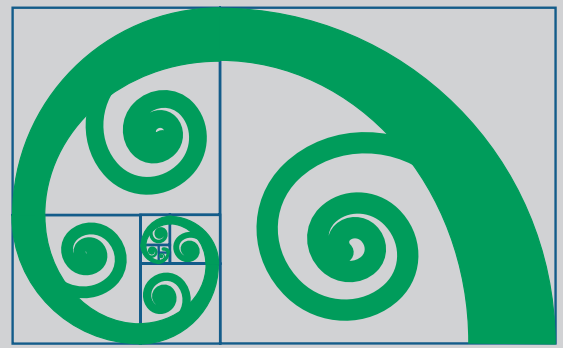


THE NEW ZEALAND INSTITUTE OF MATHEMATICS & ITS APPLICATIONS



NZIMA



THE UNIVERSITY OF AUCKLAND
NEW ZEALAND





ANNUAL REPORT

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OVERVIEW FROM CHAIR OF THE NZIMA BOARD

Sir Ian Axford DSc FRS FRSNZ, Chair of the NZIMA's Governing Board, reports:

Once again I am delighted to offer some words for the annual report of the NZIMA, on behalf of its Board. As I've written previously, I think it is wonderful to see New Zealand recognising and supporting centres of research excellence, especially in areas of fundamental importance to society and the economy.

The NZIMA has built on its early success by pursuing a suite of programmes in a variety of themes led by excellent people, by appointment of some very fine Maclaurin Fellows and postgraduate scholars, and by supporting high quality international visitors and local conferences. The benefits are apparent from the highlights mentioned in this report.

The Governing Board will play its role in the ongoing development of the NZIMA, and continue to shape its strategy in the years ahead.

We face some positive challenges in helping the NZIMA to build up its resource base, to use its centres of research excellence funding and status as leverage to obtain enhanced support for its activities, and to further its mission.

A particular challenge (which was identified in the recent review of CoREs by the Tertiary Education Commission) is that of creating a separate and distinctive identity for the NZIMA and building its profile.

There is no doubt in my mind that the NZIMA is pursuing the goals of the Centres of Research Excellence Fund in outstanding fashion, using as models a number of other renowned mathematical sciences institutes overseas. We have recognised, however, the need to publicise the activities and achievements of the NZIMA to a wider audience, to heighten awareness of the key role it plays and the benefits it is achieving for New Zealand.

I congratulate the NZIMA and all those involved in it, especially the two Co-Directors and the Executive for their efforts in facilitating its establishment and ongoing development, and look forward to its continued success.

REPORT FROM DIRECTORS AND EXECUTIVE COMMITTEE

We are very pleased to report on another great year, building on the important foundations laid from 2002 to 2004. The NZIMA was established with the aims (among others) of creating and sustaining a critical mass of researchers in concentrations of excellence in mathematics and statistics and their applications, and raising the level of knowledge and skills in the mathematical sciences in New Zealand. We are fortunate to have a number of highly successful models to follow, such as the Mathematical Sciences Research Institute (MSRI) at Berkeley, and the Isaac Newton Institute in Cambridge.

We recognise that being a Centre of Research Excellence is not just about conducting world class research, making international linkages, publication in top journals and participation in major conferences, but also involves high quality training of postgraduate students and postdoctoral researchers, fostering new collaborations, engaging with the end-users of the research (on a two-way basis), and outreach to relevant communities and the general public. It is fair to say that during the first three years of our operation, we have concentrated on the former of these (including postgraduate and postdoctoral training), but in 2004 we recognised the need to place additional emphasis on the latter responsibilities, and we have been developing new operational strategies with this in mind.

Each year we select two significant research themes in which to run a special programme. Each programme is of approximately 6 months duration, and involves a concentrated period of activity centred around a meeting or workshop (held at an appropriate location in New Zealand), participation by visiting lead experts in the theme area, and the appointment of a postdoctoral fellow and a number of postgraduate research students. We select these programmes in consultation with our International Scientific Advisory Board and other members of the NZ mathematical sciences research community. Driving the decision in each case are the founding aims of the NZIMA, and the goals of the CoRE fund. In doing this, we aim to achieve a balance between high-quality fundamental research and the application of the mathematical sciences (either to other disciplines or to practical problems in the “real world”).

During 2004 we selected three new thematic programmes to pursue in 2005 and the first half of early 2006:

- *Hidden Markov Models and Complex Systems*, led by Emeritus Professor David Vere-Jones (Victoria University of Wellington)
- *Mathematical Models for Optimizing Transportation Services*, led by Professor Andy Philpott, Assoc. Professor Matthias Ehrgott and Professor David Ryan (University of Auckland)
- *Geometric Methods in the Topology of 3-Dimensional Manifolds*, led by Professor David Gauld (University of Auckland), Dr Roger Fenn (University of Sussex) and Professor Vaughan Jones (University of Auckland and University of California, Berkeley).

In 2005 we selected two further programmes to pursue for 2006/07:

- *Modelling Invasive Species and Weed Impact*, led by Dr Jennifer Brown, Dr Alex James and Professor David Wall (University of Canterbury)
- *Partial Differential Equations: Applications, Analysis and Inverse Problems*, led by Dr Colin Fox, Dr Mike Meylan, Professor Boris Pavlov (University of Auckland).

Four of these five programmes have a significant component of **application and outreach**. Two of those begun in 2005 have already involved researchers from CRIs, government departments and NZ-based industries. Similarly, the two most recently selected programmes are likely to respectively involve engineers and physicists in New Zealand (for example at IRL, universities, and Fisher & Paykel) who use partial differential equations in solving problems in areas such as geothermal modelling, nanotechnology, sea-ice interaction, structural vibration and acoustics, and interaction with the Department of Conservation (DoC) and the Bio-Protection CoRE to investigate issues of importance to New Zealand's environment. The other one of the five programmes selected for 2005/06 will help **bring New Zealand mathematicians up to date with the latest developments** in the resolution of the Poincaré conjecture, by bringing in some of the world's experts on this matter and related aspects of the highly topical area of 3-manifolds.

Also we have decided to offer more visiting Maclaurin fellowships of shorter duration, to attract more high quality visitors and to optimise the research benefits of these. Since our last report, we have offered Maclaurin Fellowships to:

- Prof. Robert McLachlan (Massey University), for all of 2005
- Prof. Geoff Whittle (Victoria University of Wellington), for all of 2006
- Prof. Martin Liebeck (London), visitor in 2005
- Prof. John Conway (Princeton), visitor in each of 2005, 2006, 2007 and 2008
- Prof. Jonathan Borwein (Dalhousie), visitor in 2005
- Prof. Hyman Bass (Michigan), visitor in 2006.

At an early stage we decided to support a number of **postgraduate research students** enrolled for PhD or Masters degrees in the mathematical sciences in New Zealand, on a merit basis (not necessarily tied to NZIMA thematic programmes). In addition, we decided to lend some support to a proposed programme in Industrial Mathematics by way of postgraduate scholarships for students engaged in research projects in industry. More details about these are given in a later section of this report. In 2005 we took on a new student, Adam Smith, who is engaged in a Masters thesis project on the statistical validation of the NZ Marine Environment Classification, under the co-supervision of a member of staff of the Department of Conservation (DoC), and partially co-sponsored by DoC. Further students will be selected for support in this way in 2006.

In addition, we have found there is great benefit in helping facilitate more **local conferences** and **short visits to New Zealand by international figures**, in a range of fields. Relatively small amounts of money (spent mainly on travel costs) have led to new interactions and an increased level of excitement, especially among early and mid-career researchers. The pay off will be long-term and significant.

As Sir Ian Axford has pointed out in the previous section, one of our current challenges is to **build up the profile of the NZIMA**, exploiting its standing as a Centre of Research Excellence to create a separate and distinctive identity, and heighten awareness of the key role it plays and the benefits it is achieving. This does not come naturally to most mathematicians! Nevertheless we recognise both the responsibility we have to do this and the further advantages it will bring (for example in terms of greater outreach), and we are taking a number of steps in this direction already. These include a programme of promotional activities, including public lectures, new signage (for use at all NZIMA events and locations of NZIMA researchers), and publicity materials (to be sent to all relevant stakeholders, including secondary schools).

For example, Marston Conder arranged two screenings on behalf of the NZIMA of the 30-minute MSRI video **“Porridge, Pulleys, Pi: two mathematical journeys”** (starring Vaughan

Jones and Hendrik Lenstra, and offering insights to their work, their backgrounds, their personalities and interests, and the impact of their research in mathematics, physics, cryptography and molecular biology), at the University of Auckland in October 2004, and at the 2004 New Zealand Mathematics Colloquium in Dunedin in December 2004. At the University of Auckland screening, invited short lectures were also given by two of the NZIMA's Maclaurin Fellows, Rod Gover (Auckland) and Mike Steel (Canterbury). Following the success of these, copies of the "Porridge, Pulleys, Pi" video were commissioned (with MSRI approval) and donated to the six university mathematics departments in NZ.

We are very pleased to report that the NZIMA (along with the six other CoREs in New Zealand) succeeded in securing its second 3-year tranche of CoRE Funding in 2005, following the review of CoREs by the Tertiary Education Commission (TEC) in 2005.

The NZIMA is a member of the newly formed Association of CoRE Directors and Managers (aCoRE), and Marston Conder and Margaret Woolgrove have been actively taking part in its meetings and other activities on behalf of the NZIMA. This

Dr Hugo Rossi, Deputy Director of the Mathematical Sciences Research Institute (MSRI) in California, has accepted an invitation to join the NZIMA's International Scientific Advisory Board, replacing Dr Robert (Bob) Megginson, who has returned to his faculty position at the University of Michigan. This is Dr Rossi's second term as Deputy Director of the MSRI, and we are very pleased to have him join the board and gain from his wisdom and experience. We are also very grateful to Bob Megginson for his valued service on our advisory board.

Another significant development for us in 2005 was an invitation to Marston Conder and Vaughan Jones by the directors of the MSRI (Berkeley) and PIMS (Canada) to take part in a Pacific Rim Mathematical Forum at the Banff International Research Station (BIRS) in October 2005. Marston Conder attended, and gave a short presentation on the NZIMA. While there he had helpful discussion with representatives of AIM (the American Institute of Mathematics), AMSI (the Australian Mathematical Sciences Institute), IMS (the Institute of Mathematical Sciences in Singapore) and PIMS. A principal outcome of the meeting was a decision to set up a Pacific Rim Mathematical Association (otherwise known as 'PRIMA'), with the aim of promoting and facilitating the development of the mathematical sciences throughout the Pacific Rim region. This will involve improved networking, coordination of activities, training (including summer schools), infrastructural assistance, and pooling of expertise and resources. The NZIMA has become a founding member of PRIMA, and Marston Conder has been invited to join its Liaison Committee.

We would like to thank all those who have been involved positively in NZIMA's third year of operation, including (but not limited to) the following:

- Sir Ian Axford and other members of the Governing Board for their guidance and oversight
- Members of the Scientific Advisory Board for their advice and insight
- Members of the Executive Committee and others who have been involved in the selection of programmes, scholars and candidates for Maclaurin Fellowships and other support
- Programme Directors and Maclaurin Fellows for their research and research leadership
- Margaret Woolgrove for her administrative support and perspicacity
- Professor Tom Barnes (DVC (Research)) and the Science Faculty Office at the University of Auckland for their ongoing support
- Directors and managers of the other CoREs for sharing their experiences.

COMMENTS FROM SCIENTIFIC ADVISORY BOARD

The NZIMA's International Scientific Advisory Board is consulted regularly about the selection of its thematic programmes and other matters as appropriate.

No formal review by this advisory board of the NZIMA's programmes and other activities has been invited to date, but its members have kindly offered the following comments based on their knowledge and experience of these activities so far:

Sir Michael Berry FRS (University of Bristol and the Isaac Newton Institute, UK)

In the few years since its creation, NZIMA has provided a powerful boost for New Zealand mathematics (interpreted in its widest sense). This was achieved with modest resources coupled with determination and commitment. The result is an abundance of activities — thematic programmes, workshops, support for researchers — all of the highest international quality.

Andreas Dress (CAS-MPG Partner Institute for Computational Biology, Shanghai):

I visited New Zealand quite often in the last years, and it was always a great pleasure to participate at NZIMA events and to be hosted by NZIMA-affiliated colleagues. Looking back, I am particularly impressed by the speed with which New Zealand changed from a country whose best young people went abroad (and were even encouraged, for their own best, by their supervisors) to a country that can not only attract its own scientific "offspring", but can also attract very good young mathematicians (and even older ones) from all over the world. I believe that this is by far the most valuable effect the work of the NZIMA has had so far.

Peter Hall FAA FRS (Mathematical Sciences Institute, Australian National University):

It's a pleasure to write to you to tell you how much I admire the Institute that you have created and brought to such a high level of maturity. New Zealand mathematics has fared so much better than that in Australia over the four years since the inception of the NZIMA, and the Institute has made all the difference.

I don't need to convince you, or indeed any wise person with a good awareness of contemporary science, that this new century is the Century of Mathematics. That is no less true in areas of biology and agriculture than it is in engineering and technology. All these fields are ones in which New Zealand has made its international mark, and where the NZIMA has launched and sustained high-level mathematical work. More basically, the Institute's development of theoretical mathematics is providing nourishment to the discipline across all its component parts.

Through the work of the Institute, New Zealand has been positioned to lever economic growth and advantage off the most influential and most cost-effective of all the sciences — the mathematical sciences. The nation is getting extremely good value for its investment in the NZIMA, and you must be particularly proud of what you have done.

Gus Lehrer (University of Sydney, Australia):

The NZIMA conducts research programmes of varying duration in a broad range of mathematical disciplines, from the very 'pure' to applications of sophisticated mathematical methods. The principal effect of these programs has been to ensure that New Zealand is regularly host to researchers of very high world standing in mathematics and related subjects, which has had a perceptible effect in encouraging students, and much ancillary activity. For a relatively modest outlay, New Zealand has become known as a country which punches well above its weight in mathematical research. Although hard to quantify, this results in a percolation of talent into related industries, such as banking, insurance etc.

Cheryl Praeger FAA (University of Western Australia):

I attended the international conference in February that formed part of the programme on Geometry: Interactions with Algebra and Analysis. The quality of lectures and lecturers over this period was impressive. The mix (of analysis, geometry, algebra and topology) it engendered had some lasting benefits. For example, it initiated contacts with and between NZ universities. Such interactions need effort to enable them to succeed, and the involvement of young researchers along with graduate students is one of the best strategies. Resource-wise, the program had a strong multiplicative effect, bringing at least matching funding even from visitors, many who were self-funded, indicating the strength of the programme.

Dale Rolfsen (University of British Columbia and Pacific Institute of Mathematical Sciences, Canada):

I had the pleasure, in January 2006, of attending the workshop on Geometric Methods in the Topology of 3-dimensional Manifolds, in Taipa. I was especially impressed. The lectures and mini-courses were superb. Especially inspiring were the series on quantum computing and topology by Mike Freedman (a Fields medalist) and lectures on Einstein manifolds by Jeff Cheeger, a leading figure in differential geometry. The wonderful venue and friendly interaction of the participants, both from NZ and abroad, helped to make it a memorable and mathematically very relevant event.

As an outsider, I can attest that the events sponsored by NZIMA in the last few years have greatly enhanced the international stature of New Zealand mathematics, and have also made me realize, by first-hand experience, that there are some really superb mathematicians in New Zealand. I feel it is important to continue, and even increase, this momentum. Bringing more leading mathematicians to NZ, through such well-executed meetings, will serve the dual purpose of inspiring the mathematicians working there and furthering the reputation of New Zealand in the world scientific community.

Keith Worsley FRSC (McGill University, Montreal):

The NZIMA has supported world-class workshops and conferences that are vital to maintain the vitality of a relatively small but vigorous mathematical and statistical community in New Zealand.

PROGRESS WITH RESPECT TO CoRE FUND OBJECTIVES

The Centres of Research Excellence (CoRE) Fund is intended to support research that:

- is of excellent (world-class) quality,
- leads to knowledge transfer, and
- is focussed upon NZ's future development.

Below are some of the highlights of the NZIMA's activities and achievements in 2004/05 that exhibit how it is meeting these objectives. Further details can be found elsewhere in this report.

Research Excellence

- Researchers involved with the NZIMA won numerous awards in 2004 and 2005, including
 - two Fellowships of the Royal Society of NZ
 - the Massey University Research Medal for 2005
 - election to Incoming President of the Academy of the Royal Society of NZ
 - the NZ Mathematical Society's annual Research Award (all three winners in 2004 and 2005)
 - one Hood Fellowship
 - election to President of the NZ Mathematical Society
 - one Fellowship of the Institute of Combinatorics & its Applications
 - two life memberships of the NZ Mathematical Society and one of the Combinatorial Mathematical Society of Australasia.
- The NZIMA has brought to New Zealand some of the world's finest mathematical scientists, such as John Conway (Princeton), Peter Sarnak (Princeton) and C.R. Rao (Penn State)
- The NZIMA is a member of the consortium of International Mathematical Science Institutes, and has been invited to join the newly established Pacific Rim Mathematical Association
- Researchers involved with the NZIMA have published a large number of articles in some of the world's top mathematics journals, including *Annals of Pure and Applied Logic*, *Inventiones Mathematicae*, *Journal of the American Math. Society*, *Journal of the London Math. Society*, and *Transactions of the American Math. Society*
- Prof. Bert Gerards (of the CWI, Netherlands) has been invited to speak on his joint work with Geoff Whittle (Co-Director of the NZIMA's Combinatorics programme) and Jim Geelen at the 2006 International Congress of Mathematicians, to be held in Madrid in August 2006
- A research student engaged in the NZIMA's programme on Logic and Computation, was awarded a Woolf Fisher Scholarship, to study for a PhD at Cambridge University
- Two of the NZIMA's students jointly won the Aitken Prize for best student talk at the NZ Mathematics Colloquium in 2005
- Several of our programmes have involved interactions with other centres of Research Excellence in NZ (and with other leading mathematical science institutes overseas).

Knowledge Transfer

- All the NZIMA's programmes have encouraged large numbers of students and professional mathematical scientists to take part in their conferences/workshops, and have engaged two or more postgraduate students in specific research projects
- All but one of the NZIMA's programmes have engaged at least one postdoctoral fellow
- A special issue of the journal *Annals of Pure and Applied Logic* (Elsevier) resulted from the NZIMA's programme on Logic and Computation
- A special issue of the journal *Progress in Biophysics and Molecular Biology* resulted from the NZIMA's programme on Modelling Cellular Function
- The NZIMA organised or co-sponsored 14 conferences in 2004, and 15 conferences in 2005
- In addition, many of the NZIMA's programmes have included an instructional workshop and/or a seminar series, for researchers from universities and CRIs, students, and interested parties from business/industry and relevant government departments
- The Modelling Cellular Function programme has stimulated new research relationships with groups in Chicago, Kyoto, Oxford, Queensland, San Diego, Sheffield, Sydney and Utah
- The NZIMA received a very complimentary mention in the April 2004 newsletter of The London Mathematical Society
- Mike Steel (Director of the NZIMA's programme in Phylogenetic Genomics, and MacLaurin Fellow in 2004) presented his work at two international conferences, at the MSRI (Berkeley) in March 2005, and the Institut Henri Poincaré (IHP) in Paris in June 2005. The speakers at the latter conference are contributing to a book titled "New mathematical models in evolution", to be published by Oxford University Press in 2006.
- Also Mike Steel presented on the *Eureka!* Programme on National Radio in March 2005, at the RSNZ-sponsored *Dance of Mathematics* programme at Akaroa in May 2005, and on Maori Television's *Cyberworld* programme in July 2005
- The April 2005 workshop arranged as part of the NZIMA's programme on Mathematical Models for Optimizing Transportation Services included two special panel discussions sponsored by the dairy company Fonterra (New Zealand's largest corporation) and the Auckland Regional Transport Authority (ARTA), to examine important issues such as the effect of uncertainty on routing techniques and how to accommodate these in planning robust schedules
- One of the expert participants in the latter workshop made a public television appearance when asked to comment in a broadcast interview about a hotly debated proposal to introduce tolled highways to Auckland
- The NZIMA's programme on Hidden Markov Models has involved close interaction with AgResearch and NIWA on the use of such models in agriculture and weather, respectively
- The NZIMA has facilitated public lectures and newspaper articles (by/about high profile mathematicians such as John Conway), and presentations of the MSRI video "Porridge, Pulleys, Pi: two mathematical journeys" (starring Vaughan Jones and Hendrik Lenstra), and both co-Directors have given talks in NZ high schools.

Contribution to National Goals

- The NZIMA has encouraged the involvement of under-represented groups in research and postgraduate study in the mathematical sciences. For example, NZIMA scholar Garry Nathan is the first Maori student to enrol for a PhD in Mathematics Education; and in the NZIMA programme on Numerical methods for evolutionary problems, two women (Shirley Huang and Nicolette Rattenbury) have successfully completed PhDs in Mathematics (under the supervision of programme director John Butcher), and three women (Jennifer Brown, Alex James and Vivien Kirk) have been appointed as programme co-directors.
- Research students in the NZIMA's programme on Modelling Cellular Function have been investigating a wide range of topics with potentially significant outcomes in medicine: electrophysiology of interstitial cells, mechanisms of coronary autoregulation, electrical activity of the small intestine, and whole heart ischemia.
- One project forming part of the NZIMA's programme on Mathematical Models for Optimizing Transportation Services concerns "Yacht match-race simulation under a spatial weather model", and is using Valencia weather buoy data supplied by Emirates Team New Zealand to build a stochastic model of a varying wind field. This wind model will be used in simulations to assess the risk of different starting and routing strategies during the America's Cup races in Valencia in 2007.
- Other projects in the latter programme are the investigation of models for revenue management that account for competition between airlines, and optimising the routing of trains through railway junctions
- One of the two new thematic programmes chosen by the NZIMA in 2005 to take up in 2006 is a programme on Modelling Invasive Species and Weed Impact. This will involve interaction with the Department of Conservation (DoC) and the Bioprotection CoRE, in consideration of issues of obvious importance to New Zealand's environmental sustainability
- One of the NZIMA's postgraduate scholars (selected on a merit basis) is engaged in a Masters thesis project on the statistical validation of the NZ Marine Environment Classification.

THEMATIC PROGRAMMES: SUMMARY

The NZIMA has ten principal thematic research programmes at various stages of development. Key details of these programmes are given below. The first four were initiated in 2002/03, the next three in 2004, and the latest three in 2005.

Modelling Cellular Function: This programme aims to characterise, simulate and elucidate the mechanisms of cell function through the use of analytic and computational mathematical models. This involves integration of spatial-temporal scales and biological function in the hierarchy of cellular models, which will ultimately be required to link genomics with clinical medicine.

Programme director: Dr Nicolas Smith (Bioengineering, University of Auckland)

Workshop details: The key meeting was held at Waiheke Island in July 2003.

Logic and Computation: The central focus of this programme is research on the theories of computability and complexity, and the algorithmic study of randomness. Other areas are finite and computable model theory and logics of programs, including complexity of decision problems and applications to specification and verification.

Programme director: Professor Rob Goldblatt (Victoria University of Wellington)

Workshop details: The key meeting was held at Nelson in January 2004.

Numerical Methods for Evolutionary Problems: Evolutionary problems include ordinary differential equations, delay differential equations and differential-algebraic equations. Although traditional numerical methods for these problems are well established, more general methods are being developed that are capable of more efficient performance.

Programme director: Professor John Butcher (Mathematics, University of Auckland)

Workshop details: The key meeting was held in Auckland in July 2003.

Phylogenetic Genomics: This programme has brought together leading experts to investigate the following topical problem: how can new types of genomic data best be used to infer evolutionary information? This question involves many challenging combinatorial problems.

Programme director: Professor Mike Steel (University of Canterbury)

Workshop details: International phylogeny meetings were held in Kaikoura in February 2003, Tongariro in February 2004, and Whitianga in February 2005.

Combinatorics and its Applications: This programme's major focus is on recent advances in combinatorics, with the aim of enhancing and developing linkages with the world's best combinatorial researchers, and applications to computational biology, complexity theory, theoretical computer science and abstract algebra.

Programme directors: Dr Paul Bonnington (Mathematics, University of Auckland) and Professor Geoff Whittle (Victoria University of Wellington)

Workshop details: An instructional workshop was held in Auckland in July 2004 and an international conference held at Taupo in December 2004.

Dynamical Systems and Numerical Analysis: This programme deals with the theory and applications of dynamical systems and the numerical analysis of differential equations, with particular attention paid to interactions between the two areas.

Programme directors: Professor Robert McLachlan (Massey University), Dr Vivien Kirk (Mathematics, University of Auckland), Dr Rua Murray (University of Waikato)

Workshop details: An international conference took place at Raglan in August 2004, and smaller workshops at Leigh in December 2004 and Palmerston North in December 2005.

Geometry and its Interactions with Algebra and Analysis: This programme is concentrating on recent developments in geometry and related areas of algebra and analysis, including geometric function theory, structure and classification of 3-manifolds, algorithmic and probabilistic group theory, and the “matrix recognition project”.

Programme directors: Professor Gaven Martin (Massey University) and Assoc. Prof. Eamonn O’Brien (Mathematics, University of Auckland)

Workshop details: A summer workshop was held at Napier in January 2005, an international conference in Auckland in February 2005, and smaller one-day workshops in Auckland in January 2005 and June 2005.

Hidden Markov Models and Complex Systems: Hidden Markov models form a remarkably general and elastic mathematical framework for modelling partially observed complex systems (in which observed data do not directly reflect the underlying dynamics). Recent developments allow model testing and parameter estimation to be carried out within certain classes. This programme aims to further extend and exploit these developments through applications to a range of problems of both local and international significance.

Programme director: Emeritus Professor David Vere-Jones (Victoria University of Wellington)

Workshop details: An international workshop took place in Wanaka in June/July 2005, and a second workshop in Wellington in December 2005.

Mathematical Models for Optimizing Transportation Services: This programme’s main focus is on fleet and crew planning under uncertainty, and revenue management, and the interface between mathematical optimization and its applications in practical situations. This is being enhanced by engaging the support and participation of industrial partners.

Programme directors: Professor Andy Philpott, Assoc. Professor Matthias Ehrgott and Professor David Ryan (Engineering Science, University of Auckland)

Workshop details: An international workshop took place in Auckland in April 2005.

Geometric Methods in the Topology of 3-Dimensional Manifolds: This programme (begun late 2005) is looking at 3-dimensional manifolds and especially the recent progress resulting from the use of geometry. A particular focus will be on the techniques and consequences of recent work on the geometrisation conjecture.

Programme director: Professor David Gauld (Mathematics, University of Auckland), Dr Roger Fenn (University of Sussex) and Professor Vaughan Jones (University of Auckland and University of California, Berkeley)

Workshop details: A workshop was organised for holding at Taipa in January 2006.

THEMATIC PROGRAMMES: RESEARCH PROGRESS

This section outlines in some detail the progress of the NZIMA's thematic research programmes, from those initiated in its first year of operation through to those which running for the first time in 2005.

➤ **Modelling cellular function** – Dr Nicolas Smith (University of Auckland) et al

This programme has focussed on development and use of analytic and computational models to characterise, simulate and elucidate the mechanisms of cell function. Most of the programme's activity took place in 2003 and 2004, except for postgraduate research projects (which have continued beyond the initial period of concentration).

Two **postdoctoral fellows** (Drs Matt Halstead and Edmund Crampin) have been involved, with funding from both the NZIMA and the Wellcome Trust (UK).

Research has involved the **development of a hierarchical modelling approach** that is consistent with the thermodynamic principles underlying energy supply and demand in the cell. This approach incorporates detailed biophysical information, while allowing simplification of the model to enable computer simulation of the heart.

Another aim of this programme has been to introduce and promote **CellML, a markup language**, which is used to describe mathematical models of cellular function. It is intended that CellML will provide the potential for increased involvement from the mathematical community in cellular modelling, by facilitating and accelerating the means of model exchange and reuse.

There have been four **graduate students** involved in this programme, with two still enrolled in PhDs. All students achieved excellent results in their postgraduate papers and thesis proposals. These students and their research projects are as follows:

Richard Faville (PhD student)	Electrophysiology of interstitial cells
Jack Lee (ME/PhD student)	Mechanisms of coronary autoregulation
Anita Lin (ME student)	Modelling electrical activity of the small intestine
Steven Niederer (ME student)	Modelling whole heart ischemia

For example, the aim of Richard Faville's PhD research is to develop detailed mathematical and computational models of the electrophysiology of the Interstitial Cells of Cajal (ICC) and smooth muscle cells of the stomach and small intestine.

Jack Lee's research has involved the construction of an appropriate theoretical model for simulating blood flow in large and small vessels, development of an efficient numerical scheme to allow its large-scale simulations, and characterization of the autoregulatory mechanisms. Since transferring to a PhD programme, he has worked towards establishing an image-processing algorithm to extract and reconstruct vascular network morphology from various sources of medical images. The outcome of this unique capability will allow the relationship between form and the function of coronary networks to be investigated. The development of this tool is nearing its final stage and full-scale processes are being attempted.

This programme generated further research activities and provided other opportunities to develop **new research relationships** with groups in Chicago, Kyoto, Oxford, Queensland, San Diego, Sheffield, Sydney and Utah. Other positive outcomes have been reported previously.

➤ **Logic and computation** – Prof. Rob Goldblatt (Victoria University of Wellington) et al

This programme has focussed on development and use of analytic and computational models to The central focus of this programme has involved research in the theories of computability and complexity, and the algorithmic study of randomness. The main activity for this programme took place in 2003 and 2004. A very successful workshop was held in January 2004, as previously reported. Several participants in the programme also took part in an international conference held at Victoria University of Wellington during February 2004 in cooperation with the Israel Mathematical Union and the New Zealand Mathematical Society. An additional International Workshop on Automata, Structures and Logic was held at Auckland in December 2004. This workshop attracted some of the top researchers from USA, Europe, Singapore, New Zealand, and Australia in the areas of logic, theoretical computer science and complexity.

Programme Director Rob Goldblatt has continued his general programme of studies of the theory of coalgebras, and well as of the model theory and algebraic analysis of modal logics. A highlight has been joint work with Prof Ian Hodkinson of Imperial College (also supported by the programme) and Dr Yde Venema of the University of Amsterdam, resulting in the **solution of a thirty-year old problem** concerning two conceptually different properties of logics that had been conjectured to be equivalent.

A major output from the programme is a collection of research papers published in a **special issue** of the top-ranking journal *Annals of Pure and Applied Logic* (Elsevier), guest-edited by Professors Rod Downey and Rob Goldblatt (Victoria University of Wellington). This will appear as Volume 38 of the journal in March 2006.

Dr Liang Yu was appointed to a two-year **postdoctoral fellowship** at Victoria University for the period 1 July 2003 to 30 June 2005, under the supervision of Prof Rod Downey. His tenure of this fellowship was very productive and included collaborations with a number of other researchers, proving significant results and solving open problems. He used complexity theory to characterise certain notions of randomness, applied the theory of randomness to study locally countable orderings on the reals, and investigated the initial segment complexity of random reals. He also obtained results in pure recursion theory about the structure of the ordering of the degrees of unsolvability. He has produced a substantial body of publications, which have been accepted for publication in high-ranking journals.

Two **Masters students** (David Friggens and Ranald Clouston) completed research theses under the supervision of Rob Goldblatt. These were the first enrolments at VUW for Masters in the subject Logic and Computation. Both were awarded the degree with Distinction.

- David Friggens developed a symbolic language for describing properties of coalgebras (which are mathematical systems that are used to model data structures, automata, and other state-based transition systems), and adapted methods from the proof theory of modal logic to construct certain final coalgebras, which play an important role in representing the possible behaviours of processes. David was awarded a VUW Postgraduate Scholarship and is now enrolled for a PhD in computer science.
- Ranald Clouston developed category-theoretic characterizations of certain important classes of coalgebras (behavioural covarieties) that are defined by properties that have computational significance. Ranald was subsequently awarded the very prestigious Woolf Fisher Scholarship, to study for a PhD at Cambridge University in the mathematical foundations of programming language semantics.

➤ **Numerical methods for evolutionary problems** – Prof. John Butcher (University of Auckland) et al

The principal aim of this programme has been to develop numerical methods for the solution of ordinary differential equations, delay differential equations and differential-algebraic equations, and special methods for problems that evolve on manifolds, within a geometric integration framework. The main programme activity took place in 2003. A follow-up meeting was held in Auckland in April 2004, and proceedings of that meeting will be published in *Applied Numerical Mathematics*, with guest editors John Butcher, Allison Heard and Helmut Podhaisky.

The **postdoctoral fellow**, Dr Helmut Podhaisky, has worked on a number of topics, including two-step W-methods for ordinary differential equations and parallel time integration, and the velocity of calcium waves. He has also played a central part in efforts to identify optimal methods in the new IRKS family and to find out how they should be implemented to produce computer algorithms which are competitive in terms of accuracy, efficiency and stability. He has maintained an active association with NZ, visiting most recently in September 2005. The influence of the programme has spread through him to his colleagues in Halle and he continues to work in both theoretical numerical analysis and in application areas, especially in biological modelling.

The programme's two **graduate students** have both completed their PhDs:

- Shirley Huang studied implementation questions for the special class of general linear methods that have the Inherent Runge-Kutta Stability (IRKS) property. In particular she explored possible predictors for the stages of stiff methods in this family. This is important from the point of view of obtaining robust and efficient stage calculations for the methods.
- Nicolette Rattenbury (née Moir) studied a generalization of Runge-Kutta methods known as “Almost Runge-Kutta” methods (ARK methods). Two of her notable contributions were the derivation of a special fourth order method that behaved numerically as though the order were five, if implemented in the right way, and the derivation of a new method for the solution of the important class of stiff problems.

Other research in this programme has led to the **construction of an experimental code** for “stiff” problems, using a more sophisticated criterion for stepsize and order based on optimisation principles. A very satisfactory by-product of experiments that use of this code leads to marked improvements in computational performance.

Programme director John Butcher was invited to give a main **plenary lecture** at SciCADE (the main international conference on Scientific Computation and Differential Equations) at Nagoya, Japan, in May 2005, where also the first winner of the John Butcher Award was announced — see below.

A visit by Tatiana Marquez Lago, sponsored by the NZIMA (as **winner of the inaugural John Butcher Award at SciCADE**), led to a workshop in December 2005, which was in effect a continuation of the programme but the subject was widened to include biomathematics as well as numerical analysis. Approximately 30 people took part and there was a full one-day schedule of 12 lectures. Participants from institutions outside Auckland included many from the Allan Wilson Centre, AgResearch Ltd, and the University of Queensland.

➤ **Phylogenetic genomics** – Prof. Mike Steel (University of Canterbury) et al

This programme has concentrated on the development of combinatorial methods to use new types of genomic data to infer evolutionary information. One of its goals was to bring together leading experts to investigate the following topical problem: How can new types of genomic data best be used to infer evolutionary information? This question involves many challenging combinatorial problems. The main activity for this programme took place in 2003 except for postgraduate research projects (which have continued beyond the initial period of concentration).

Two **postdoctoral fellows** were involved:

- Stefan Grunewald, who has developed new techniques for analysing reticulate evolution, and related combinatorial problems, and found a much sought-after, elegant and transparent proof of the Boecker-Dress phylogenetic patchwork theorem
- Magnus Bordewich, who (with Charles Semple) developed and published new results on super-tree theory, as well a far-reaching extension (with Mike Steel and Charles Semple) of an earlier result that prescribes precisely how many ‘characters’ are required to reconstruct a phylogenetic tree.

The programme brought in several **expert visitors**, including Professors Andreas Dress and Daniel Huson (Germany), Vincent Moulton, Katherina Huber, Johan Karström and Carl Masek (Sweden), Rod Smallwood (UK), and Peter Jarvis (Tasmania). The programme has also involved many other biological and mathematical scientists from within New Zealand.

Three **postgraduate students** were engaged in research projects:

Philip Daniel (MSc student)	Supertree methods: Some new approaches
Tobias Thierer (MSc student)	Generalized & directed characters in phylogenetics
David Phillips (MSc student)	Reconstructing hybrid phylogenies

Philip Daniel and Tobias Thierer have both completed their theses, and were both awarded an MSc with Distinction.

The key people involved in this programme participated (and helped to organise) the **annual NZ phylogeny workshop**, “Whitianga05”, held at Whitianga in February 2005. Also Mike Steel presented his work at two international conferences, at the MSRI (Berkeley) in March 2005, and the Institut Henri Poincaré (IHP) in Paris in June 2005. The speakers at the latter conference are contributing to a book titled “New mathematical models in evolution”, which is being edited by Olivier Gascuel and Mike Steel, and will be published by Oxford University Press in 2006.

Mike Steel continued his research in this area with support from a MacLaurin Fellowship in 2004.

In addition, he presented on the *Eureka!* Programme on National Radio in March 2005, at the RSNZ-sponsored *Dance of Mathematics* programme at Akaroa in May 2005, and on Maori Television’s *Cyberworld* programme in July 2005.

➤ **Combinatorics and its Applications** – Paul Bonnington (University of Auckland) and Geoff Whittle (Victoria University of Wellington) et al

This new programme began in the second half of 2004, with its major focus on major recent advances in combinatorics, and aiming to enhance and develop linkages with the world's best combinatorial researchers and their institutions. Additional points of focus are applications to computational biology, complexity theory and theoretical computer science.

The programme began with an **instructional workshop** held at Auckland in July 2004, in which a series of lectures was given on each of six key focus areas, by internationally recognised experts (from Australia, Canada, New Zealand and the USA).

The programme's main event was an **international conference** at Taupo in December 2004, held jointly with the Combinatorial Mathematics Society of Australasia's 29th Australasian Conference in Combinatorial Mathematics and Combinatorial Computing. This meeting was a great success, and widely regarded the most significant event worldwide in combinatorics for 2004, as well as being the largest pure mathematics conference to be held in New Zealand since 1978. The range and calibre of the invited speakers were outstanding, and are unlikely to be repeated anywhere in the foreseeable future. Over 150 participants from 19 different countries took part, including 39 students and other researchers from NZ.

Researchers Paul Bonnington, Bruce Richter, Mark Watkins, Dan Archdeacon, Bojan Mohar, Primož Potocnik, Jana Siagiova, Marston Conder and Jozef Siran have been collectively involved in at least **eight different projects** (working in small groups). These cover various topics on topics on fractal Cayley maps and more general embeddings of graphs and digraphs in surfaces, cycle spaces of infinite graphs, ends and fibres in infinite graphs, and graph labellings. Geoff Whittle has been involved in a number of different projects with local and overseas colleagues on properties of matroids, and on a significant project aimed at resolving Rota's Conjecture and the matroid well-quasi-ordering conjecture.

Two **postdoctoral fellows** were appointed to work in the programme, each for a one-year term at the University of Auckland from September 2004 to September 2005:

- Dr Jana Siagiova worked in 2004/0 on two related problems: the degree-diameter problem for graphs (networks having certain optimal communication properties), and the genera of particular families of Cayley maps. These projects are continuing, with the involvement of PhD student Eyal Loz and others at the University of Auckland
- Dr Primož Potocnik worked very productively on a number of questions concerning regular maps, Cayley graphs, and infinite transitive planar graphs. These projects are also continuing, with the involvement of Paul Bonnington, Marston Conder and Jozef Siran.

The programme has involved two **postgraduate students**:

- Robin Christian, who has begun a Masters thesis on "Induced non-separating cycles in highly-connected graphs"
- Eyal Loz, who has completed a Masters degree and is about to begin a PhD in aspects of structural graph theory.

The programme has had several **visitors**, including Professors Dan Archdeacon (Vermont), Jim Geelen (Waterloo, Canada), Bert Gerards (Eindhoven), Bojan Mohar (Ljubljana), Bruce Richter (Waterloo, Canada), Gordon Royle (Western Australia), Paul Seymour (Princeton), Carsten Thomassen (Copenhagen), Mark Watkins (Syracuse, New York), Dominic Welsh (Oxford).

➤ **Dynamical Systems and Numerical Analysis** – Prof. Robert McLachlan (Massey University) et al

This programme's focus is on the theory and applications of dynamical systems and the numerical analysis of differential equations, with particular attention being paid to the interaction between the two areas.

Its **main international conference** took place at Raglan in August 2004. The Raglan meeting had 55 participants from universities and research institutions in six countries. The 36 NZ participants came from six universities and from AgResearch. Plenary talks were given by Professors Alan Champneys (Bristol), Arieh Iserles (Cambridge), Edgar Knobloch (Leeds and Berkeley), Jeroen Lamb (Imperial College), and Andrew Stewart (Warwick).

A follow-up **workshop** was held in December 2004 at the University of Auckland's Leigh Marine Laboratory. A total of 32 people attended this meeting, with 11 from Australia, the UK and USA. Plenary talks were given by Professors Jerrold Marsden (Caltech), Jeroen Lamb (Imperial College) and Robert McLachlan (Massey University). Also series of 14 seminars was held at the University of Auckland during 2004, with participants from five NZ universities, and representation from five departments at the University of Auckland.

A **one-day conference** was held in July 2005 at the University of Auckland, and another in December 2005 at Massey University (as a **special session** of the 2005 New Zealand Mathematics Colloquium). In fact 22 of the Colloquium's 55 speakers requested to join the latter special session. In addition, the **Aitken Prize** for the best student talk at the Colloquium was awarded jointly to two of the session's student speakers: Elan Gin (University of Auckland) for her talk "Calcium waves and buffers", and Amanda Elvin (Massey University) for her talk "The role of gap junctions in a neural field model". These talks will be published in the NZ Mathematical Society Newsletter in 2006.

Dr Bart Oldeman was appointed as **postdoctoral fellow** at the University of Auckland, where he has been studying bifurcations in dynamical systems numerically, and developing algorithms to carry out such investigations. He has given research seminars at the four programme workshops, and at other conferences and universities, as well as helping local students graduate Elan Gin (MSc, Auckland), Mirela Domijan (MSc, Waikato) and Amanda Elvin (PhD, Massey, Albany).

A particular highlight of this programme has been the breadth and quality of **overseas experts** who have taken part in programme activities, including: Prof Alan Champneys (Bristol), Prof Arieh Iserles (Cambridge), Prof Edgar Knobloch (Berkeley), Dr Jeroen Lamb (Imperial College London), Prof Andrew Stuart (Warwick), Prof Jerrold Marsden (Caltech), and Prof. Reinout Quispel (La Trobe).

Three **postgraduate students** have been involved:

- Elan Gin has completed a Masters degree at the University of Auckland, with a thesis titled "A bifurcation analysis of calcium buffering", under the supervision of Dr Vivien Kirk
- Philip Zhang is undertaking a PhD at Massey University under the supervision of Prof. Robert McLachlan, on "Dynamics and numerics of generalized Euler equations"
- Mirela Domijan has completed a Masters degree at the University of Waikato, with a thesis titled "Dynamical probing of mechanisms underlying Calcium oscillations", under co-supervision by Dr Rua Murray (Waikato) and James Sneyd (Auckland).

➤ **Geometry: Interactions with Algebra and Analysis** – Prof. Gaven Martin (Massey University) et al

This new programme began at the end of 2004, with a significant emphasis on the interactions between three key areas of pure mathematics. One focus has been on geometric function theory and questions about the structure and classification of 3-manifolds. Another significant focus is on algorithmic and probabilistic group theory, with research contributing to the “matrix recognition project” — a major international research project that seeks to develop well-understood high-performance practical algorithms for the study of linear groups and their representations.

An **instructional workshop** on the interaction between analysis and geometry took place in Napier in January 2005. This featured lecture series from a group of distinguished international speakers, including Professors Ben Andrews (ANU), Craig Evans (Berkeley), Martin Liebeck (London), Alex Lubotzky (Jerusalem), Peter Jones (Yale) and Peter Sarnak (Princeton).

Professor John Conway (Distinguished John von Neumann Professor of Mathematics at Princeton) participated in the Napier meeting, and delivered a **public lecture** there titled “Winning ways: Beating children at their own games”. He was also a participant in the wider programme, when he was subsequently hosted for two weeks by the University of Auckland. On 27th January 2005, he gave **another public lecture** on “The Free-Will Theorem” to a very large audience. This was a fascinating account of joint work with his colleague, Simon Kochen (Princeton), taking three basic axioms about the universe, and proving that a consequence of these is that if even one person has “free will”, then ordinary particles must have it too. This event generated considerable media publicity for mathematics, attracting radio interviews and newspaper articles. He subsequently committed to visiting NZ for a few months every year, as a visiting Maclaurin Fellow of the NZIMA.

Also a **one-day workshop** was held at the University of Auckland in January 2005. It featured five one-hour lectures by speakers from Adelaide, Berkeley, Emory, Osaka and Princeton. Topics ranged from real and complex analysis, through geometry, to abstract algebra.

An **international conference** was held at the University of Auckland in February 2005. This focussed on the interaction between algebra and geometry, and attracted around 75 participants, including 25 students and staff from New Zealand universities. The conference featured 18 one-hour invited lectures, including speakers from Australia, Germany, Israel, the Netherlands, New Zealand, and the United Kingdom. The theme was interpreted broadly, and subjects covered included representation theory, profinite groups, projective planes, word-hyperbolic groups, and mappings between manifolds. Speakers included Professors Marston Conder (Auckland), Aimo Hinnkanen (Illinois), Bill Kantor (Oregon), Gus Lehrer (Sydney), Martin Liebeck (Imperial College, London), Colin Maclachlan (Aberdeen), Cheryl Praeger (Western Australia), Peter Schmid (Tübingen), and Akos Seress (Ohio).

A further **two-day workshop** was held at Massey University’s Albany campus in June 2005. This had nine speakers (from universities in Auckland, Canterbury, Melbourne, Otago and Sydney), and the workshop was well attended, attracting 25 participants from NZ universities.

Dr Richard Evans (the programme’s **postdoctoral fellow**) has been working productively on aspects of the tameness conjecture for hyperbolic 3-manifolds, and deformations of Kleinian groups. At the 2-day workshop mentioned above he outlined his very recent proof of a conjecture by Fields medallist Curt McMullen related to dynamical systems and deformation

spaces of hyperbolic 3-manifolds. In fact Evans has proved this conjecture for a large class of deformation spaces, generalising all previously known results about it, and he has presented this work as an invited speaker at an American Mathematical Society conference at the University of Michigan. Also he has proved an interesting theorem that describes “non-wrapping” of particular points in the boundary of a deformation space (in joint work John Holt, another former graduate of the University of Auckland), and has formulated an alternative and significantly simplified proof of a particular case of the “ending lamination conjecture” for 3-manifolds (recently resolved by Brock-Canary-Minsky).

Two **postgraduate students** have been involved so far, under the supervision of Eamonn O’Brien (at the University of Auckland):

- Tian Zhang (BSc (Hons) and Masters) has explored the use of “helper subgroups” in the development of new algorithmic techniques to improve the construction of equivalence classes of orbits under a group action
- Tara Bonda (BSc (Hons) and now Masters student) has commenced research on the use of coset diagrams to prove results about certain quotients of the modular group, seeking to complete a classification of these.

➤ **Mathematical Models for Optimizing Transportation Services** – Professor Andy Philpott, Assoc. Professor Matthias Ehrgott and Professor David Ryan (University of Auckland) et al

This programme commenced in 2005, when mathematicians, traffic modellers and operations research practitioners gathered for an **international workshop** in April at the University of Auckland. This workshop had over 80 registrations and was truly international in flavour, with participants and speakers from Australia, Canada, Chile, China, Denmark, Germany, India, Israel, the Netherlands, Norway, Singapore, Spain, Sweden, USA and New Zealand.

The theme of the workshop was “optimization of transportation services”, with a focus on three broad topics of major importance: transportation planning under uncertainty, optimizing the design of transportation systems, and pricing and revenue management. The workshop ran over four days with approximately half a day being devoted to each of the focus areas. A special session was also held on the use of modelling, optimization, simulation and other mathematical tools for improving the efficiency of emergency services (ambulance, fire, police).

A novel feature of the conference was the addition of two special **panel discussions** that were sponsored respectively by the dairy company Fonterra (New Zealand’s largest corporation) and the Auckland Regional Transport Authority (ARTA). The panel discussions were introduced and led by researchers at these organisations, who gave fascinating descriptions of their transportation issues. For example Fonterra must collect milk from 15,000 farms each day, a challenge for any vehicle routing software. A major issue debated by the panel was the effect of uncertainty on the routing techniques and how to accommodate these in planning robust schedules. The ARTA discussion was also lively with uncertainty in origin-destination forecasts emerging as a key concern for planners. The first day of the workshop was notable for a **public television appearance** by Mike Florian who was asked to comment in a broadcast interview about a hotly debated proposal to introduce tolled highways to Auckland. A clip of his interview can be downloaded from <http://www.esc.auckland.ac.nz/Transportation>.

The workshop has stimulated a number of **new research interactions**, and has encouraged a number of experts in the field to visit or return to New Zealand to work in this thematic area (such as Michael Trick, Professor of Operations Research at Carnegie Mellon University and former President of INFORMS).

Four **postgraduate students** have been engaged in this programme, and information on them follows below. A decision was made early on in the programme to involve additional research students in place of a postdoctoral fellow. All these students are enrolled in the Engineering Science Department at the University of Auckland.

- Hamish Sheild is working for a Masters degree on “Yacht match-race simulation under a spatial weather model”, under the supervision of Prof. Andy Philpott. He is using Valencia weather buoy data supplied by Emirates Team New Zealand to build a stochastic model of a varying wind field. This research is being carried out in collaboration with Prof. Shane Henderson at Cornell. The wind model will be used in simulations to assess the risk of different starting and routing strategies during the America’s Cup races in Valencia in 2007.
- Amir Joshan is undertaking a PhD under the supervision of Dr Golbon Zakeri, on the subject of “Airline network revenue management”. Working with data supplied by Air New Zealand, he is investigating models for airline revenue management that account for competition between airlines.

- Richard Lusby, another Masters student, is investigating “Routing trains through railway stations” under the supervision of Prof. David Ryan and Assoc. Prof. Matthias Ehrgott. The problem of routing trains through a railway junction is an integral part of railway operations, on strategic, tactical, and operational levels, and a novel approach to it is being taken by converting it to a set-packing problem, and then solving the dual.
- Andrea Raith is undertaking a PhD under the supervision of Matthias Ehrgott and Dr Judith Wang (Civil Engineering), on the subject of “Multiobjective transportation and routing problems”. The aim of her project is to study the mathematical structure of such multi-objective problems, and develop algorithms for their solution (for example, recognising the connection between repeated solution of constrained shortest path problems and the solution of their Lagrangian dual).

➤ **Hidden Markov Models** – Emeritus Prof. David Vere-Jones (Victoria University of Wellington)

This programme commenced mid-2005. Hidden Markov models (HMM) form a remarkably general and elastic framework for modelling systems through data that do not directly reflect the underlying dynamics.

Major activities during the year included two **workshops** — one in Wanaka (at the end of June and early July), and another in Wellington (in December 2005) — and a **seminar series** organised through the Victoria University of Wellington’s School of Mathematics, Statistics and Computer Science, during the 3-month period August to October 2005.

The underlying aim of these workshops was to bring together NZ-based researchers who use hidden Markov models in a range of contexts, to share their own expertise and to learn from overseas experts about recent developments. Both workshops attracted additional sponsorship (from AgResearch Ltd and Victoria University of Wellington respectively), and attracted over 30 researchers and students. The seminar programme was unexpectedly successful in attracting both speakers and audience. In addition, Peter Smith organised a statistical modelling session, which included HMM-related presentations by a number of participants.

Dr Peter Thomson (a key member of this programme) was invited to present the **2005 Knibbs Lecture** by the Canberra Branch of the Australian Statistical Association, and addressed them on hidden Markov models as a modelling vehicle, with particular reference to hidden Markov and semi Markov models for rainfall.

Two **postdoctoral fellows**, Dr Junko Murakami and Dr Pierre Ailliot, have been appointed, with Dr Ailliot’s position being funded jointly by NIWA. Both are working at Victoria University of Wellington (VUW). Dr Murakami is investigating particle filters and HMMs for earthquakes, and Dr Ailliot is studying multivariate HMMs for rainfall. Negotiations were started for a third postdoctoral fellow (to be funded jointly by VUW), but this possibility had to be terminated because of visa complications.

The programme involves two **postgraduate students** so far: Shaochuan Lv has recently begun a PhD at VUW, on the topic “HMM models for earthquake occurrence”, and Wang Ting, supported independently, is expected enrol at Massey University in 2006, for a thesis on “Robust geophysical modelling using HMMs”.

MACLAURIN FELLOWSHIPS & DIRECTORS' RESEARCH

Full-year Maclaurin Fellowships

- **Associate Professor Rod Gover** (Mathematics, University of Auckland) took up a year of full-time research in 2004 and completed this in early 2005. In joint work with overseas colleagues, he investigated several topics concerning conformal differential geometry and related structures. He spent the second half of his fellowship term mostly in Auckland, further developing and writing up collaborative and independent work.

Dr Gover's research was concentrated on two main (related) topics: "Gauge companion operators and Q-curvature" and "The ambient constructions and tractor calculus". The first has resulted in construction of a new class of invariant operators ("Q-operators", which act on closed differential forms and recover the celebrated Q-curvature as a special case), a new class of invariant elliptic differential complexes (called detour complexes) on curved conformal structures, and new differential complexes for fields satisfying the Yang-Mills equations. The second has established a new characterisation of the Fefferman metric (in joint work with Andreas Čap (Vienna)), and a new construction of Laplacian type conformally invariant differential operators on Einstein manifolds, among other things.

- **Prof. Mike Steel** (University of Canterbury) also took up a year of full-time research in 2004 and completed this in early 2005. The objective of his research was to apply techniques from the study of random discrete structures to the analysis of maximum likelihood (and information-theoretic results for evolutionary reconstruction under general Markov processes), to outstanding questions related to random autocatalytic networks (which have been studied in origin of life models), and to stochastic models for tree shape.

He made considerable progress on all of these, partly in collaboration colleagues in the US and NZ. One significant outcome has been a new Ramsey-theoretic fact about trees, and an application of this to establish the sequence length required to distinguish (with high probability) the 'true' tree from a rival tree, showing that a constant sequence length suffices — independent of the size of the tree. Another two were the development of a new and simple greedy algorithm for maximizing phylogenetic diversity (and extensions of it), and development of theory that explains a characteristic concave relationship in the decay of phylogenetic diversity as species go extinct under various scenarios. His new student (Klaas Hartmann) is working on a PhD thesis will develop these ideas further.

- **Prof. Robert McLachlan** (Massey University) was appointed as a Maclaurin Fellow for a 12-month period from early 2005. His research has focussed on a range of topics associated with his main field of expertise, namely geometric integration.

One such topic has been the study of foliations and diffeomorphism groups, in which he has developed theory of a vector field preserving the foliations induced by two or more subgroups of a Lie group action. Another has involved joint work with others on 'explicit integrators', in which he has successfully explored splitting methods for volume-preserving systems, producing many interesting new results and applications. Also he has investigated generalized Euler equations (partial differential equations that describe the geodesics on

diffeomorphism groups with respect any left-invariant metric), considering various metrics on $\text{Diff}(\mathbb{R})$ and $\text{Diff}(\mathbb{R}^2)$, and in work with students, has undertaken research on variable time steps for N-body simulations (such as the solar system), and on splitting methods for systems of coupled $\text{SO}(3)$ spins, which arise in several branches of physics.

Short-term Visiting Maclaurin Fellowships

- Prof. **Martin Liebeck** (Imperial College London) was appointed as a Visiting Maclaurin Fellow for a 6-week period beginning January 2005. Professor Liebeck took part in the workshop and conference associated with the NZIMA's thematic programme on Geometry: Interactions with Algebra and Analysis, and also gave lectures at the University of Auckland, where he worked with Assoc. Professor Eamonn O'Brien) and others on the development of algorithms to determine the characteristic of a group of Lie type, and related problems.
- The NZIMA also appointed Prof. **Jonathan Borwein** (Dalhousie University, Canada) as a Visiting Maclaurin Fellow for 2004/2005, but he was unable to visit because of unforeseen additional commitments and he will visit at a later date. Professor Borwein is a leading international researcher in the fields of non-smooth analysis and optimisation.
- Professors **Hyman Bass** (Professor of Mathematics Education and Roger Lyndon Professor of Mathematics at the University of Michigan) and **John Conway FRS** (John von Neumann Distinguished Professor of Mathematics at Princeton University) have been appointed Visiting Maclaurin Fellows for 2006. Hyman Bass is a highly distinguished mathematician, known recently for ground-breaking research on the mathematics content knowledge of teachers and its relevance to teacher education John Conway is one of the world's most illustrious mathematicians, and an excellent public speaker. He has made profound and major contributions to geometry, group theory, knot theory, number theory, combinatorial game theory and coding theory, and has been the recipient of a significant number of awards and prizes for both mathematics and mathematical exposition.

Directors' Research

- **Prof. Marston Conder** has been furthering his research (supported by the Marsden Fund and in 2005 also by a Hood Fellowship) in combinatorial and computational group theory, with applications to the study of discrete objects with maximum symmetry.

Particular **highlights** have been his construction of the first known 5-dimensional chiral polytopes having maximal symmetry (without any reflections), construction of short-length presentations for alternating and symmetric groups (in joint work with Charles Leedham-Green (London) and Eamonn O'Brien (Auckland)), and development of a new classification of finite 3-valent symmetric graphs according to the types of arc-transitive groups they admit (in joint work with Roman Nedela (Slovak Academy of Sciences)).

In addition, in joint work with Vaughan Jones he has found a **surprising connection** between imprimitive permutation groups of small rank related to intermediate subfactors of von Neumann algebras and finite projective planes.

- **Prof. Vaughan Jones** has been continuing his investigations into a foundational question in quantum mechanics and the study of pairs of intermediate subfactors of type II factors.

The **quantum mechanics** question is the Hilbert space description of two highly entangled quantum systems. If the degree of entanglement is extremely high, then certain observables on one system could become identical to observables on the other. This suggests a 'relative' tensor product, and he is examining the use of the Connes tensor product of Hilbert spaces over a von Neumann algebra. Circumstantial evidence comes from Chern-Simons gauge field theory and many 2-dimensional lattice models. The following is an important test question: accepting the correctness of the usual tensor product as a description of the quantum states of the union of two systems, a highly entangled system must have somehow evolved from an ordinary union. This means that the coefficients in the Connes tensor product should be asymptotic to coefficients in an ordinary tensor product. This can be made into a precise mathematical conjecture whose proof would strongly support, and indicate how to use, the Connes tensor product in quantum theory.

Intermediate subfactors exhibit an extraordinarily rich structure. They include as special cases subgroups of groups, intermediate subgroups of groups, certain subalgebras occurring in representations of compact groups and many 'sporadic' examples from conformal field theory. With Feng Xu, Vaughan Jones recently showed that the intersection of a family of finite index subfactors has finite index if and only if the algebra generated by the projections onto them is finite dimensional; this extends a result in Galois theory. His main effort, however, is in the systematic classification of pairs of intermediate subfactors and the angles between them (building on old work with Bisch on the case of a single intermediate subfactor). The situation appears to be quite rigid and he has shown (with his student Grossmann) that there are only two examples where the intermediate subfactors themselves have no extra structure. One is from group theory and thus has integer index, and the other involves the "GHJ" subfactor construction and has index $2(2+\sqrt{2})$. This led to some conjectures about the group case, and the joint work with Marston Conder reported above.

POSTGRADUATE STUDENT RESEARCH

- Each of our **thematic programmes** has a number of postgraduate research students engaged in it, and their research is reported earlier under “Thematic programmes”. Typically, each programme involves up to three Masters or PhD students, some of who hold Top Achiever Doctoral Scholarships or other scholarships, alongside others who are supported by the NZIMA, and many more who take part in the programme’s main conference or workshop.
- In addition, the following postgraduate students are undertaking research projects sponsored by the NZIMA (on a merit basis):
 - **Zhaojing (Jean) Gong** has been undertaking a PhD in **medical statistics** at the University of Canterbury. She has completed work on various models (including the Causal Cox Model (CCM), the Bayesian Causal accelerated Failure time model (BC-AFT)), and the mathematical formulation for the EM-Survival Models (allowing non-compliance), plus application to HIP data. In July she gave presentation her research at the New Zealand Statistical Association (NZSA) conference in Dunedin and the 20th International Workshop on Statistical Modelling (IWSM) in Sydney.
 - **Garry Nathan** recently completed an MA with First Class Honours in Mathematics Education. His thesis studied **students’ conceptions of calculus** at the Year 13 Secondary School level, and at first year level of University mathematics. It identified and interpreted key influences that contributed to students' conceptions of calculus, as well as the robust nature of these conceptions. Garry has now enrolled for a PhD at the University of Auckland. In his PhD project he will examine the **form and structure of students’ mathematical argumentation** in tertiary level mathematics. An anticipated outcome of this research is that it will continue to inform the development of tertiary mathematics programmes, and identify pedagogical approaches that encourage mathematical reasoning, argumentation, and proof.
 - **Tissa Senanayake** is undertaking a PhD in **magnetohydrodynamics** at the University of Waikato, investigating the reconnection rate and eigenfunction description of a disturbed X-type neutral point configuration with the effect of Hall current. Results have been obtained numerically, and their general validity checked by comparing them to previous work by Craig and Watson (1992). He has completed a part of his draft thesis and is continuing further analytical works related to viscous, Hall and inertial effects of the hear wave dissipation in planar magnetic X-point.
 - **Josef Silhan** is enrolled for a PhD in **differential geometry** at the University of Auckland. The research is finished and he is currently working on the final version of his PhD thesis (with submission expected in March 2006). The main goal of Josef’s study was the construction of invariant differential operators, in the setting of conformal geometry. The results of his work on the conformal Killing operator on forms have revealed a new approach to the study of solutions of conformal operators.
 - **Adam Smith** is engaged in a Masters thesis project at the University of Auckland (from July 2005) on the **statistical validation of the NZ Marine Environment Classification**, under the supervision of Drs Marti Anderson and Clinton Duffy (from the department of Conservation).

- **Krasimira Tsaneva-Atanasova** completed a PhD in 2004 at the University of Auckland, in **cell modelling**. During the year she completed her bifurcation analysis of the point coupled model system of three oscillators, and also spent two months visiting the Mathematical Biosciences Institute (MBI) at Ohio State University, USA. During her visit she participated in MBI workshops and attended seminars and discussions. Also during her stay in the USA she visited David Yule's lab in the School of Medicine and Dentistry at the University of Rochester, NY. All the work for her PhD was done in close collaboration with this group and it was a great experience for her to visit them. In June 2004, Krasimira was awarded a postdoctoral fellowship with the NIH Visiting Program at the Laboratory of Biological Modelling, National Institute of Diabetes and Kidney Diseases, USA, and took this up towards the end of 2004.

- The NZIMA has continued to lend its support to **research projects in Industrial Mathematics**. Five students were supported during 2004 and 2005, as follows:
 - **Jae-Hoon Chung** (University of Auckland), project in **modelling of breast deformation** during X-ray (mammographic) and MRI imaging
 - **Jack Lee** (University of Auckland), project in **modelling vasoregulatory mechanisms**
 - **Steven Niederer** (University of Auckland), project in **modelling whole heart ischemia**
 - **Kirk Spragg** (University of Waikato), project in **metallurgic applications of magnetohydrodynamics**
 - **Asher Treby** (University of Auckland), project on **simulation modelling of TranzRail's freight network and terminal operations**.

CONFERENCES AND VISITORS

The NZIMA used its CoRE funding and status to lend support to the following **conferences held in New Zealand** in 2004/05:

- In August 2004 around 60 mathematicians, physicists and astronomers from around the world gathered in Christchurch to celebrate the **70th birthday of Emeritus Professor Roy Kerr, and his solution of Einstein's equations describing the space outside a rotating star or black hole**. A special commemorative volume based on the plenary lectures at this Kerr Fest is to be published in 2005 by Cambridge University Press. Also it was announced at the meeting that Roy Kerr will receive the Grossmann Award at the next Marcel Grossmann Meeting in St Petersburg in 2006; in place of a medal, recipients (who in the past have included Stephen Hawking and Roger Penrose) receive the TEST sculpture, which is a representation (cast in silver) of particle motion in the vicinity of a Kerr black hole.
- The **International Conference of Bioinformatics (InCoB)** was held in Auckland in September 2004. This is the official conference of APBionet, and in total 140 international delegates attended. The programme itself was divided into sessions on Genome Bioinformatics, Applied Bioinformatics, Evolutionary Bioinformatics, Biomedical Bioinformatics, Biodiversity Bioinformatics, Microarray and Proteomics, Phylogenetics, and Rapidly Evolving Pathogens and Platforms and Applications. Sponsorship from the NZIMA was used to bring two distinguished scientists to the conference — Professors Robert Gentleman (Harvard) and Terry Speed (Berkeley) — who presented their research in the session on Microarrays and Proteomics and discussed possibilities for future collaboration. Preceding this conference, a workshop on parallel computing was held at the Albany Campus of Massey University, hosted by the Allan Wilson Centre for Molecular Ecology and Evolution (another CoRE) and the University of Auckland's Bioinformatics Institute.
- In October 2004 the NZIMA arranged a **special screening of the 30-minute video “porridge, pulleys and Pi: two mathematical journeys”** (produced by the Mathematical Sciences Research Institute, Berkeley) and short lectures by the NZIMA's current Maclaurin Fellows, Dr Rod Gover (Auckland) and Prof. Mike Steel (Canterbury). The MSRI video gives a portrait of Vaughan Jones (Co-Director of the NZIMA) and Hendrik Lenstra, offering insights to their work, their backgrounds, their personalities and interests, and some of the impact of their research in mathematics, physics, cryptography and molecular biology. Rod Gover and Mike Steel described some of their recent work in differential geometry and phylogenetics (respectively). The evening was a great success, and attended by around 60 people.
- An **international conference “VIC2005”** was held in Wellington in February 2005, with the themes of non-commutative geometry, quantum groups and representation theory. Fifteen participants (including nine speakers) from Europe, China, Israel and New Zealand attended this successful two day meeting.
- A **conference on “Approximation and Harmonic Analysis”** was held in Auckland in February 2005. Speakers and other participants came from Australia, Canada, Hungary, Israel, Korea, Singapore, United States of America, and New Zealand.

- A **workshop on “Data Analysis and Statistical Learning”** was held in Hamilton in March 2005, partly to honour a visit by Professor Calyampudi R. Rao, Eberly Professor Emeritus of Pennsylvania State University, one of the world’s leaders in statistical science over the last six decades. Professor Rao gave a plenary lecture, and others were given by Professors Shayle Searle (Cornell), Eugene Seneta (Sydney) and George Seber (Auckland). This workshop involved 19 invited lectures and 13 contributed papers, with 48 participants from 14 different countries (NZ, Australia, Canada, China, England, Estonia, Finland, Germany, Israel, Japan, South Africa, Spain, Ukraine, and the USA).
- A **conference on “Sampling and Missing Data”** was held in Auckland in April 2005 to celebrate the career of one of New Zealand's foremost mathematical scientists, Professor Alastair Scott, and to advance research in areas where he has made his greatest contribution. The conference addressed problems which are important in many areas of scientific inquiry, and brought together in New Zealand the largest concentration of first-rank international statisticians in one place at one time for a considerable period.

The NZIMA also sponsored the following **visitors to New Zealand** in 2004/05:

- **Dr Daryl Daley (Centre for Mathematics & its Applications, Canberra)** came to work with Prof. David Vere-Jones (Victoria University of Wellington) on a monograph and also participate in a workshop on “Point Process Models in Reliability” in Wellington in September 2004.
- **Professor Peter Kuchment (Texas A&M)**, in December 2005. Professor Kuchment is an expert on quantum graphs, a rapidly growing subject on the border between the theory of differential operators, combinatorics and mathematical physics. He gave an invited lecture at the 2005 NZ Mathematics Colloquium, and another lecture at the University of Auckland, where he interacted with Professor Boris Pavlov and colleagues.
- **Tatiana Marquez Logo, winner of the inaugural John Butcher Award** (see “Awards and Honours” below), in December 2005. Tatiana gave an invited lecture at the 2005 NZ Mathematics Colloquium, and also took part in a workshop at the University of Auckland organised by John Butcher and his research group.

AWARDS AND HONOURS

The following is a selection of awards and honours won by people involved with the NZIMA over the 18-month period from July 2004 to December 2005:

- An annual award (called the “**John Butcher Award**”) has been established to recognise Professor John Butcher's long and productive career in numerical analysis, and in particular in the numerical solution of ordinary differential equations. The inaugural award (for 2005) was won by Tatiana Marquez Lago (of the University of New Mexico) for her talk “Numerical estimation of progesterone transcriptional activity in the ERB1 pathway using Chemcell” at the SciCADE 2005 conference held in Nagoya, Japan, in May 2005.
- Ranald Clouston (a Masters student on the NZIMA’s Logic and Computation programme) has been awarded a **Woolf Fisher Scholarship**, one of only three awarded annually, and this will provide Ranald with full financial support for three years of doctoral research at Cambridge University (UK).
- Prof. Marston Conder (NZIMA Co-Director) was elected **President-Elect of the Academy of the Royal Society of New Zealand**, made a **Fellow of the Institute of Combinatorics & its Applications (ICA)**, made an **Honorary Life Member of the NZ Mathematical Society**, and awarded one of the University of Auckland’s first **Hood Fellowships** in 2004.
- Prof. Rod Downey (Governing Board member and Maclaurin Fellow for 2003) was made a **life member of the Combinatorial Mathematical Society of Australasia**
- The **Aitken Prize** for best student talk at the NZ Mathematics Colloquium was awarded jointly to two speakers, from the NZIMA programme on Dynamical Systems: Elan Gin (University of Auckland) for her talk “Calcium waves and buffers”, and Amanda Elvin (Massey University) for her talk “The role of gap junctions in a neural field model”. Also Dion O’Neale (another participant in Dynamical Systems programme) was given an honourable mention for his talk “Geometric integration for a two spin system”.
- Rob Goldblatt (Director of the NZIMA's Programme in Logic and Computation) has been made an **Honorary Life Member of the NZ Mathematical Society**, and has been appointed **Coordinating Editor of the *Journal of Symbolic Logic***.
- Bakh Khoussainov (a key member of the NZIMA programme on Logic and Computation in 2003/04) was elected **Fellow of the Royal Society of New Zealand** in November 2005.
- Gaven Martin (a member of the NZIMA's Governing Board and Co-Director of the NZIMA’s Geometry programme) has been appointed **Managing Editor of the American Mathematical Society’s journal *Conformal Geometry and Dynamics***, and elected **President of the NZ Mathematical Society** for a 2-year term.
- Robert McLachlan (Maclaurin Fellow and director of the NZIMA programme on Dynamical Systems and Numerical Analysis) won the **Massey University Research Medal** for 2005.
- Professor Robert McLachlan (Maclaurin Fellow and director of the NZIMA programme on Dynamical Systems and Numerical Analysis) and Professor James Sneyd (a member of the NZIMA's Governing Board and a key member of the NZIMA programme on Modelling Cellular Function) were **joint winners of the NZ Mathematical Society's Research Award** for 2005.

- Eamonn O'Brien (Co-Director of the NZIMA's Geometry programme) has been appointed to the **Editorial Board of the prestigious *Journal of Algebra***. He also won the **NZ Mathematical Society's Research Award** for 2004, for his work in computational algebra
- James Sneyd (a member of the NZIMA's Governing Board and a key member of the NZIMA programme on Modelling Cellular Function) was elected a **Fellow of the Royal Society of New Zealand** in November 2005.
- Krasimira Tsaneva-Atanasova (former NZIMA scholar) has been appointed to a **postdoctoral fellowship at the US National Institutes of Health (NIH)**, to work in the Laboratory of Biological Modelling, Washington DC.

In addition to these, the NZIMA received a very complimentary mention in the April 2004 newsletter of The London Mathematical Society, in a report prepared by Professor Caroline Series on her time in New Zealand as a Forder Lecturer. A full copy of this commentary can be found at <http://www.lms.ac.uk/newsletter/325/325main.html> on the page "Reports and Records of Society Meetings".

INTERNATIONAL LINKAGES

- The NZIMA is a member of the **International Mathematical Sciences Institutes (IMSI)**, an international consortium of research institutes in the mathematical sciences that run thematic programmes and have large visitor programmes, and is listed on the IMSI website
<http://www.fields.utoronto.ca/aboutus/IMSI.html>
- Communication linkages with such institutes overseas have been set up through **visits** by one or both of the two Co-Directors (often while attending other conferences). These include the Fields Institute in Ontario, the Mathematical Sciences Research Institute (MSRI) in California, and the Pacific Institute of Mathematical Sciences (PIMS) in British Columbia. In particular, Marston Conder visited PIMS in October 2005 — see also the establishment of “PRIMA” below.
- Very strong international linkages have been developed by the NZMRI through its earlier **programme of annual summer workshops**, and these are being taken further by the involvement of **invited overseas experts** in NZIMA programmes and as visiting MacLaurin Fellows. The NZIMA’s **website** and the **quarterly NZIMA newsletter** (sent to a large number of people overseas) are proving useful devices for maintaining and enhancing international contacts.
- Overseas visiting experts in 2004 included Dan Archdeacon (Vermont), Rosemary Bailey (London), Michael Baines (Reading), Walter Bossert (Montreal), Richard Brualdi (Wisconsin), Darryn Bryant (Queensland), Peter Cameron (London), Alan Champneys (Bristol), Maria Chudnovsky (Princeton), Bruno Courcelle (Bordeaux), Joe Flaherty (Rensselaer Polytechnic Institute), Takeo Fujihira (Imperial College), Jim Geelen (Waterloo), Bert Gerards (Eindhoven), Sergei Goncharov (Novosibirsk State University), Catherine Greenhill (UNSW), Ian Hodkinson (Imperial College), Arie Iserles (Cambridge University), Carl Jockusch (Illinois at Urbana-Champaign), Alice Jukes (Imperial College), Edgar Knobloch (Leeds), Dexter Kozen (Cornell University), Jeroen Lamb (Imperial College), Steffen Lempp (Wisconsin-Madison), Jerrold Marsden (Caltech), Bojan Mohar (Ljubljana), Herve Moulin (Rice University), James Oxley (Louisiana), Reinout Quispel (LaTrobe), Bruce Richter (Waterloo), Neil Robertson (Ohio State), Gordon Royle (UWA), Paul Seymour (Princeton), Alan Sokal (New York), Andrew Stuart (Warwick), Yajuan Sun (LaTrobe), V.S. Sunder (Institute of Math. Sciences, Madras), Robin Thomas (Georgia), Carsten Thomassen (Denmark), Priscilla Tse (LaTrobe), Tom Tucker (Colgate, NY), Mark Watkins (Syracuse University, NY), Dominic Welsh (Oxford), Zahari Zlatev (National Environmental Research Institute, Denmark).
- Overseas visiting experts in 2005 included Ben Andrews (Canberra), Mark Berman (CSIRO), Emery Brown (MIT/Harvard), Roger Bryant (Manchester), Peter Clifford (Oxford), Arjeh Cohen (Eindhoven), John Conway (Princeton), Craig Evans (Berkeley), Peter Fleischmann (Kent), Michael Florian (Montreal), Michel Gendreau (Montreal), Marcel Herzog (Tel Aviv), Bob Howlett (Sydney), Huei Chuen Huang (Singapore), Ellis Johnson (Georgia), Peter Jones (Yale), William Kantor (University of Oregon), Anton Kleywegt (Georgia), Laszlo Kovacs (ANU), Gilbert Laporte (Montreal), Gus Lehrer (Sydney), Martin Liebeck (Imperial College), Alex Lubotzky (Jerusalem), Colin Maclachlan (Aberdeen), Oli Madsen (Denmark), Chuck

Miller (Melbourne), Anna Nagurny (Massachusetts), Paul Norbury (Melbourne), Cheryl Praeger (UWA), C.R. Rao (Penn State), Lawrence Reeves (Melbourne), Dale Rolfen (UBC), Werner Romisch (Berlin), Garret van Ryzin (Columbia, NY), Peter Sarnak (Princeton), Peter Schmid (Tübingen), Anita Schöbel (Göttingen), Carlo Scoppola (Rome), Akos Seress (Ohio State), Rolf Turner (New Brunswick), Hal White (San Diego).

- These linkages are also being maintained through the NZIMA's **International Scientific Advisory Board**, which includes a number of representatives from other members of the IMSI (such as the CMA, MSRI and PIMS), as well as prominent New Zealand-born mathematical scientists and others resident overseas.
- Marston Conder and Vaughan Jones were invited by the directors of the MSRI (Berkeley) and PIMS (Canada) to take part in a Pacific Rim Mathematical Forum at the Banff International Research Station (BIRS) in October 2005. Marston Conder attended, and gave a short presentation on the NZIMA. Also he had helpful discussion with representatives of AIM (the American Institute of Mathematics), AMSI (the Australian Mathematical Sciences Institute), IMS (the Institute of Mathematical Sciences in Singapore) and PIMS.

A principal outcome of this meeting was a decision to establish a **Pacific Rim Mathematical Association** (otherwise known as 'PRIMA'), with the aim of promoting and facilitating the development of the mathematical sciences throughout the Pacific Rim region. It is intended that this will involve improved networking, coordination of activities, training (including summer schools), infrastructural assistance, sharing of expertise, pooling of resources etc. More information about PRIMA and its intended activities can be now be found on its website <http://www.primath.org/>. One forthcoming likely initiative is a Pacific Rim Mathematical Congress, to be held in 2008 or 2009. The NZIMA is a founding member of PRIMA, and Marston Conder has been invited to join the Liaison Committee of this new organisation.

PUBLICATIONS

The following give a selection of publications by researchers either supported or stimulated by (or otherwise involved with) the NZIMA's activities during 2004 and 2005. Note that the 2004 list contains some of the publications listed in the NZIMA's annual report for the 2003/04 financial year.

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FINANCIAL REPORT

This is a limited report on the financial performance and financial position of the NZIMA, covering only the activity supported by the award to it from the NZ government's Centres of Research Excellence (CoRE) Fund. Because of the change in reporting cycle, it comes in two parts: the first part for the 12-month period 1 July 2004 to 30 June 2005, and the second for the 12-month period 1 January 2005 to 31 December 2005.

Statement of Financial Performance for the 2004/05 financial year

Income	Actual	Budget	Variance
CoRE Funding	\$ 1,631,111	\$ 1,631,111	\$ 0
Host/Partner Support	30,716	37,990	(7,274)
Total Income	\$ 1,661,827	\$ 1,669,101	\$ (7,274)
 Expenditure	 Actual	 Budget	 Variance
<i>Salaries</i>			
Director & Principal Investigators	\$ 62,473	\$ 78,000	\$ 15,527
Associate Investigators	104,503	190,000	85,497
Postdoctoral Fellows	281,087	208,000	(73,087)
Research/ Technical Assistants	0	0	0
Others	26,236	23,400	(2,836)
<i>Total Salaries (a)</i>	<i>\$ 474,299</i>	<i>\$ 499,400</i>	<i>\$ 25,101</i>
<i>Other Costs</i>			
Project Costs	\$ 238,859	\$ 109,200	\$ (129,659)
Postgraduate Student Support	208,777	333,311	124,534
Travel	138,542	104,000	(34,542)
Indirect Costs: Overheads	283,001	499,400	216,399
Equipment depreciation	657	37,990	37,333
Rental - equipment	34,563	65,000	30,438
Subcontractors	0	0	0
Extraordinary expenditure	0	20,800	20,800
<i>Total Other Costs (b)</i>	<i>\$ 904,398</i>	<i>\$ 1,169,701</i>	<i>\$ 265,303</i>
Total Expenditure	\$ 1,378,697	\$ 1,669,101	\$ 290,404
 <i>Operating surplus for year</i>	 <i>\$ 283,130</i>		
<i>Surplus carried fwd from 30 June 2004</i>	<i>1,029,641</i>		
Nett Surplus (committed forward)	\$ 1,312,771		

Notes:

1. Host/Partner support lower than budgeted because University of Auckland did not charge the NZIMA for depreciation on capital equipment
2. Overall expenditure lower than budget because of phasing of student scholarships and other timing issues for thematic programmes.

Statement of Financial Performance for the 2005 year

Income	Actual	Budget	Variance
CoRE Funding	\$ 1,223,333	\$ 1,631,111	\$ (407,778)
Host/Partner Support	12,653	37,990	(25,337)
Total Income	\$ 1,235,987	\$ 1,669,101	\$ (433,114)
Expenditure	Actual	Budget	Variance
<i>Salaries</i>			
Director & Principal Investigators	\$ 70,488	\$ 78,750	\$ 8,262
Associate Investigators	90,533	191,900	101,367
Postdoctoral Fellows	223,937	210,000	(13,937)
Research/ Technical Assistants	0	0	0
Others	17,513	23,625	6,112
Total Salaries (a)	\$ 402,471	\$ 504,275	\$ 101,804
<i>Other Costs</i>			
Project Costs	\$ 222,528	\$ 110,250	\$ (112,278)
Postgraduate Student Support	234,845	321,311	86,466
Travel	98,870	105,000	6,130
Indirect Costs: Overheads	311,938	504,275	192,337
Equipment depreciation	492	37,990	37,498
Rental - equipment	4,804	65,000	60,196
Subcontractors	0	0	0
Extraordinary expenditure	0	21,000	21,000
Total Other Costs (b)	\$ 873,477	\$ 1,164,826	\$ 291,349
Total Expenditure	\$ 1,275,948	\$ 1,669,101	\$ 393,153
Operating deficit for year	\$ (39,961)		
Surplus carried fwd from 31 Dec 2004	1,058,016		
Nett Surplus (committed forward)	\$ 1,018,055		

Notes:

1. CoRE Funding lower than budgeted because of delayed timing of final quarterly payment
2. Host/Partner support lower than budgeted because University of Auckland did not charge the NZIMA for depreciation on capital equipment
3. Overall expenditure lower than budget because of phasing of student scholarships and other timing issues for thematic programmes.

Statement of Financial Position as at 31 December 2005

The (limited) assets of the NZIMA are property of the University of Auckland and are treated as part of the University of Auckland's accounts, so there is nothing to report here that is not covered by the above statements of financial performance.

CONTACT DIRECTORY

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URL: <http://www.nzima.auckland.ac.nz>

APPENDIX 1: AIMS AND STRUCTURE OF THE NZIMA

The New Zealand Institute of Mathematics and its Applications (NZIMA) was established in 2002 as one of the five Centres of Research Excellence selected by the New Zealand government in March 2002. It is hosted at the University of Auckland and headed by Fields Medallist and Distinguished Alumni Professor Vaughan Jones *DCNZM DSc FRS FRSNZ* (Berkeley) and Professor Marston Conder *DSc FRSNZ* (Auckland), with involvement of many of the best pure and applied mathematicians and statisticians from across the country.

The principal aims of the NZIMA are to

- create and sustain a critical mass of researchers in concentrations of excellence in mathematics and statistics and their applications
- provide NZ with a source of high-level quantitative expertise across a range of areas
- facilitate access to new developments internationally in the mathematical sciences, and
- raise the level of knowledge and skills in the mathematical sciences in N.Z.

It is modelled on similar mathematical research institutes in other countries, notably the Fields Institute (Canada), MSRI (Berkeley), and the Newton Institute (UK). In particular, it places considerable emphasis on world-class research in fundamental areas of the mathematical sciences and the use of high-level mathematical techniques in modern application areas such as bioengineering, bioinformatics, medical statistics, operations research, and risk assessment.

Its key activities include

- the organisation of 6-monthly programmes on themes drawn from a range of fields of significant interest
- associated workshops held at various locations around NZ
- establishment of postdoctoral fellowships in the theme areas
- establishment of PhD and/or Masters degree postgraduate scholarships in the theme areas
- establishment of a small number of merit-based open scholarships for research students (from New Zealand or worldwide) in unrestricted areas of the mathematical sciences
- establishment of annual Maclaurin Fellowships (*), to enable mathematical scientists from NZ or worldwide to take time out from their usual occupations and undertake full-time research in New Zealand (or partly overseas if based in New Zealand).

(* Richard Cockburn Maclaurin was a graduate of Auckland University College who went on to study at Cambridge, where he won the Smith Prize in Mathematics and Yorke Prize in Law, and was appointed as Foundation Professor of Mathematics at Victoria University College in 1899, and later Dean of Law and Professor of Astronomy. In 1908 he was invited to become President of the Massachusetts Institute of Technology (MIT), and helped transform that institution into the world-class research-based technological university it is today.)

The NZIMA was formally established in June 2002 as a partnership between the University of Auckland (its host) and the N.Z. Mathematics Research Institute (NZMRI). The NZMRI is an incorporated society, which for the last ten years has organised summer meetings in New Zealand on particular topics of contemporary significance in mathematics, with support from the Marsden Fund and contributions by individuals (from N.Z. and overseas) and by mathematics and statistics departments at N.Z. universities. The NZIMA is building on this activity.

Governing Board

The NZIMA is overseen by a *Governing Board*, with seven members appointed by each of the University of Auckland and its partner organisation the NZMRI (Inc.), and has an independent chairperson. The Governing Board's responsibilities are to oversee the Institute's activities and finances and ensure that it is meeting its responsibilities under the terms of the joint venture agreement and those of the Centres of Research Excellence Fund.

In particular, the Governing Board will help formulate the research strategy of the NZIMA, the method by which its research programmes and projects are developed, and the strategy and responsibility for the recruitment, education and ongoing development of students and other new researchers. The Governing Board also has responsibility for appointing an International Scientific Advisory Board (see below) and an Executive Committee (see below), approving annual budgets and financial accounts prepared by the Co-Directors and the Executive Committee, and ratifying contracts and fellowships that are let by the NZIMA. The Governing Board is to meet at least twice yearly, in person or by audio-conference.

The current membership of the NZIMA Governing Board is as follows:

Chair of Board

- Sir Ian Axford *DSc FRS FRSNZ*

Members appointed by the University of Auckland:

- Professor Philippa Black (University of Auckland)
- Emeritus Prof. John Butcher (University of Auckland)
- Prof. Peter Hunter (University of Auckland)
- Dr John Kernohan (Auckland UniServices Ltd)
- Prof. David Ryan (University of Auckland)
- Prof. Alastair Scott (University of Auckland)
- Prof. James Sneyd (University of Auckland)

Members appointed by the NZMRI (Inc.):

- Prof. Rod Downey (Victoria University of Wellington)
- Prof. Mike Hendy (Massey University)
- Prof. Gaven Martin (Massey University)
- Prof. Mike O'Sullivan (University of Auckland)
- Prof. Andy Philpott (University of Auckland)
- Emeritus Prof. David Vere-Jones (Statistical Research Associates)
- Dr Graham Weir (Industrial Research Ltd).

Co-Directors (ex officio):

- Prof. Marston Conder (University of Auckland)
- Prof. Vaughan Jones (University of Auckland and University of California Berkeley).

International Scientific Advisory Board

The NZIMA seeks advice and guidance on its research programmes from an *International Scientific Advisory Board*, which is made up of prominent New Zealand mathematical scientists resident overseas, representatives from similar organisations (such as the CMA, MSRI and Fields Institute), and other notable individuals with a positive record of contact with the New Zealand mathematical sciences community. The composition of this advisory board is arranged to ensure balanced representation across the various disciplines of the mathematical sciences.

Members of the International Scientific Advisory Board are invited to review proposals for NZIMA programmes and applications or nominations for Maclaurin Fellowships, and to recommend new themes, suitable visitors and workshop speakers. This advisory board will meet virtually, by electronic mail, however the NZIMA plans to invite one of two members each year to visit New Zealand and take part in some of the NZIMA's activities.

One new member joined the NZIMA's International Scientific Advisory Board this year, and the current members are as follows:

- Prof. Sir Michael Berry (University of Bristol)
- Prof. Andreas Dress (Universität Bielefeld)
- Prof. Peter Hall (CMA, Mathematical Sciences Institute, Australian National University)
- Prof. Gus Lehrer (University of Sydney)
- Prof. Jerrold Marsden (California Institute of Technology)
- Prof. Hugo Rossi (Mathematical Sciences Research Institute, Berkeley, California)
- Prof. Cheryl Praeger (University of Western Australia)
- Prof. Dale Rolfsen (University of British Columbia)
- Prof. Mike Saunders (Stanford University)
- Prof. Bruce Weir (North Carolina State University)
- Prof. Keith Worsley (McGill University, Montreal)
- Prof. Margaret Wright (Courant Institute, New York University).

Co-Directors and Executive Committee

Management of the NZIMA's activities is the responsibility of the two *Co-Directors* and an *Executive Committee* appointed by the Governing Board. The Co-Directors and Executive Committee have delegated authority to manage the affairs of the NZIMA in accordance with the policy of the Governing Board.

The main responsibilities of the two *Co-Directors* are to:

- recommend policy to the Governing Board
- carry out the directions of the Governing Board
- convene meetings and discussions of the Executive Committee and other sub-committees
- maintain financial oversight of activities, staffing, and resources
- coordinate administrative matters with the host and partner organisations (the University of Auckland and the NZMRI), the CoRE Fund administrators, and other funding agencies

- coordinate collaboration with other organisations involved in research in the mathematical sciences in New Zealand (such as the NZ Mathematical Society (NZMS), the NZ Statistics Association (NZSA), the Operations Research Society of NZ (ORSNZ), and the NZ branch of Australia & New Zealand Applied Mathematics (ANZIAM))
- maintain and further promote linkages with other mathematical research institutes overseas.

The Executive Committee consists of the two Co-Directors (ex officio) plus three other members (each appointed for a 2-year term), with assistance from an Executive Administrator. Appointments to the Executive Committee will be on a rotating basis, with the aim of ensuring balanced representation both in terms of pure/applied focus and affiliation.

The main responsibilities of the Executive Committee are to assist the Co-Directors in:

- developing policy for and carrying out the directions of the Governing Board
- selecting (preliminary) proposals for NZIMA programmes to be developed into full proposals for consideration by the Governing Board
- selecting candidates for Maclaurin Fellowships, postdoctoral fellowships, student scholarships, and other activities for NZIMA support
- appointing programme directors and committees
- setting programme budgets and reviewing reports if required.

The *Executive Committee* considers such matters in consultation with the two Co-Directors on a regular basis, either in person, or by electronic mail, or by audio-conference.

Programme Committees and Programme Directors

All special thematic programmes run by the NZIMA are organised by *Programme Committees*, each convened by a Programme Director.

Each Programme Committee is charged with the responsibility of organising the programme (or theme) as approved by the Governing Board, and includes the Programme Director plus at least one member appointed by the NZIMA Executive Committee. The main responsibility of the programme committee is the organisation of the programme, including conferences/workshops, and selection and appointment of visiting experts, postdoctoral fellow and postgraduate scholars.

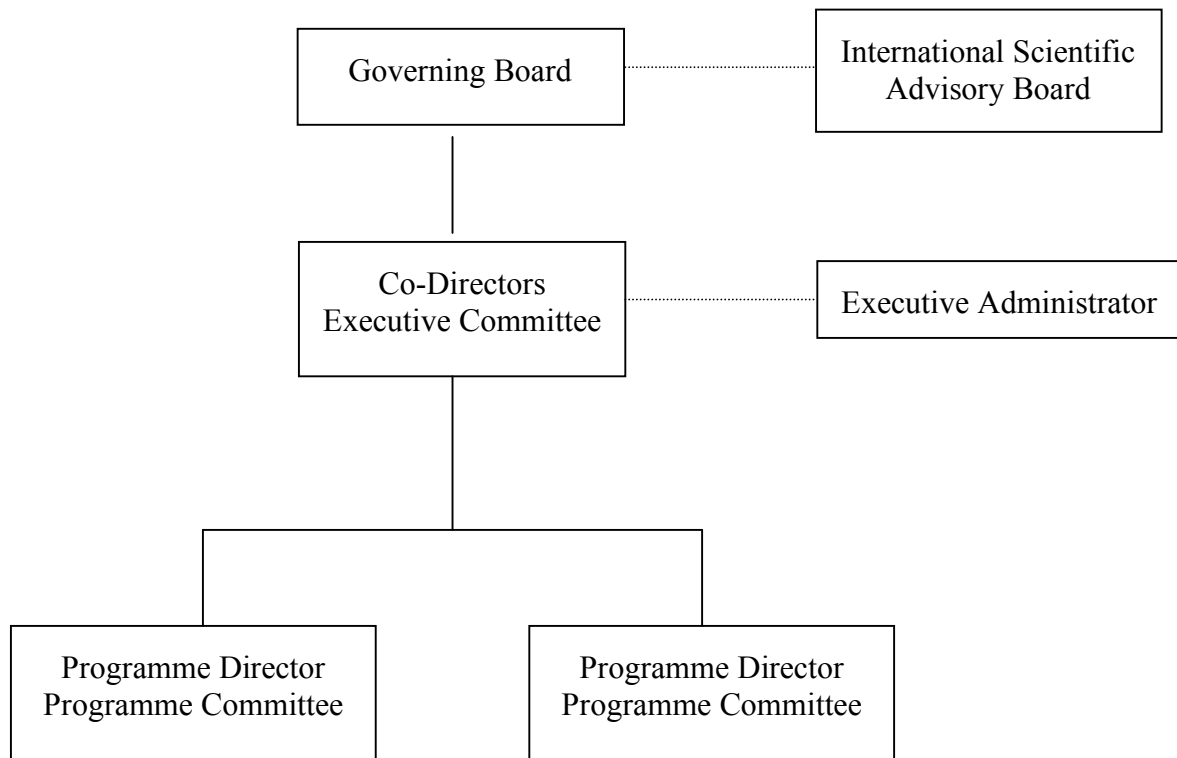
Each Programme Director is expected to provide written interim and final reports through the Executive Committee to the Governing Board, on both scientific activity and financial arrangements. These reports include a final financial statement for the entire programme, a list of all persons involved, and a list of scientific publications and other research outputs resulting from the programme.

Executive Administrator

The main responsibilities of the *Executive Administrator* are to:

- provide HR, financial and other administrative assistance to the Executive Committee and Co-Directors
- help coordinate workshop and conference organisation for each programme committee
- liaise with Programme Directors, Maclaurin Fellows and scholarship holders
- maintain correspondence for the NZIMA
- prepare and disburse publicity material on the activities and outputs of the NZIMA.

Organisational Chart



Host and partner arrangements

Office accommodation is provided by the host organisation (the University of Auckland) for the NZIMA Co-Directors and Executive Administrator, along with support services for administrative functions, including human resource and management accounting services. The costs of these are covered from overhead funding in the NZIMA's CoRE Fund budget. A partnership agreement between the host organisation and the partner organisation (the NZMRI) has been negotiated to ensure appropriate division of responsibilities, revenue and expenses (including allocation of overheads).

Arrangements are made for subcontracting services (including programmes and Maclaurin Fellowships as necessary) through the University of Auckland's Research Office. Arrangements will be made as necessary for commercialisation of NZIMA-funded research and protection of intellectual property through Auckland UniServices Ltd, which has a wealth of experience and a track record of success in this area.

The NZIMA offices are housed at the University of Auckland, on Floor 3 of the same building in which the Departments of Mathematics and Statistics are housed (Building 303), on the corner of Princes and Wellesley Streets, Auckland.

APPENDIX 2: PROFILES OF BOARD AND EXECUTIVE

Chair of the NZIMA Governing Board

Sir Ian Axford DSc FRS FRSNZ is a distinguished scientist who recently retired from his position as Director of the Max-Planck Institute für Aeronomie in Germany. He was named New Zealander of the Year in 1995, in recognition of his distinguished international career in the field of space science. His work placed him at the forefront of near-Earth and Solar System research. He was closely involved with the Voyager 1 and Voyager 2 planetary explorers, the Giotto space-probe, and the Ulysses galaxy explorer. He has made a lifelong commitment to excellence in research and also to the growth and popularisation of science. He previously held positions as a professor at Cornell University (New York) and at the University of California at San Diego, Vice-Chancellor of Victoria University of Wellington, and Chair of the Marsden Fund. He is a Fellow of the Royal Society of London and an Honorary Fellow of the Royal Society of New Zealand, and has an Honorary Doctorate from Victoria University of Wellington.

Governing Board Members

Philippa Black FMSam FRSNZ is a Professor of Geology at the University of Auckland, where she has also served as Dean of Graduate Studies and Associate Deputy Vice-Chancellor (Research). She is a former President of the Royal Society of New Zealand, and also formerly chair of the University of Auckland's Postgraduate & Scholarships Committee. She has considerable experience and wisdom in dealing with academic and research matters.

John Butcher DSc FRSNZ is an Honorary Research Professor of Mathematics at the University of Auckland, having previously been Head of the Applied and Computational Mathematics Unit, Head of the Computer Science Department, and Head of the Mathematics Department during his distinguished career. He is a world authority on the numerical solution of ordinary differential equations, won the NZ Mathematical Society's annual Research Award in 1991, and won the Hector Medal (of the Royal Society of NZ) in 1996.

Rod Downey FRSNZ has a personal chair in Mathematics at Victoria University of Wellington, is one of the five (voluntary) directors of the NZMRI, and was President of the NZ Mathematical Society for the last two years. He won the Hamilton Award of the Royal Society of NZ in 1990, the NZ Mathematical Society's annual Research Award for 1992, the NZ Association of Scientists' Research Medal in 1994, and has won numerous other awards for his work in logic and computational complexity.

Michael Hendy FICA FRSNZ holds a personal chair in Mathematical Biology at Massey University, and is Co-Director (with David Penny) of the Allan Wilson Centre (one of the other Centres of Research Excellence in NZ). He has been Head of the Mathematics discipline group in the Institute of Fundamental Sciences at Massey University and Assistant Editor of the journal *Molecular Biology and Evolution*.

Peter Hunter FRSNZ is a Distinguished Professor at the University of Auckland, and is Director of its Bioengineering Institute. He was awarded a James Cook Fellowship in 1991, and was elected a Fellow of the American Institute for Medical and Biological Engineering in 2001. He has also been Chair of the Physiome Commission of the International Union of Physiological Sciences and a member of the Scientific Advisory Board of Physiome Sciences Ltd.

John Kernohan is the retired Chief Executive Officer of Auckland UniServices Ltd, which is responsible for commercial research and consultancy partnerships, forming new business ventures based on University research, and developing intellectual property. With a PhD in Chemistry, he spent some years in R&D management for General Electric and as CEO of several businesses for ICI New Zealand Ltd. He was appointed UniServices' founding CEO in 1988, and helped it grow from small beginnings to a significant entity with annual revenue of \$70m pa.

Gaven Martin FRSNZ is a Distinguished Professor of Mathematics at Massey University (Albany), and is one of the five (voluntary) directors of the NZMRI. He won the NZ Mathematical Society's annual Research Award for 1994, held a James Cook Fellowship from 2001 to 2004, and has also won several other prestigious awards, prizes, fellowships and visiting positions overseas. He is joint author of a recent book *Geometric function theory and non-linear analysis* published by Oxford University Press. He is currently serving as the chair of the Royal Society of New Zealand's Standing Committee for Mathematical and Information Sciences

Mike O'Sullivan FIPENZ has a personal chair in Engineering Science at the University of Auckland, and is a former Head of the Department of Engineering Science. His speciality is mathematical and computational modelling of geothermal fields, and has been involved as a consultant for over 20 geothermal projects in Indonesia, Japan, Kenya, New Zealand, USA and Mexico. He is Associate Editor of the journal *Geothermics*, and has supervised over 40 postgraduate research students at Masters and PhD level.

Andy Philpott has a personal chair in Engineering Science at the University of Auckland, where he is currently Head of the Department of Engineering Science. He is also a former chair of the Royal Society of New Zealand's Standing Committee for Mathematical and Information Sciences. His research interests are in stochastic optimisation and operations research.

David Ryan FIMA FIPENZ FRSNZ is a Professor of Operations Research at the University of Auckland, a former Head of the Department of Engineering Science, and is currently Deputy Dean of the Engineering Faculty. He is well known internationally for his work on developing methods for solution of large-scale linear programming problems, especially in the context of scheduling. He won the Engineering Excellence Award in Information Technology from the Institution of Professional Engineers New Zealand (IPENZ) in 1999, and won the Hans Daellenbach Prize of the Operations Research Society of NZ in 2001.

Alastair Scott FASA FIMS FRSNZ FRSS is a recently-retired Professor of Statistics at the University of Auckland, and was previously Head of the Departments of Mathematics and Statistics. He has a worldwide reputation for his research on sample survey statistics, and has been appointed to many editorships, fellowships of professional societies, and visiting positions at universities and laboratories overseas. His expertise has also been recognised by appointments to government and professional bodies (such as the NZ Environmental Risk Management Authority).

James Sneyd FRSNZ is Professor of Applied Mathematics and Head of the Applied Maths Unit at the University of Auckland. He is best known for his work in physiological modelling, and was joint winner of the American Association of Publishers' Award in 1998 for Best New Title in Mathematics, for his book *Mathematical Physiology* (co-authored with J. Keener). He is also closely involved with programmes at the Mathematical Biosciences Institute (in Ohio).

David Vere-Jones FRSS FRSNZ is an Emeritus Professor at Victoria University of Wellington, and a director of Statistical Research Associates (a private consultancy firm). He specialises in

mathematical and statistical modelling, with particular interests in geophysics and in statistics education. He won the International Statistical Institute's Henri Willem Methorst Medal in 1995, and the Royal Society of New Zealand's Rutherford Medal in 1999, and has won a significant number of other grants and awards and distinctions.

Graham Weir DSc FRSNZ is leader of the Applied Mathematics group at Industrial Research Ltd, and is currently chair of the NZ Branch of the professional organisation ANZIAM (Australia and New Zealand Applied Mathematics). He specialises in the mathematical modelling of physical systems. He won a Ministerial Award for Excellence in Science in 1987, a Royal Society of NZ Science and Technology Medal in 1996 and the NZ Mathematical Society's annual Research Award for 2000. He has also served on several key committees.

Co-Directors

Marston Conder DSc FRSNZ FTICA is a Professor of Mathematics at the University of Auckland, best known for his work on the application of combinatorial and computational group theory to the analysis and construction of discrete objects with maximum symmetry. He obtained his doctorate from the University of Oxford, where he won the Senior Mathematical Prize and Johnson Prize in 1980. He held a postdoctoral fellowship at the University of Otago in 1981, followed by a Royal Society (UK) Research Fellowship at the University of Tübingen (Germany) in 1982, and a Fellowship from the Alexander von Humboldt Foundation in 1987. He won the NZ Mathematical Society's annual Research Award for 1993, was elected a Fellow of the Royal Society of NZ in 1998, and awarded a DSc by the University of Oxford in 1999.

He was President of the NZ Mathematical Society from 1993 to 1995, co-founder and initial convenor of the NZ Mathematical and Information Sciences Council (now a standing committee of the RSNZ) in 1994, and is a co-founding Director of the NZMRI (Inc.). He participated as a lead expert in the MoRST Review of New Zealand's Scientific Knowledge Base in 1996, was a member of the TEAC Research Working Group (2000–2001), and in 2002 chaired the NZ Ministry of Education's Working Group that developed recommendations for a Performance Based Research Fund (PBRF) for tertiary education institutions in NZ. At the University of Auckland he was Head of the Department of Mathematics from 1996 to 1998, and served a term as Deputy Vice-Chancellor (Research) from 1999 to 2001. He is a member of the Editorial Board of the *NZ Journal of Mathematics*, was a member of the Marsden Fund Council (and convenor of its Mathematical & Information Sciences panel) from 2002 to 2005, and is now President-Elect of the Academy of the Royal Society of New Zealand.

Vaughan Jones DCNZM DSc FRS FRSNZ is a Professor of Mathematics at the University of California at Berkeley and Distinguished Alumni Professor of the University of Auckland. After obtaining a Masters degree with first class honours at Auckland in 1973, he won a Swiss Government Scholarship and an FWW Rhodes Memorial Scholarship to study for a doctorate at the University of Geneva. In 1979 he was awarded the degree of *Docteurs Sciences (Mathematique)*, and the following year the Vacheron Constantin Prize for his doctoral thesis. He held postdoctoral positions at the University of California at Los Angeles (UCLA) and the University of Pennsylvania. During the 1980s his research focussed on von Neumann algebras, and in the course of this work he discovered a new polynomial invariant for knots which led to surprising connections between apparently quite different areas of mathematics.

He was awarded a Fields Medal at the 1990 International Congress in Kyoto (Japan) for his remarkable and beautiful mathematical achievements, and he is believed to be the only person from Australia or New Zealand ever to have won this prestigious award. Since then he has gone on to receive numerous awards and honours, including a Guggenheim Fellowship in 1986, Fellowship of the Royal Society (of London) in 1990, the Rutherford Medal in 1991, honorary doctorates from the University of Auckland in 1992 and the University of Wales in 1993, membership of the US National Academy of Sciences in 1999, the Onsager medal of Trondheim University (Norway) in 2000, foreign membership of the Norwegian Royal Society of Letters and Sciences 2001, and a Distinguished Companionship of the Order of New Zealand in 2002.

He has been invited to lecture at numerous international congresses, and has served as editor or associate editor of many top international journals, including the *Transactions of the American Mathematical Society*, *Reviews in Mathematical Physics*, and the *Journal of Mathematical Chemistry*. Also he has been a member of the Scientific Advisory Boards of the Fields Institute for Mathematics (Canada), the Erwin Schrödinger Institute for Mathematical Physics (Vienna, Austria), the Mathematical Sciences Research Institute (USA), the Center for Communications Research (USA), and the Institut Henri Poincaré (Paris, France). He is also currently a Vice-President of the American Mathematical Society.

He is founder and principal director of the NZMRI, a role in which he has been instrumental in attracting some of the world's best mathematicians to NZ. His own style of working is informal, encouraging the free and open interchange of ideas, and this has rubbed off on many others. His efforts have made it possible for graduate students to gain first-hand knowledge of developments at the leading edge of their discipline, here in NZ.

Executive Administrator

Margaret Woolgrove has a background in research project management, both in New Zealand, where she worked for the Health Research Council from 1997 to 1999, and in the USA and Britain. She spent three years with the Michigan Public Health Institute, and has worked for both the University of Auckland and Massey University since she returned to New Zealand in 2002. Margaret gained an MBA degree (with Distinction) from Massey University in 2005.

