

## Proposal for a national centre in the mathematical sciences

***This is a summary only. A revised proposal is in preparation by AMSI.***

Mathematical sciences institutes and centres have become internationally recognised as an effective means of providing the infrastructure for both discipline-based and cross-disciplinary research essential for innovation and training across many areas.

Australia is perhaps unique among developed countries with which we are usually compared in having no mathematical research institutes. Canada for example has three, plus a large industrial and applied mathematics network of centres. This document makes the case for such a centre to be established in Australia. The following pages document:

- *The evidence for action*
- *A vision for the Centre*
- *The programs proposed*
- *Proposed budget*

An accompanying document draws on examples from other nations that illustrate the programs and contributions that collaborative centres can make.

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## Evidence

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- On average the OECD countries graduate 2.5 times as many mathematical scientists as Australia in percentage terms (2007). This graduation rate is failing to provide Australia with enough teachers, professionals and researchers in the mathematical sciences.
- The mathematical sciences in Australian universities are acknowledged in all the discipline reviews to have suffered a considerable contraction in the last 15 or 20 years. This has led to the concentration of research capacity in a limited number of institutions with a corresponding reduction of diversity of research expertise. *In fact, four institutions now account over half of all Australian university R&D expenditures in mathematics and statistics and for nearly two thirds of national competitive grant income in the field.* (Thomas Barlow, personal communication 2009.)
- Australia's share of world research publication output in the mathematical sciences is smaller than the corresponding Australian share in almost all other disciplines. However, the quality of this output is evident as the Australian mathematical sciences ranked third in international publication impact in a comparison of all Australian scientific publications (2001-2005).
- The mathematical sciences had the highest success rate by discipline in the 2010 ARC Discovery Project round, again indicating the quality of Australia's limited mathematics and statistics endeavour.
- *There are significant, proven benefits in bringing together mathematical scientists and research experts, and clients in other scientific disciplines and from business, industry and government, to work on joint projects.* (National Strategic Review of the Mathematical Sciences in Australia 2006).
- Government, business, industry and academia acknowledge that urgent action must be taken to boost Australia's capabilities in the mathematical sciences. Without this action both our international competitiveness and the educational opportunities for young Australians will be further eroded.

## Conclusion

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*Increasing capacity in the mathematical sciences is critical. A broad skills base in these disciplines is essential for a robust and adaptable research community. The innovative and collaborative character of the mathematical sciences in Australia and the undoubted quality of the researchers guarantee outcomes of highest strategic impact in national and international terms.*

## Vision

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The discipline, through its membership of AMSI, believes that the establishment of an Commonwealth funded centre, centrally administered by AMSI, will most effectively service the research, research training and engagement needs of the entire mathematical sciences spectrum. Specifically, the Centre will conduct two theme programs annually, a national summer school for honours and postgraduate students, a national workshop program, an annual bioinformatics event, an annual graduate school for early career researchers and PhD students and a vacation research scholarship scheme for undergraduates. These activities will be distributed Australia wide and supported by an e-research network. This model reflects current international best practice in the mathematical sciences tailored to Australia's demographic demands.

We must turn back the dual trends of shrinking diversity and increasing research concentration and this can only be done through national collaboration. An inclusive centre, linking Australia's capacity both in the universities and in government agencies such as the Australian Bureau of Statistics and CSIRO's division of Mathematics, Informatics and Statistics, will provide much needed resources to affected departments allowing them to regrow their capacity and increase research diversity. Simultaneously, the Centre will give the Australian mathematical sciences community the crucial opportunity to improve its connection and engagement with the latest global developments. These developments involve both mathematics and statistics proper and the application of the mathematical sciences in an ever-expanding sphere of influence (see the accompanying evidence document or a representative list). In Europe, Asia and the Americas national research institutes are driving groundbreaking progress at a rapid rate by providing leadership and discipline wide resources and we must respond without further delay.

### ***A National Resource***

This new centre will deliver AMSI's current distributed research, research training, higher education flagship programs and some of its industry and outreach activities along with a new program of themes. This portfolio reflects the nature of centres in mathematical sciences in North America, Asia and Europe. There is very considerable strategic benefit in having all these programs planned and managed together. In particular, the Research Centre Management Committee (RCMC) which comprises a national research director and state and territory directors, will bring strong entrepreneurial leadership to the wide spectrum of the Centre's activities.

It is our ardent wish to create a vibrant research environment which will retain and develop Australia's younger talent and attract many high performing expatriates back home. Such an environment will undoubtedly attract strong candidates to positions in Australia's universities and create confidence in

investors that Australia's mathematical capacity can support their enterprise.

### **Theme Programs**

AMSI's current activities are described elsewhere in this proposal so here we concentrate on our vision for the themes component and for the national mathematical sciences remote collaboration network.

We propose a nationally distributed series of major theme programs including workshops and symposia, industry short courses and graduate courses, all around the latest topics in pure mathematics, applied mathematics and statistics. These theme programs will include coverage of naturally strategic areas such as biomedical science, climate modelling, water and resource management, transport and logistics, mining, finance and other areas of industry where the mathematical sciences can bring significant developments and innovation. The programs will be awarded on a competitive basis.

This series will

- be outward facing towards other disciplines and end users,
- engage with Commonwealth agencies such as CSIRO, BoM, ABS, DSTO, DAFF, DoHA, APRA, etc.,
- bring the latest mathematical and statistical developments to Australia,
- further enhance Australia's areas of strength in the mathematical sciences,
- renew capacity and diversity in theoretical mathematics and statistics,
- lead to innovative developments in industrial and commercial arenas,
- create national and international collaboration,
- improve access and support for mathematical scientists in small departments,
- generate increased research outputs, PhD completions and grant success,
- support current ARC funded activities in the mathematical sciences, cognate disciplines and multidisciplinary CoEs,
- enhance postgraduate experience and outcomes,
- be productively and thoroughly integrated with AMSI's existing industry and higher education programs,
- make a significant contribution to the public awareness of the importance and excitement of modern mathematics and statistics.

Following international best practice these theme programs will have a significant outreach component to school students and teachers, government and private enterprise and to the wider Australian community. This outreach is fundamental to increasing the mathematical engagement of students, teachers

and potential beneficiaries of mathematical and statistical expertise. AMSI's DEEWR-funded career work will form a natural adjunct to these activities.

### ***e-Research Infrastructure***

In order for all the programs of the Centre to be truly national, inclusive and of maximal impact there must be an expansion of the dedicated, high level Access Grid Room (AGR) communication/e-research network that partially links Australia's mathematical science institutions and links to the international mathematical sciences community. It is this national e-research network which will reconnect departments of re-emergent research capacity with each other and with the major research centres and re-establish diversity. AMSI's current network is already used for the delivery of honours and postgraduate courses, seminars and workshops and it will be the key to remote access for researchers and students to theme activities outside periods of full-time local access.

*The program of themes and the extension of the e-research infrastructure, along with those AMSI activities currently funded by DEEWR, can be implemented in an initial period of five years with an overall budget cost of approximately \$23m with AMSI providing a further \$1.64m. [The current budget can be found at the end of this summary but should be regarded as indicative.]*

## Rationale

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*Mathematical sciences institutes are an effective way of supporting national and international collaboration and providing access to new ideas in a timely and cost effective manner.*

(National Strategic Review of the Mathematical Sciences in Australia 2006)

AMSI was set up with broad missions in science, education and industrial outreach, but it has not received the support from government for research infrastructure enjoyed by our international counterparts. A sample of extensive, publicly funded programs undertaken in other national centres is described in Evidence A.

It is also vital to understand the contribution of national mathematical sciences institutes to their home countries in terms of research output, research leadership, higher-level education and training, teacher education, and practical contributions based on mathematical and statistical processes as well as the capacity for international research leadership. Evidence B comprises short summaries of some of the recent contributions made by mathematical centres in some other countries.

The outstanding success of these programs rests with the opportunity for local researchers and their early career colleagues to exchange ideas, create research collaborations and to interact with and be mentored by world experts. The importance of interaction in the mathematical sciences cannot be overestimated. Australia, arguably in greatest need of such a program, does not have one. It is easier for Australian mathematicians to run a program at the Newton Institute (UK) than one here. This imbalance has led to the departure of many of Australia's finest mathematicians and statisticians.

Almost universal international experience shows that such theme programs supercharge research output. Publication of research articles and books is the lifeblood of mathematicians and statisticians. Many researchers write papers as they are producing results, and so the intensity of the theme program environment feeds immediately into increased research outcomes. The publication track record of some research institutes can be found in Evidence C.

The conduct of such major theme programs with their graduate level courses, workshops, industry short courses and multidisciplinary character is indispensable in the provision of research training and the encouragement of innovative research. An extensive program of events that attracts eminent international lecturers and participants worldwide will greatly enhance learning and research opportunities and go a long way towards encouraging outstanding talent to remain in or return to Australia. It will attract students into the mathematical sciences and assist in dealing with the significant research workforce shortages in the discipline. Through the program some of the world's best mathematicians and statisticians will participate in high profile events, deliver lectures and short courses across the AGR network and be keynote speakers at major conferences.

Mathematics and statistics are noted for their unusual efficacy as tools for analysis and development in a wide range of disciplines. AMSI is particularly keen for its programs to facilitate the transfer of quantitative techniques in areas of national research priority such as environmental science, climate studies, risk management and human health, astronomy and engineering. Through its theme programs, workshop program and graduate schools the Centre will aim to work with and support Australia's publicly funded research in these areas.

As well as its utilitarian aspects, mathematics is one of the most enduring, important and beautiful creations of the human intellect. There is no doubt that capacity and progress in theoretical mathematics are the foundations upon which exciting applications are built and so our plans must simultaneously involve the renewal of the central areas of pure and applied mathematics and statistics.

The proposed program to be undertaken by the new centre and delivered nationally through the AMSI membership, initially over five years, links the growth and enhancement of electronic communications at Australian institutions with an expanded program of key educational and research activities. In many cases these activities will utilise the AGR network to provide greater effectiveness and efficiency of delivery.

At the moment AMSI has a low cost and effective e-research network of 15 AGRs in mathematical sciences precincts in both metropolitan and regional Australia. This network is used to deliver honours and postgraduate coursework, seminars, lectures and research collaborations. The hardware is flexible and can be used with various conference software applications. This network will be expanded and enhanced as part of the Centre's activities. Post-graduates, early career researchers, established researchers, undergraduate and honours students will all benefit from these improvements which will facilitate greater collaborative research, wider availability of courses and the more efficient and effective access to the major theme programs, workshops, seminars and national lecture series (such as the recent tour by Fields medallist Terry Tao).

This e-research capacity will connect the staff and students in those universities with an emerging research base to the national enterprise in the mathematical sciences. At the same time, the increased use of AGRs will have a positive impact on the carbon footprint of research programs through the reduction in travel overheads.

## Centre Program

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At its inception in 2002 AMSI received initial funding from the Victorian Government, and, subsequently, has been supported by subscription fees from the Universities and other partners that constitute its membership base. These fees have been the sole source of funds for AMSI's research workshop funding. A one-off direct grant from the then Minister for Science, Brendan Nelson, permitted the first AMSI Summer School in 2003. Subsequent funding for the International Centre for Education in Mathematics (ICE-EM) permitted significant growth in educational activities, including continued funding for the annual AMSI Summer School, the Graduate School for ECRs and the Vacation Research Scholarships amongst others.

Both these sources of funding ended some years ago. In 2007 Collaborative and Structural Reform Fund (CASR) funding was obtained which allowed many of these activities to continue. CASR funding ends in March 2011. Thus the proposed Centre Program will not only enable the successful higher educational and research training activities of AMSI to continue and flourish, but also, and equally importantly, provide a much needed new dimension giving critical support to high level research through the major themes program and the growth and enhancement of the AGR network.

The proposed program consists of:

- **Major Theme Programs.** A series of twice yearly major theme programs of 4 or 5 months duration including embedded workshops and short courses, all aimed at the latest topics central to the mathematical sciences. Many of these theme programs will include coverage of areas such as biomedical science, climate modelling, water and resource management, transport and logistics, mining, finance and other areas of industry where transfer from the mathematical sciences is important to significant developments and innovation. There will be a short term fellowship program in conjunction with the themes to enable the semester-long involvement of mid career researchers as theme leaders. Three postdoctoral fellowships of two years duration will be attached to each theme program. These positions will anchor the ongoing benefit of the programs.
- **The AMSI Workshop Program\*\*.** AMSI currently sponsors and facilitates around 15 workshops every year on a competitive basis. Details at <http://www.amsi.org.au/events.php>
- **The Summer School** for honours and postgraduate students\*. AMSI has already delivered 8 annual summer schools to 850 of Australia's honours and postgraduate students . See: [http://www.amsi.org.au/summer\\_school.php](http://www.amsi.org.au/summer_school.php)
- **The Graduate School** for Early Career Researchers\*. Five AMSI graduate schools have taken place at The University of Queensland



engaging 220 students in advanced level courses given by eminent international mathematical scientists. See:

[http://www.amsi.org.au/graduate\\_school.php](http://www.amsi.org.au/graduate_school.php)

- **The BioInfoSummer events\*\***. BioInfoSummer brings together Australian honours, masters, PhD students and early career researchers from mathematical and biological sciences to introduce participants to state-of-the-art bioinformatics research and to develop further applications of mathematics to biology. Following successful events funded by AMSI at ANU from 2004 to 2007 BioInfoSummer will be revived in 2010 at the Walter and Eliza Hall Institute. Details at <http://www.amsi.org.au/bioinfosummer.php>
- **The Vacation Research Scholarships\***. More than 150 undergraduate students have benefited from this introduction to research and the experience of the CSIRO's Big Day In. Details at <http://www.amsi.org.au/vs.php>
- **AMSI Industry Events\*\***. As part of its industry engagement exercise AMSI runs annual events such as the *Industry Workshop And Short Course On The Mathematics Of Water Supply And Pricing* (2008). The 2011 event will be *Statistics & the Law*. See [http://www.amsi.org.au/industry\\_events.php](http://www.amsi.org.au/industry_events.php)

\* CASR funds ceasing 03/2011

\*\* currently funded by AMSI

This wide-ranging program reflects AMSI's continuing mission of improving the engagement of mathematicians and statisticians with users of mathematics in the research, industrial and education sectors. It will require increasing the existing e-research (AGR) installations from 13 to around 23 and upgrading the communications quality and capability to a uniform level. This engagement and the innovation opportunities it brings are vital to the health of the mathematical sciences in Australia.

## Stakeholders

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The AMSI membership includes almost all of Australia's universities, the Australian Mathematical Society, the Australian Bureau of Statistics and CSIRO Mathematical and Information Sciences. DSTO and other government agencies are regular AMSI partners.

AMSI is a collaborative unincorporated joint venture involving universities and other bodies related to the mathematical sciences. The University of Melbourne acts as lead agent. A Joint Venture Agreement (JVA) was signed by six Full Member universities in 2002, since establishment an additional four universities have become Full Members. The full membership now comprises the Group of Eight along with RMIT University and La Trobe University.

Full details of the Institute and its programs can be found at [www.amsi.org.au](http://www.amsi.org.au)

## Regional benefit

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Almost all of Australia's regional universities are members of AMSI and the research and higher education activities of the Institute form particularly important discipline infrastructure for them. National capacity building is one of the key tasks of the proposed Centre and regional involvement will be an imperative for the program. Approximately \$2.44m of the five year Centre budget will be spent on specific regional participation and incentive measures (this does not of course mean that the remainder is dedicated to metropolitan activities because the program is national in scope). Details of these measures are available on request.

## Summary Budget 2011 - 2015

This is a outline draft budget for a competitive grant, not been approved by any of the parties.

Component		5 Year Total
<b>Research Directorate</b>		
At central location, research personnel and direct support plus Lead Agent costs	3,520,427	
At diverse locations, research personnel and direct support	2,154,704	
		<b>\$5,675,131</b>
<b>Theme Programs – 9 over 5 years</b>		
Host university, personnel and direct support	1,250,403	
Lecturers, stipend and expenditure	1,479,499	
Postdoc positions, three per program	5,114,433	
Domestic attendees, 40 per program	1,158,040	
Early career researchers, 12 grants per program	108,000	
PhD students, 10 support allowances per program	383,769	
Theme leader fellowships, 3 per program	1,562,115	
Outreach program	349,487	
International ECR support, 10 grants per program	315,000	
		<b>\$11,720,746</b>
<b>Higher Education and Research</b>		
Annual BioInfoSummer symposia	282,145	
Annual Graduate School for ECRs	765,653	
Annual Summer School in Mathematics *	1,276,304	
Vacation Research Scholarships, 40 per year *	632,000	
Industry Workshops and Short Courses, 2 per year *	210,976	
AMSI scientific conferences, seminars, workshops *	1,240,000	
AMSI society lecturers, 1.6 per year *	40,000	
* AMSI provided contributions	-1,645,000	
		<b>\$2,802,078</b>
<b>e-Research and remote course delivery</b>		
Upgrades and new installations	1,420,992	
Direct operational costs	1,541,014	
		<b>\$2,962,006</b>
<b>Project Total</b>		<b>\$23,159,961</b>
<b>Net after AMSI contributions</b>		

<b>Specific components of Expenditure</b>	
Capital/infrastructure	<b>1,220,000</b>
Regional expenditure: participation, infrastructure, incentive measures	<b>2,441,801</b>
Operational, administrative support by Lead Agent University, excluded if Grant is Category 1.	<b>750,000</b>