

CLOSING THE GAP

***CONNECTING RESEARCHERS TO THE INNOVATION
SYSTEM THROUGH SUSTAINED INVESTMENTS IN
COLLABORATIVE RESEARCH INFRASTRUCTURE***

*Submission to the Review of the National Innovation System
- Australian eResearch Infrastructure Council (AeRIC)*

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CHANGES IN THE OPERATING ENVIRONMENT

eResearch is an essential element of the national innovation system

A strong innovation system demands a high-quality research sector, equipped to adapt to complex challenges. In addition, today's big science and social questions are becoming increasingly global in focus and urgent in nature. To contribute, researchers need an environment that encourages and enables creativity in their work, in the way they work, and in the way their work takes effect.

Much of the research carried out around the globe is now conducted with the assistance of Information and Communications Technology (ICT) tools and services. Entirely new fields of research are emerging and researchers can now collect, move and manipulate large amounts of data, enabling new and much more complex problems to be addressed. It is important to equip Australian researchers, and institutions, for this new world of ICT enabled research, or 'eResearch'.¹

eResearch is in fact central to all stages of the innovation cycle, as it provides the necessary tools for advanced and collaborative problem solving, as well as platforms for the deployment of these findings and mechanisms for the rapid diffusion of ideas.

eResearch platforms encourage collaboration between researchers by providing the infrastructure to enable the pooling of research resources, including intellectual and physical resources, to tackle large and complex problems. Bringing researchers closer together, across institutional and geographical boundaries, increases the collective accessible intellectual capital and hence creates a greater potential for breakthroughs in the pursuit of common research goals.

Much more needs to be done to build Australia's eResearch capacity from its current level. The scale of funding support should match our aspirations to be a strong global research participant in an increasingly networked world; this will necessitate an increased investment of a significant order.

Solving the big challenges we face as a country, an industry and a community

Global issues such as climate change, sustainable energy, emerging diseases and an ageing population are significant problems, each with deep implications for Australia. These issues are complex and it is vital that Australia's research capability can match this complexity.

Policy makers need an evidence base for their work and researchers must have the mechanisms to input research findings to government decision making. A robust eResearch infrastructure can improve information flows and provide the mechanisms

¹ The term 'eResearch' is used in Australia to refer to research activities that apply advanced ICT capabilities and which embrace new research methodologies enabled by ICT infrastructure. This infrastructure includes broadband communications networks, high performance computing resources, research instruments, collaborative software and services, and tools such as simulation software. The United Kingdom has used the term "eScience" and the United States "cyber-infrastructure" to refer to the same set of eResearch activities.

through which researchers can expose their new ideas to government and the broader community.

Using the best tools and techniques in research

Australian institutions have a key role to play in encouraging researchers to access and apply new technologies and cutting-edge research tools, and should be appropriately supported in this role.

Investments in shared eResearch facilities can provide researchers with access to large scale resources, allowing their home institution to share the cost and risk of the investment and allowing researchers and research institutions to draw on shared resources, such as ICT expertise, training and support.

A robust eResearch infrastructure would:

- provide researchers with the mechanisms to address more urgent research questions in much shorter timeframes than ever anticipated
- support research that is relevant and competitive in the global research marketplace by providing the improved predictive power needed to meet the major challenges facing the country
- provide the means for effective access to the data, knowledge and expertise needed to progress our research however dispersed nationally and globally
- provide, through a cohesive access framework, the means to manage the immense pressures on the research system from the exponential growth of research data

Current eResearch infrastructure investments are focused on the provision of easy to use eResearch tools and services that encourage researchers to adopt new research methods and improve the efficiency and effectiveness of their endeavours. These activities are making high-end eResearch resources, such as high performance computing systems, accessible through the provision of user-friendly web-based tools.

Significant cultural change is required to ensure that shared investments occur naturally and build on existing successful collaborative infrastructure investments within public sector research institutions. Increasing the scale of funding available to support fundamental eResearch infrastructure, on the basis of collaboration, increases the likelihood of such take-up.

ASSUMPTIONS UNDERPINNING CURRENT POLICY PROGRAMS

For the Australian innovation system to stay at the cutting edge, it needs to develop and maintain the flexibility to respond to emerging global challenges.

A number of changes are occurring in the operating environment that challenge existing assumptions underpinning current funding approaches. These changes include the growing complexity associated with the globalisation of research, the need to overcome cultural and mechanical impediments to collaboration, and the problems caused by finite resources and the limited expertise available to implement the scale of change required.

Participation in a global research system

Globalisation has moved the research operating environment into the international domain.

As a result, Australia is becoming increasingly involved in international research projects. The Minister for Innovation, Industry, Science and Research has recently indicated that Australia will increase its participation in Europe's Seventh Framework Programme for research and technology development (FP7), which is the European Union's main instrument for funding research². The successful Australian projects funded during the first year of FP7 are in fields that have significant eResearch requirements, including health, energy, nanotechnology, the bio-economy and nuclear research and infrastructure.

If Australia succeeds in its bid to host the Square Kilometre Array (SKA), it will be an enormous boost to Australia's international science and research profile, and will create hundreds of high-skill, high-wage jobs, as well as attract foreign investment. It will generate huge spin-offs in supercomputing, fibre-optics, non-grid and renewable energy, construction and manufacturing. This project will be absolutely dependent on a robust eResearch infrastructure, including significant high performance computing resources, optic fibre networks and international communication links and will increase the demand for skilled ICT and eResearch professionals.

In these and other cases, the scale of research infrastructure investment now required to position the Australian research sector globally is beyond the realms of a single institution's grasp and often beyond the resources of a single country. Effective eResearch infrastructure that can underpin our participation in global research efforts is essential for ensuring Australia's research capability is able to keep pace with the requirements of modern research and remains internationally competitive.

² European Commission *FP7: the future of European Union research policy*
http://ec.europa.eu/research/fp7/index_en.cfm

Competitive research funding vs collaborative research infrastructure provision

Publicly funded research

There is a tension between encouraging collaboration in the investment in and use of research infrastructure on the one hand, and competitive funding for research on the other.

Increasingly researchers are being asked to address problems that cannot be solved by teams within a single institution, organisation or jurisdiction. The research environment now has a larger number of participants and to achieve credibility, research teams must pool resources and combine intellectual power.

Conversely, the majority of funding for research is distributed on a competitive basis. This is often the case for specific research projects, where funding is usually targeted within a single discipline. While competition itself can encourage innovation, it is at odds with the pragmatic requirement to pool resources to remain competitive on the global stage. Particularly at the national level, the benefits of collaboration are many, and include cost sharing across infrastructure investments, the potential to develop new research methods, new cross-discipline approaches, new relationships and enhanced research outputs.

eResearch technologies should be used to underpin cultural change in research institutions and amongst researchers, and to provide a platform for sharing collective findings and methodologies between the research, businesses and government sectors.

Government agencies

The national research effort would be significantly enhanced if researchers had ready access to government expertise and research resources; such as the various important data holdings within Government agencies.

The sector wide collaborative approach, taken by the National Collaborative Research Infrastructure Strategy (NCRIS)³, is assisting researchers to connect with government bodies in the domain of health and geosciences. However, a sustained and significant effort is required to bring researchers and owners of government data closer together.

Industry

Research collaboration between publicly funded research institutions and businesses is not prominent in Australia. A 2006 Inquiry into Pathways to Technological Innovation found that there are impediments for researchers to commercialise their findings and that there are structural and cultural incompatibilities between public and private sector organisations that act as impediments to linkages⁴.

However, there are clear benefits to industry from working with research institutions, including universities. Such benefits include exposure to young talent and future

³ For more information on the NCRIS program, see page “Policy Drivers” 7, or www.ncris.dest.gov.au

⁴ www.apf.gov.au/house/committee/scin/pathways/tor.htm

recruits, the ability to draw on specialist skillsets and to address research problems of a larger scale than would be possible in-house, leading to ultimate bottom-line improvements.

Mechanisms through which Australian universities and public research agencies, and private sector research effort can work together are required. Such mechanisms could also deepen collaboration between public and privately funded research.

Funding and eligibility rules such as those in NCRIS that actively encourage collaboration and co-investment can act as an incentive for broader collaboration. A similar incentive model could be applied to encourage industry investment in collaborative research.

Limited availability of eResearch expertise

It is widely accepted that the difficulty in accessing appropriately skilled people is a limiting factor in the deployment of eResearch and that there is a clearly identified skills shortage in this area.⁵

A wide range of diverse eResearch expertise is required to support Australian research. The deficit of skills is across the spectrum, at the application level for scientists unfamiliar with eResearch technology, through to the generic ICT skills required for an eResearch service provider. In between there are domain specific ICT skills required to provide generalist ICT support and training.

The potential for large scale ICT research projects, such as the SKA, to bring high-skill, high-wage jobs to Australia can only increase the demand for skilled ICT and eResearch professionals.

The report of the eResearch Coordinating Committee (2006) identified skills as a key challenge for eResearch in Australia and nominated possible models for addressing the problem. Most recommendations made by the Committee, including the development of a central eResearch management body, dispersed training efforts and the provision of eResearch scholarships, have yet to be addressed.⁶

NCRIS-sponsored eResearch platforms have assisted in developing capacity in specific eResearch capabilities, attracting talented eResearch specialists through investments made in interoperability infrastructure, high performance computing and data management.

However, providing for eResearch career pathways remains to be addressed, as does the means for effective exposure to eResearch techniques and resources early in a researcher's career. Higher education and research institutions have a significant role to play in this endeavour and should be appropriately supported in this role.

⁵ Preliminary findings of the NCRIS Roadmap Review process (www.ncris.dest.gov.au/development_folder/roadmap_review_2008.htm);

Australia 2020 Summit: Initial Report (www.australia2020.gov.au/report/index.cfm)

⁶ An Australian e-Research Strategy and Implementation Framework; Report of the e-Research Coordinating Committee

www.dest.gov.au/sectors/research_sector/publications_resources/profiles/e_research_strat_imp_framework.htm

POLICY DRIVERS

The domestic policy imperative

The current focus of Australian Government investment in national eResearch infrastructure is through the NCRIS program. NCRIS is a major research infrastructure funding program that includes investments in eResearch infrastructure⁷.

The eResearch infrastructure component of the program, known as “Platforms for Collaboration,” addresses common recommendations made following extensive consultation in relation to large-scale, national eResearch infrastructure requirements.

These include:

- The final report of the National Research Infrastructure Taskforce (NRIT, 2004)⁸ noted the requirement for a national strategic approach to research infrastructure investments, to provide researchers with modern and relevant research infrastructure. The NRIT recommendations informed the Government’s design of NCRIS.
- The Prime Minister's Science, Engineering and Innovation Council Working Group on Data for Science Report (2006)⁹ recommended a whole of government response to the issue of data management for Australian science, including a national network of data repositories, improved data management structures for access, sharing and collaboration around data and developing a skilled workforce for best practice in data management.
- The final report of the e-Research Coordinating Committee (eRCC, 2007)¹⁰ proposed an eResearch Strategic Framework that would build eResearch capability through a number of measures, including through skill development via incentives and funded research scholarships.

Partly in response to these studies, the Government is investing \$82 million in Platforms for Collaboration under NCRIS to provide a suite of services and infrastructure that underpins all other NCRIS investments. The investments provide:

- National peak computing facilities and high performance computing tools through the National Computational Infrastructure (NCI).
- Grid-enabled technologies and infrastructure to provide connections between computational and data resources, eResearch services and collaboration tools through the Australian Research Collaboration Service (ARCS).

⁷ See the NCRIS Committee’s submission to the NIS Review (the NCRIS Committee has oversight of the program investments).

⁸ The National Research Infrastructure Strategic Framework: Final Report of the National Research Infrastructure Taskforce
www.dest.gov.au/sectors/research_sector/policies_issues_reviews/reviews/previous_reviews/national_research_infrastructure_taskforce_framework/

⁹ From Data to Wisdom: Pathways to Successful Data Management for Australian Science: Working Group on Data for Science Report to PMSEIC
http://www.dest.gov.au/sectors/science_innovation/publications_resources/profiles/Presentation_Data_for_Science.htm#abstract

¹⁰ Final Report of the e-Research Coordinating Committee (eRCC)
www.dest.gov.au/sectors/research_sector/publications_resources/profiles/e_research_strat_imp_framework.htm

- Data management, access, discovery and curation through the Australian National Data Service (ANDS). ANDS is being established to enable researchers to better share, identify, locate, access and analyse research data.
- A trusted resource sharing framework through national authorisation and authentication services provided by the Australian Access Federation, and complemented by related work within ANDS and ARCS.
- Network access through high capacity bandwidth provided as part of the Australian Research and Education Network (AREN), which connects researchers across the country.
- The development of eResearch tools and services leading the further evolution of the national eResearch infrastructure, being provided by the National eResearch Architecture Taskforce (NeAT), which scopes and recommends development projects that can broaden the appeal of eResearch services.
- Expertise and support skills as part of the above investments, to assist researchers in further developing and making best use of the funded infrastructure.

AeRIC undertakes a significant coordination role in relation to the Platforms for Collaboration infrastructure. AeRIC is tasked with ensuring the integration and sustainability of research infrastructure and services capitalising on the Government's substantial investments in NCRIS capabilities.

The international policy imperative

There is also an international imperative driving eResearch infrastructure development in Australia. Australia must maintain world class eResearch infrastructure, so that Australian researchers can fully participate in international research, and be at all relevant in some disciplines. The Australian approach to eResearch investment must also co-exist within a global context so that Australian researchers can easily work with their international colleagues.

Consequently, a number of key international programs such as the e-infrastructure program from JISC (UK)¹¹ and the National Science Foundation's work on Cyber-Infrastructure (US) contributed to the policy underpinning for the current Platforms for Collaboration implementation.¹²

The continued development of an internationally robust framework for strategic investment in eResearch infrastructure should also provide the ability for the power and spinoffs of the infrastructure to be harnessed for the benefit of Australian research, business and the wider community.

¹¹ JISC: e-Infrastructure programme (UK)

www.jisc.ac.uk/whatwedo/programmes/programme_einfrastructure.aspx

¹² National Science Foundation (US) <http://nsf.gov/index.jsp>

RESPONSES TO DATE

The funding provided so far under Platforms for Collaboration represents a significant contribution. However, the total proposed expenditure over 2006-2011 is less in real terms than the expenditure on national networks and grid computing activities alone over 2004-2006. The broader spread of investment, while essential, means that each individual element of the underpinning eResearch services and infrastructure is under-scaled. These difficulties were highlighted in the development of the Platforms for Collaboration investment plan, and subsequent implementation.¹³

The current scale of funding is inadequate to keep pace with international developments and to encourage the cultural change required amongst Australian institutions undertaking research. Failure to keep pace with developments has the potential to significantly compromise research quality, hinder researcher training and reduce the attractiveness of Australia to inward investment.

Continuation of essential national eResearch infrastructure

A number of specific investments will require ongoing investment.

High bandwidth networks

The Australian Research and Education Network (AREN) is a specialised high-bandwidth network that connects universities and the CSIRO with each other and to comparable international networks. The NCRIS focus on government and private sector researchers as well as universities and CSIRO, means that the network now needs to extend to researchers and research resources wherever they are located.

The existing network infrastructure for research is insufficient in some key areas, such as certain regional areas. International connectivity also requires significant upgrading over the next few years, particularly if the Australian bid for the SKA project is to be seen to be feasible. While a high-bandwidth network is a vital underpinning component of the eResearch system in Australia, there is currently no existing source of funds to support expansion, upgrade or strategic investment in such a network.

High performance computing capability (HPC)

An investment of \$26 million has been provided to the Australian National University (ANU) under Platforms for Collaboration through to mid 2011 to ensure Australian researchers of merit continue to have access to leading edge HPC capability.

The cost of world-class HPC facilities that can support activities such as climate modelling and biomedical research is rising steeply. While co-investment in the HPC facility at the Australian National University is expected, it is unlikely to be sufficient to support the operation of a truly world-class HPC facility. Higher funding levels and continuing rounds, perhaps every three years, of equivalent funding are needed to enable the provision of world-class, 'tier 1' systems.

¹³ A more comprehensive view of requirements will follow the outcomes of the NCRIS Roadmap Review process (see www.ncris.dest.gov.au for more information).

Interoperability and collaboration infrastructure

The Australian Research Collaboration Service (ARCS) provides national eResearch services via grid-enabled infrastructure. ARCS provides a vital platform for research collaboration including seamless access to research facilities and services, such as high performance computing resources, via interoperable middleware, as well as providing for the analysis and movement of large data sets. ARCS is funded by Platforms for Collaboration with \$20m through to mid 2011 and provides national services through a cohesive collaboration of regional partners.

Addressing the new challenges: Managing research data

The deluge of research data is accelerating as the number, frequency and resolution of data sources rises, as information becomes increasingly 'born digital' and as the capacity to process, transform and transfer information expands. Today's scientific instruments generate terabytes of data and the capacity to store this data, in a format that is accessible to other researchers for discovery and re-use, is of increasing concern. The growth in sensors and laboratory automation is still in its infancy; so dramatic scale-ups in data acquisition are foreseeable and have yet to be addressed in a planned way. Appropriate frameworks for the management, accessibility and use of research data need to be developed to realise the greatest possible benefit from the investments being made in research and research data capture.

The \$24m of funding provided to establish the Australian National Data Service (ANDS), as part of Platforms for Collaboration, will support the development of policies, services, rules for data repository management and a degree of data management; but is insufficient to support all data management. Significant, enduring and increasing funding is required to sustain long-term data management infrastructure. This is true whether the function is shouldered by universities, research agencies or Government.

Specific issues to be addressed in such frameworks should include:

The retention of research data: an enduring source of funding or national structural arrangement is needed to support the long-term retention of research data. Any solution to long-term data retention, requires the commitment of entities who can be held responsible for enduring service provision.

Digitisation of, and access to, research resources: A number of research disciplines need primary research materials to be digitised to make them accessible so that research can be conducted in an electronic, collaborative manner.

Data analysis tools: Consultations have highlighted a requirement for tools and services that allow researchers to value-add to their research data, through advanced data analysis tools, such as modelling and visualisation, to produce more meaningful and interactive research data. Ongoing funding and development is required in smart tools to assist with the analysis of data.

RECOMMENDATIONS

1. An accelerated, sustained and strategic investment in collaborative ICT research infrastructure should be provided

Strategic, sustained and accelerated investment in collaborative ICT research infrastructure is required, on a scale not yet envisaged in this country. The current scale of funding is failing to keep pace with international developments and is insufficient to drive the cultural change required amongst Australian research institutions. Such investments should build on existing successful collaborative and shared infrastructure investments within public sector research institutions.

Increasing the scale of funding available to support fundamental eResearch infrastructure, on the basis of collaboration, increases the likelihood of collaborative behaviour and the take-up of eResearch. There are of course practical limitations on deployment as it takes time to create large scale infrastructure that requires continuing support and commitment. Similarly, the ability to expand the scope of investment depends on the availability of expertise and skilled people that could be reasonably recruited to fill key positions.

2. Strategies should be developed to provide new career pathways and build significant expertise

There is a widespread recognition that eResearch investments must be accompanied by strategies to develop appropriate skills and expertise.

The eResearch Coordinating Committee's recommendations included flexible structures for undergraduate training; the provision of eResearch scholarships; incentives for skilled eResearch professionals and outreach programs aimed at skills transfer to the wider research community. The report proposed that dispersed training effort supported by central coordination was needed for effective skills transfer.

While AeRIC values the work of the eRCC, the skills shortage should be addressed in further consultation with research communities. A key principle for any strategy is that there should be a process whereby more eResearchers are encouraged to take up the tools of the trade in future and also encourage their fellow researchers to do so.

3. A strengthened and strategic coordination framework should be provided

The National eResearch infrastructure is fundamental infrastructure and is not specific to one or a number of disciplines. Consequently, the investments under Platforms for Collaboration are in national systems and services. The majority of these services are new and therefore do not yet have a natural owner in the system.

A peak authority is needed to rationalise the coordinated roll-out of such eResearch investments and to provide an holistic oversight of the activities contributing to the development of Australia's e-Research capability. AeRIC currently plays this role and believes that, over time, it will be necessary to explore appropriate national governance frameworks that can better enable the coordination of the eResearch services vital to the future of Australian research.