Feng Chen from the School of Mathematics and Statistics, University of New South Wales visited Professor Peter Hall at The University of Melbourne in October to collaborate on papers.
- Professor Ming-Yen Cheng from the National Taiwan University visited The University of Melbourne in July to hold discussions on potential collaborations with Professor Peter Hall and Professor Aurore Delaigle.
- Professor Peter Donnelly from University of Oxford and Wellcome Trust for Human Genetics, UK, visited Professor Kerrie Mengersen at Queensland University of Technology in November to be a Keynote Speaker at Bayes on the Beach.
- Mr Daniel Elazar and Ms Sybille McKeown from the Australian Bureau of Statistics visited Professor Kerrie Mengersen at Queensland University of Technology in October to further their ACEMS collaboration.
- Professor Peter Green from University of Technology, Sydney and University of Bristol, UK, visited Professor Kerrie Mengersen at Queensland University of Technology in November to be a Keynote Speaker at Bayes on the Beach.
- Professor Moshe Haviv from the Department of Statistics, The Hebrew University of Jerusalem, Israel visited the University of Melbourne in July to work on a research collaboration with Professor Peter Taylor on insensitivity in queuing systems.
- Mr Jesper Ipsen from Bielefeld University, Germany visited Professor Peter Forrester at The University of Melbourne in October as a visiting PhD student.
- Dr Jevgenijs Ivanovs from the University of Lausanne visited Professor Peter Taylor to work on modelling Markov-modulated Levy processes.
- Professor Tony Krzesinski from Stellenbosch University visited Professor Peter Taylor to work on their joint project Modelling the Bitcoin Blockchain.
- Dr Shawn Means from the Auckland Bioengineering Institute, University of Auckland, New Zealand visited Professor Kevin Burrage at Queensland University of Technology in August to initiate collaboration on the modeling of the human gut. Dr Means also gave a seminar in the school.
- Professor Alexander Meister from the University of Rostock, Germany visited the University of Melbourne in July to hold discussions with Professor Aurore Delaigle and to hold a seminar on the Optimal Classification and Nonparametric Regression for Functional Data.
- Professor Bernard Nienhuis from the Institute for Theoretical Physics, The Netherlands visited Associate Professor Jan de Gier at The University of Melbourne in December to collaborate on the collective behaviour in supersymmetric quantum chains.
- Associate Professor Alicia Nieto-Reyes from the University of Cantabria, Spain visited Professor Peter Hall and Professor Aurore Delaigle at The University of Melbourne in December to work on functional data.
- Dr Alvaro Pelayo from the University of California, USA, visited Professor Peter Forrester at The University of Melbourne in October to discuss and give a talk on classical and semi-classical integrable systems.
- Dr Anita Ponsaing from LPTHE - CNRS - University of Paris 6, France visited The University of Melbourne in August to present a seminar on the Quantum KZ equation in an algebraic scheme.

ACEMS has had 32 visitors to its nodes in the second half of 2014, which has far exceeded expectations as well as our key performance indicator requirement.

- Professor Annie Qu from the Department of Statistics, University of Illinois at Urbana-Champaign, USA visited Professor Peter Hall and Professor Aurore Delaigle at The University of Melbourne in November to discuss networks and deliver a seminar on time varying networks estimation and dynamic model selection.
- Professor Eric Ragoucy-Aubezon from Laboratoire d'Annecy-le-Vieux de Physque Theorique, France visited Associate Professor Jan de Gier at The University of Melbourne in November to work on Generalisations of asymmetric exclusion processes.
- Senior Inspector of Mines, Mr Tilman Rasche, from the Department of Natural Resources and Mines Australia visited Professor Kerrie Mengersen in December in relation to their Baesian statistics collaboration.
- Professor Vladimir Rittenberg of Bonn University, Germany visited Associate Professor Jan de Gier at The University of Melbourne in October to collaborate on Markov chains with conformally invariant stationary state.
- Professor Judith Rousseu from Université Paris Dauphine, France visited Professor Kerrie Mengersen at Queensland University of Technology in November to be a Keynote Speaker at Bayes on the Beach.
- Professor Fabrizio Ruggeri from the Institute of Applied Mathematics and Information Technology, Milano, Italy visited Professor Anthony Pettitt at Queensland University of Technology in December as a visiting Adjunct Professor.
- Professor Edward Saff from the Centre for Constructive Approximation, Department of Mathematics, Vanderbilt University, Nashville USA visited The University of Melbourne in July to discuss a joint project with Professor Peter Forrester on energy minimisation problems.
- Professor Richard Samworth from the Statistical Laboratory, Centre for Mathematical Sciences, Cambridge UK attended the University of Melbourne in July to meet with Professor Aurore Delaigle to conduct research collaboration regarding the classification of indirectly observed data.
- Dr David Taggart from The University of Adelaide visited Professor Kerrie Mengersen at Queensland University of Technology to take part in the "Virtual Wallabies" experiment on 20 August 2014, as well as other collaborative projects.
- Professor Darryl Veitch from The University of Melbourne visited Professor Matt Roughan at The University of Adelaide in November to work on a collaboration on tomography and network topology.
- Professor Ole Warnaar from The University of Queensland, Australia visited Associate Professor Jan de Gier at The University of Melbourne to discuss their work and to hold a seminar on Generalised Rogers-Ramanujan identities and arithmetic.
- Dr Michael Wheeler visited Associate Professor Jan de Gier at The University of Melbourne in August to work on a collaboration on the theory of functions of many variables.
- Professor Qiwei Yao from the Department of Statistics, London School of Economics and Political Science visited The University of Melbourne in July to give a seminar on Matching Quantiles Estimation.
- Professor Paul Zinn-Justin from Université Pierre et Marie Curie - Paris, France visited Associate Professor Jan de Gier at The University of Melbourne in December to work on a research collaboration on the theory of functions of many variables.



SCIENTIFIC LINKAGES

OUTREACH

In its first six months, ACEMS has engaged the public through many avenues and has started contributing to currently running wide-reaching programmes, which include:

Mathematicians in Schools

The CSIRO's Mathematicians in Schools (MiS) is:

"[A] free national program supporting long-term, professional partnerships between practising mathematicians and teachers across Australia".

Many of the Centre's personnel, including CIs, participate in MiS, including Prof Peter Taylor (Elizabeth Blackburn School of Science), Prof Phil Pollett (St Aidan's Anglican Girls School) and prof Dirk Kroese (St Peter's Lutheran College). Through MiS the Centre engages students in New South Wales, Queensland, South Australia and Victoria.

Growing Tall Poppies in Science

Growing Tall Poppies in Science (GTP) is a comprehensive and professional series of education programmes for high school students. The project, which has been jointly designed by scientists and educators, aims to "connect students and the science community to explore science knowledge, the process of its formation and the relevance it has to community and society".

The Centre has commenced discussions with the GTP in Science programme, and will soon enter into a formal partnership. ACEMS has already contributed to GTP with Centre personnel Dr Michael Wheeler and Tania Smith having given guest lectures as a part of the programme.

ACEMS also engages students outside of formal programmes. For example, Node Director Prof Kerrie Mengersen makes an annual visit Coonabarabran State School in regional NSW.

The Centre has also started working with Brunswick South-West Primary School to create educational multipurpose playground equipment to allow teachers and students to work on many areas of the mathematics curriculum through interactive play.

In addition to face-to-face engagement, ACEMS is building a public media profile. The Centre has participated in a range of media activity, ranging from an article in The Australian Financial Review featuring the Centre's launch, to being sought out for media consultation. For example, Dr Sandra Johnson gave expert commentary for news reports about the use of Bayesian statistical modelling used in developing drones for monitoring Australian wildlife.

The Centre is also engaging the public through social media with the creation of a Facebook page that shares the Centre's achievements and pop-science content promoting mathematics and statistics.

In addition to public outreach, the Centre has also been active in facilitating teaching courses and workshops for students, staff and colleagues. These include Prof Kerrie Mengersen teaching courses on Bayesian analysis in Indonesia and Bayesian statistics in Perth. The Centre was also pivotal in running the workshop, "A new era in Clinical Mathematics" which was held at QUT and had high participation from both within and external to ACEMS

In addition to public outreach, the Centre has also been active in facilitating teaching courses and workshops for students, staff and colleagues.

Media Commentaries

Given the time since establishment of the Centre, ACEMS is developing a strong media presence. ACEMS media coverage includes all print and electronic media, podcasts, television and radio. The media coverage listed included commentary prior to the commencement of the Centre to ensure all media is collected and is included:

- The Melbourne Newsroom published an article in February 2014; Melbourne awarded $20M for new ARC Centre of Excellence. The Australian Online picked this up on February 11, 2014, with the article, Applying method to data madness and via the article, Invidious comparisons, The Australian, Higher Education, 6 January 2014.
- *Holiday road trips made easier with maths and stats*, Australian Mathematical Sciences Institute, 27 December 2014, http://amsi.org.au/2014/12/27/holiday-road-trips-made-easier-maths-stats/
- *Mysterious Statistical Law May Finally Have An Explanation*, Wired, 27 October 2014, http://www.wired.com/2014/10/tracy-widom-mysterious-statistical-law/
- *Australia Research Council tackles big data*, enterpriseinnovation.net, 30 September 2014, http://enterpriseinnovation.net/article/australia-research-council-tackles-big-data-50447297
- *Australian government launches US$17.7 million Big Data innovation centre*, Datacentre.ME, 26 September 2014, http://www.datacentre.me/news/australian-gvmt-launches-us-17-7m-big-data-innovation-centre-4657.htm
- *Australian government launches US$17.7 million Big Data innovation centre*, FutureGov, 26 September 2014, http://www.futuregov.asia/articles/2014/sep/24/australian-government-launches-us177-million-big-d/
- *Big data is watching you*, ABC Science, 18 September 2014, http://www.abc.net.au/science/articles/2014/09/17/4081914.htm
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- *GP co-payment would increase emergency department wait times,* The Conversation, 11 July 2014, http://theconversation.com/gp-co-payment-would-increase-emergency-department-wait-times-28658
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PUBLICATIONS

ACEMS members have published 24 peer-reviewed journal papers in 2014.

Refereed Publications

1. RC. Cope, JM. Lanyon, JM. Seddon, PK. Pollett; *Development and testing of a genetic marker-based pedigree reconstruction system `pr-genie' incorporating size-class data*, Molecular Ecology Resources 14 (JUL 2014), no. 4, 857-870.
2. KJ. Davies, JEF. Green, NG. Bean, BJ. Binder, JV. Ross; *On the derivation of approximations to cellular automata models and the assumption of independence*, Mathematical Biosciences 253 (JUL 2014), no. 1, 63-71.
3. Jd. Gier, C. Finn; *Exclusion in a priority queue*, Journal of Statistical Mechanics: Theory and Experiment (JUL 2014).
4. DA. Stanford, PG. Taylor, and I. Ziedins; *Waiting time distributions in the accumulating priority queue*, Queueing Systems 77 (JUL 2014), no. 3, 297-330.
5. E. Cameron, A. Pettitt; *Recursive pathways to marginal likelihood estimation with prior-sensitivity analysis*, Statistical Science 29 (AUG 2014), no. 3, 397-419.
6. P. Hall, J. Jiashun, H. Miller; *Feature selection when there are many influential features*, Bernoulli 20 (AUG 2014), no. 3, 1647-1671.
7. KB. Burrage, PM. Burrage, DM. Donovan, TA. McCourt, HB. Thompson; *Estimates on the coverage of parameter space using populations of models, Modelling and Simulation* (SEP 2014).
8. J. Davis, K. Mengersen, S. Bennett, L. Mazerolle; *Viewing systematic reviews and meta-analysis in social research through different lenses*, SpringerPlus 3 (SEP 2014), 511.
9. P. Hall, Y. Ma; *Quick and easy one-step parameter estimation in differential equations*, Journal of the Royal Statistical Society Series B-Statistical Methodology 76 (SEP 2014), no. 4, Pages: 735-748.
10. T. Székely, K. Burrage, M. Mangel, MB. Bonsall; *Stochastic dynamics of interacting haematopoietic stem cell niche lineages*, PLoS Computational Biology 10 (SEP 2014), no. 9.
11. S. Tao, J. Corcoran, I. Mateo-Babiano, D. Rohde; *Exploring bus rapid transit passenger travel behaviour using big data*, Applied Geography 53 (SEP 2014), 90-104.
12. PPY. Wu, J. Pitchforth, K. Mengersen; *A hybrid queue-based bayesian network framework for passenger facilitation modelling*, Transportation Research Part C: Emerging Technologies 46 (SEP 2014), 247-260.

13. PJ. Forrester, JL. Lebowitz; *Local central limit theorem for determinantal point processes*, Journal of Statistical Physics 157 (OCT 2014), no. Issue: 1 Pages: 60-69.
14. D. Rohde, J. Corcoran; *The evidence for smoke alarm type: Photoelectric vs ionisation*, Australian and New Zealand Journal of Public Health 38 (OCT 2014), no. 5, 494-444 SI.
15. MN. Tran, P. Giordani, X. Mun, R. Kohn, MK, Pitt; *Copula-type estimators for flexible multivariate density modeling using mixtures*, Journal of Computational and Graphical Statistics 23 (OCT 2014), no. 4, 1163-1178.
16. C. Mellin, K. Mengerson, CJA. Bradshaw, MJ. Caley; *Generalizing the use of geographical weights in biodiversity modelling*, Global Ecology and Biogeography 23 (NOV 2014), no. 11, 1314-1323.
17. GW. Peters, AXD. Dong, R. Kohn; *A copula based bayesian approach for paid-incurred claims models for non-life insurance reserving*, *Insurance*: Mathematics and Economics 59 (NOV 2014), 258-278.
18. T. Székely Jr, K. Burrage; *Stochastic simulation in systems biology*, Computation and Structural Biotechnology Journal 12 (NOV 2014), no. 20-21, 14-25.
19. J. Vercelloni, MJ. Caley, M. Kayal, S. Low-Choy, K. Mengersen; *Understanding uncertainties in non-linear population trajectories: A bayesian semi-parametric hierarchical approach to large-scale surveys of coral cover*, PLoS ONE 9 (NOV 2014), no. 11, A109.
20. F. Zeng, F. Liu, C. Li, K. Burrage, I. Turner, and V. Anh; *A crank-nicolson ADI spectral method for a two-dimensional Riesz space fractional nonlinear reaction-diffusion equation*, SIAM Journal on Numerical Analysis 52 (NOV 2014), no. 6, 2599-2622.
21. J. Corcoran, T. Li, D. Rohde, EC, Charles-Edwards, D. Mateo-Babiano; *Spatio-temporal patterns of a public bicycle sharing program: The effect of weather and calendar events*, Journal of Transport Geography 41 (DEC 2014), 292-305.
22. MD. Huque, HD. Bondell, L. Ryan; *On the impact of covariate measurement error on spatial regression modelling*, Envirometrics 25 (DEC 2014), no. 8, 560-570 Special Issue.
23. DM. Kempthorne, IW. Turner, JA. Belward; *A comparison of techniques for the reconstruction of leaf surfaces from scanned data*, SIAM Journal on Scientific Computing 36 (DEC 2014), no. 6, B969-B988.
24. S. Tao, D. Rohde, J. Corcoran; *Examining the spatial-temporal dynamics of bus passenger travel behaviour using smart card data and the flow-comap*, Journal of Transport Geography 41 (DEC 2014), 21-36.

Conference Proceedings and Other Publications

1. M. R. R. Bowden, and N. Bean; *Cold: Pop-level network topology synthesis*, 10th ACM International on Conference on Emerging Networking Experiments and Technologies (CoNEXT) (DEC 2014), 173-184.
2. L.H. Campbell and PG. Taylor; *Renfrey Burnard Potts 1925–2005*, Historical Records of Australian Science 25 (DEC 2014), no. 2, 291-305.
3. J. Geweke; *Review essay on Charles F. Manski's public policy in an uncertain world: Analysis and decisions*, Journal of Economic Literature 52 (SEP 2014), no. 3, 799-804.
4. MT. Moores, CC. Drovandi, K. Mengersen, CP. Robert; *Pre-processing for approximate bayesian computation in image analysis*, Statistics and Computing (DEC 2014).
5. L. Ryan; *Perspectives on diversity, in 'Past present and future of statistical science'*, Committee of Presidents of Statistical Societies (2014), 229-233.
6. P. Tune, M. Roughan; *Maximum entropy traffic matrix synthesis*, ACM SIGMETRICS Performance Evaluation Review 42 (SEP 2014), no. 2, 43-45.

ACEMS LOCATIONS

THE UNIVERSITY OF MELBOURNE

The University of Melbourne
Parkville Campus

Corner Swanston Street and Monash Street, Parkville
Mathematics and Statistics Building
ACEMS Head Office
G31, Richard Berry Building

QUT Queensland University of Technology

Queensland University of Technology
Gardens Point Campus

Corner Swanston Street and Monash Street, Parkville
School of Mathematics and Statistics
GP O-Block, Room 617

UTS
UNIVERSITY OF TECHNOLOGY, SYDNEY

University of Technology Sydney
School of Mathematical and
Physical Sciences

Building 7, level 5 and Building 8, level 9
15 Broadway, Ultimo, NSW, 2007
Assembling is best done in the lobby of Building 1 –
Tower Building

THE UNIVERSITY of ADELAIDE

The University of Adelaide
School of Mathematical Sciences

North Terrace Campus,
Ingkarni Wardli (F12 on campus map)
Level 6.

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

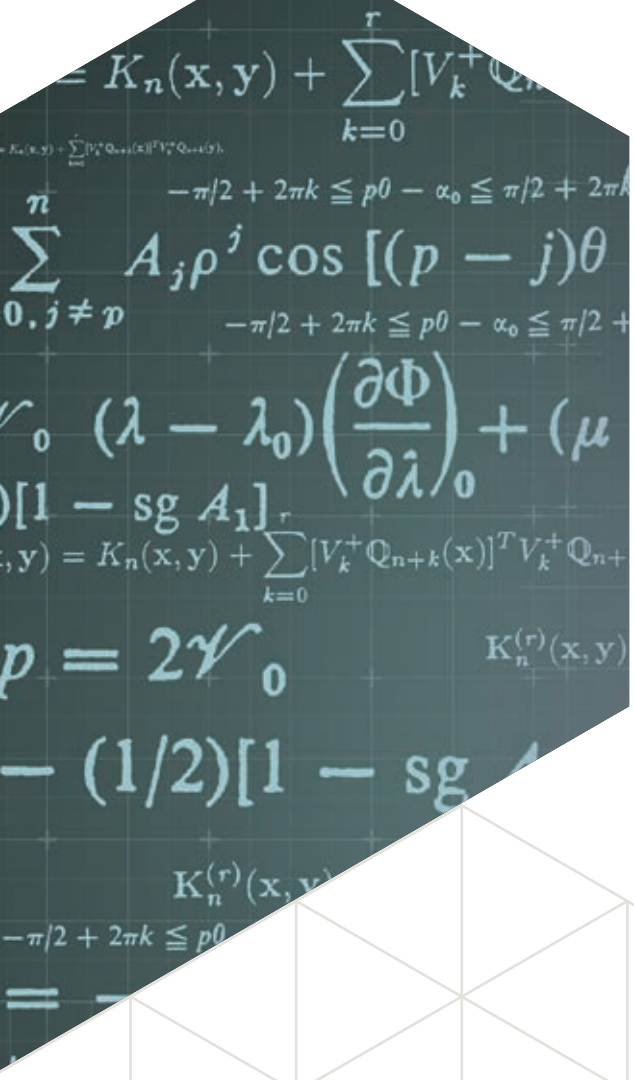
University of Queensland
School of Mathematics

Level 6
Priestley Building (67)
St Lucia, Brisbane 4072

UNSW
AUSTRALIA

University of New South Wales, Australia
School of Mathematics and Statistics

High St
Kensington, NSW 2052
Australia



GRANTS

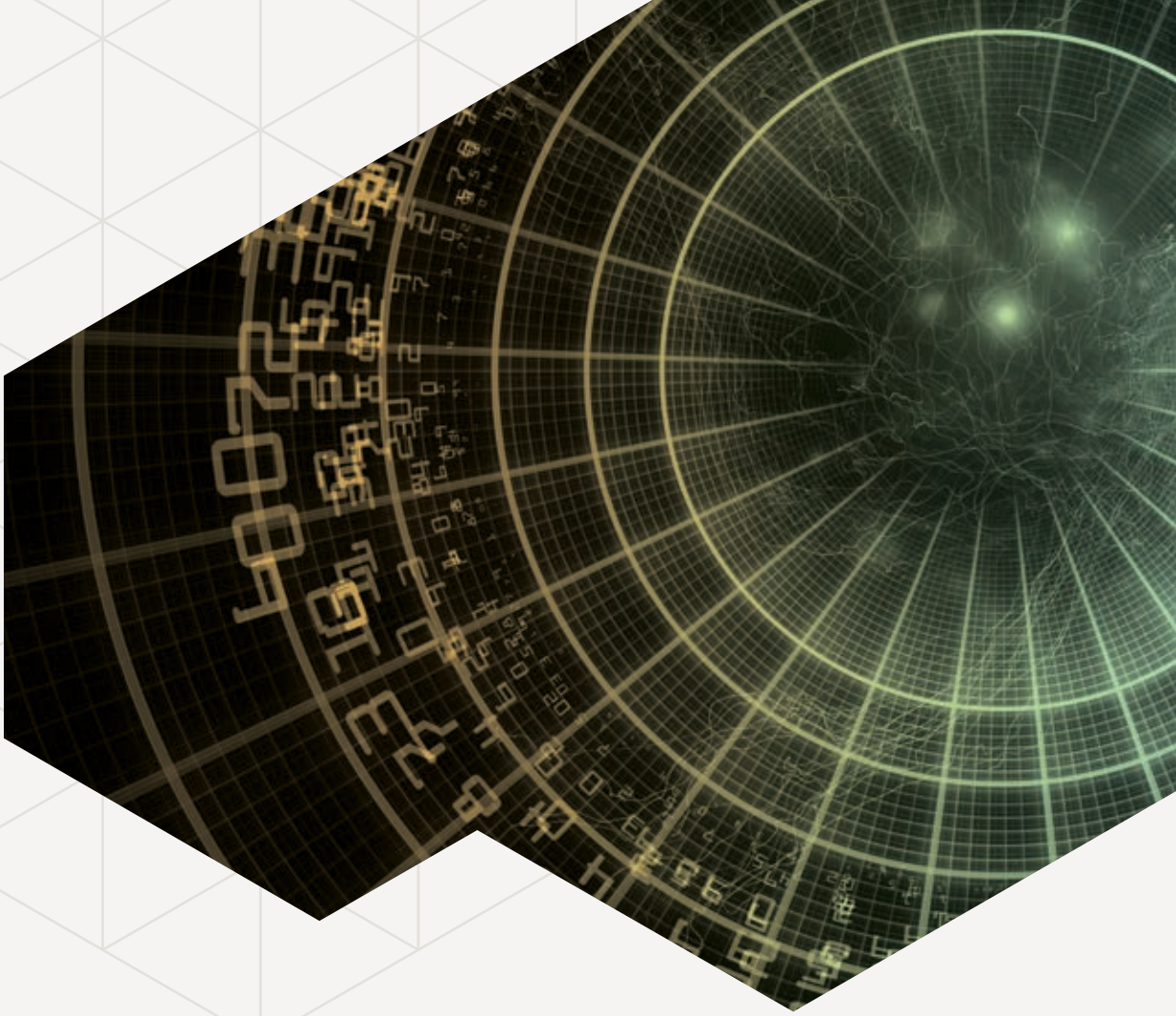
ACEMS members attracted $1,946,000 in additional support in 2014:

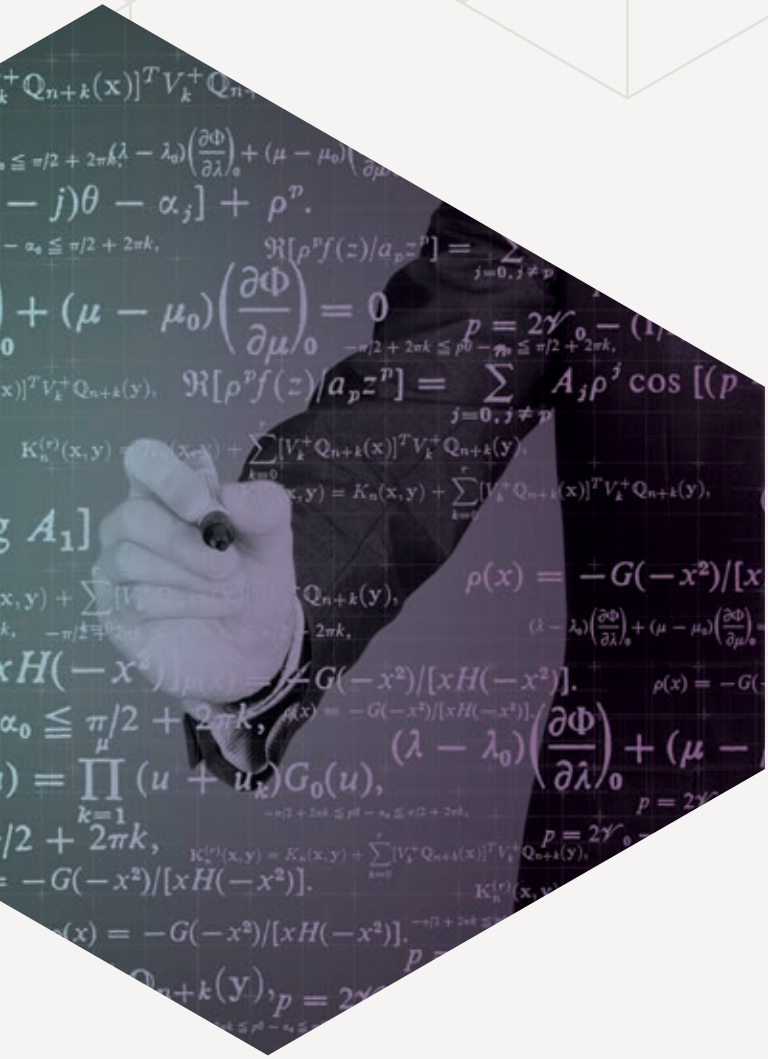
ARC linkage		
Customer Responsive Risk-Managed Network Planning	K. Mengersen	$525,000
Improving Productivity and Efficiency of Australian airports – A Real Time Analytics and Statistical approach	K. Mengersen	$660,000
Modelling Healthcare Systems	P. Taylor	$410,000
Discovery Project		
New Directions in Bayesian Statistics: formulation, computation and application to exemplar challenges	K. Mengersen	$351,000

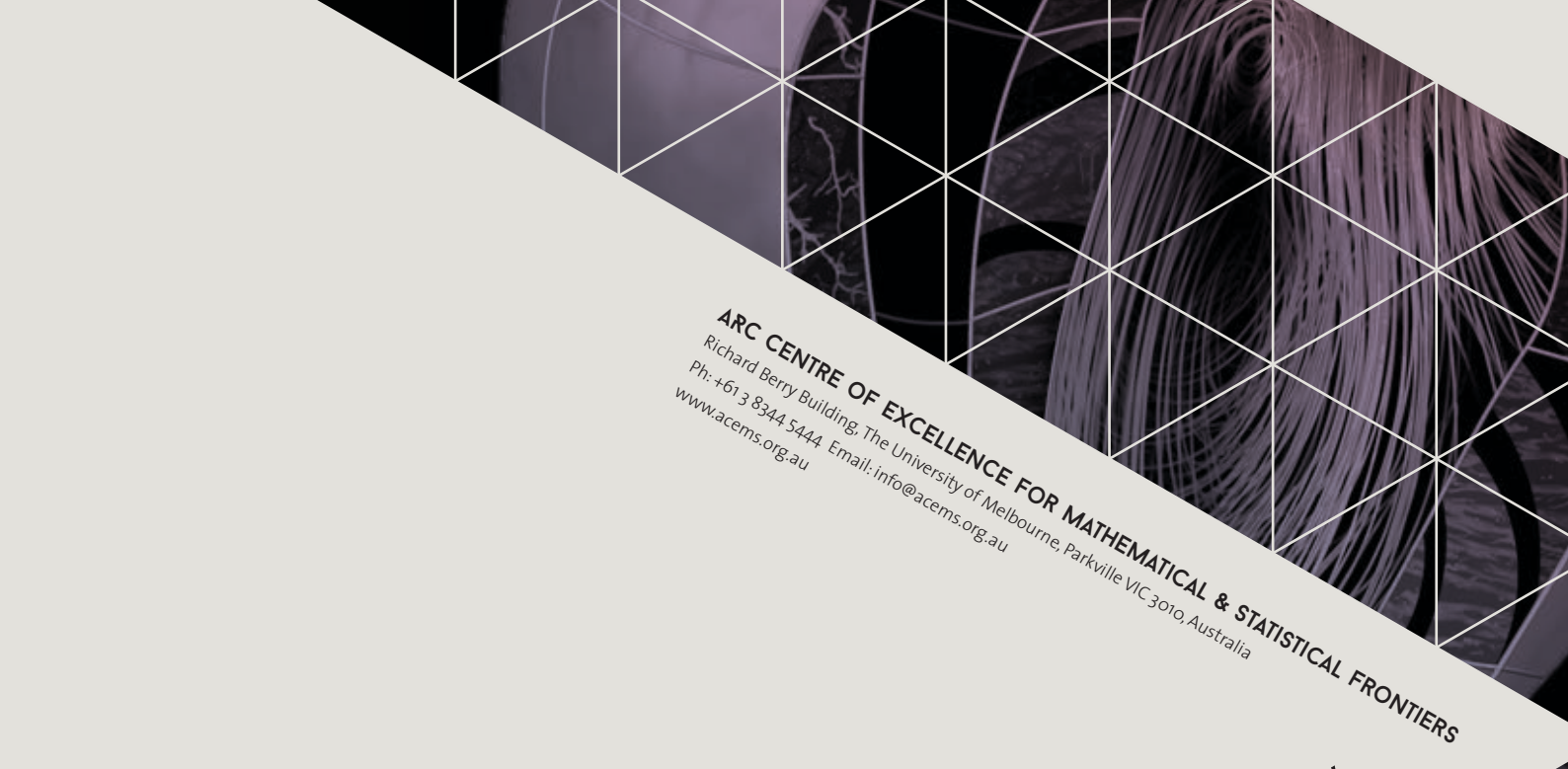
FINANCIAL STATEMENT

ACEMS FINANCIAL REPORT JULY – DECEMBER 2014				
	2014 Reporting Period ($)		2015 Reporting Period (Estimated) ($)	
Carry Forward	$ 0		$ 0	
Other Funds	$ 2,943,491.93 $ 838,682.00	ARC Income Node Contribution	$ 2,857,142.00 $ 1,091,167.00	ARC Income Node Contribution
Total Income	**$ 3,782,173.93**		**$ 3,948,309.00**	
Expenditure	$ 226,747.04	Salaries	$ 2,399,065.87	Salaries (Incl Postdocs)
	$ 17,974.10	Equipment	$ 36,025.90	Equipment
	$ 53,417.21	Travel, Accommodation and Conference	$ 530,318.00	Travel, Accommodation and Conference
	$ 109,324.00	Materials, Provisions and Services	$ 142,632.00	Materials, Provisions and Services
	$ 4,790.09	Scholarships	$ 140,000.00	Scholarships
	$ 5,007.00	Marketing, Outreach and Sponsorship	$ 222,424.00	Marketing, Outreach and Sponsorship
	$ 33,919.80	General & Clawback	$ 477,843.23	General
Total Expenditure	**$ 451,179.24**		**$ 3,948,309.00**	
Balance	**$ 3,330,994.69**		**$ 0**	

In-Kind Report JULY – DECEMBER 2014	
University of Melbourne	$ 607,876
Queensland University of Technology	$ 300,033
The University of Adelaide	$ 253,775
University of New South Wales	$ 384,468
The University of Queensland	$ 448,959
University of Technology Sydney	$ 263,681
AT&T	$ 10,780
Australian Bureau of Statistics	$ 59,967
CSIRO	$ 0
MITACS	$ 7,180
VicRoads	$ 86,236
SAX Institute	$ 6,870
AIMS	$ 150,208
Monash University	$ 19,803
Total	**$ 2,464,653**
In-Kind contributions were calculated over the six-month period, from 1 July 2014, in line with the Centre start up. A number of contributions have been lower than anticipated due to some collaborations commencing later than expected. CSIRO had a change in staff, which affected ACEMS and therefore a new CSIRO representative was not formally agreed upon until 2015. As a result, no in-kind contribution could be recorded.	







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