

**eResearch Discussion Paper**

1. **ISSUE**

Under the PVC Research (Performance and Innovation) portfolio Professor Peter Nelson is responsible for coordinating and overseeing the development of a University-wide eResearch strategy that enables Macquarie to harness the opportunities eResearch offers.

eResearch underpins all four of Macquarie University’s Strategic Research Framework Key Research Objectives[[1]](#footnote-1) and is a fundamental enabler of the Strategic Priorities set out in the University’s A Framing of Futures[[2]](#footnote-2), particularly speaking to the aims of ‘*an accelerated and impactful performance in discovery’*. A strategy is needed to guide development of Macquarie’s eResearch capabilities and deliver on our objectives to produce world-leading research and deliver world-changing impact in an accelerated research environment.

This discussion paper presents the findings of a consultation and benchmarking process undertaken by a small eResearch working party consisting of the PVC Research (Performance and Innovation) and PVC Research Project Coordinator. In this paper we discuss the eResearch landscape both locally and internationally, describe the activity that has and is taking place at Macquarie and discuss options for progressing the University’s eResearch capacity. Finally, we ask readers to consider these options and contribute to discussion that will help consolidate a vision and strategy for eResearch at Macquarie.

1. **DEFINITION**

The most common definition of eResearch refers to the use of advanced information and communications technologies that support and enhance research. These technologies encompass but are not limited to data storage facilities, high performance computing, mobile research tools, the cloud, virtual labs, simulation environments and visualisation tools. The technologies themselves can serve to reduce risk associated with data storage, increase the size and scope of research datasets, accelerate data collection, analysis and results, enable collaboration and maximise research outcomes.

A range of eResearch perspectives were discussed during the course of the consultation process. While these perspectives illustrate the heterogeneity of eResearch practice and needs perhaps the most accurate summation was the suggestion that “in a very short time the term eResearch will cease to exist; it will just be research”. This signals the pervasiveness of eResearch across the research environment.

1. **BACKGROUND**

eResearch tools and infrastructure are creating fundamental changes in the way research is done, characterised by openness, collaboration, accelerated results and re-purposing of data. Digital data storage facilities for active and archive data are now basic requirements for research institutions. Digital tools and mobile technologies are being employed for data capture. High performance computing is making critical advances in data analysis. The now standard requirement for open access journal articles has paved the way for funding bodies to encourage, and in some cases mandate researchers to make their data open, accessible and re-useable.

Macquarie University has engaged with eResearch to a degree and some groups have produced significant eResearch advances. However, as an institution there is much scope to strategically embrace opportunities to enhance our competitiveness. Institutions who have done so locally and internationally are leading major changes in research practice and consequent outcomes.

Macquarie University’s Information Technology unit is currently developing a call-for-tender for data storage and high performance computing. This will be a significant advance for the University and help overcome data management issues, minimise risk associated with data loss and corruption, and advance our research capabilities.

In addition to these steps it is vital the University commit to an organisational eResearch strategy. At a rudimentary level we need to improve our data management practices. At a strategic level we must invest in infrastructure, tools and building capability in our staff and students. It is only by developing the material and personnel capabilities needed to respond to rapid eResearch advances that Macquarie will remain competitive, win funding, meet the mandatory requirements of funding bodies, engage as a collaborator of choice and produce innovative and impactful research.

1. **CONSULTATION AND RESEARCH**

The eResearch working party has scanned the national and international research environment, with a particular focus on the way eResearch is shaping research practices and opening up exciting opportunities for research outcomes with real world impact.

We have reviewed how other universities are approaching eResearch by looking at different approaches to policy, staffing, infrastructure and support at a number of institutions and through attendance at a number of conferences and events (eResearch Australasia, Digital Humanities Conference, ANDS Open Research Data Showcase).

Over a three month period the eResearch working party met with individuals and groups across the University – those with an interest or expertise in eResearch, and key stakeholders within Faculties and Offices. We thank these people who generously gave us their time and shared their expertise to shape the development of this paper:

* Louise Fleck and Semira Dautovic, Research Office
* A/Prof Shawn Ross, Dr Brian Ballsun-Stanton, Dr Adela Sobotkova, Federated Archaeological Information Management Systems
* A/Prof Steve Cassidy, Department of Computing
* Dr Mary Davies, Grant Sayer, Noel Valenti, Information Technology
* JoAnne Sparks, Vladimir Bubalo, Fiona Burton, University Library
* Prof Johanna Westbrook, Prof Jeffrey Braithwaite and Prof Enrico Coeria, Australian Institute of Health Innovation
* Dr Josh Madin, Department of Biology
* Faculty Associate Deans, Research
* Faculty Associate Deans, Higher Degree Research
* Faculty Research Managers

In addition to these meetings the informal eResearch Group, established by University Librarian JoAnne Sparks in 2014, has met monthly to discuss current eResearch activity and concerns. Members of this informal group include staff from the Library, Research Office, Information Technology, DVCR Office and Faculties, some of whom are also named above.

1. **FINDINGS**

**5.1 The National and International eResearch Landscape**

*5.1.a Government eResearch infrastructure investment and strategy*

* *Australia*

In Australia the National Collaborative Research Infrastructure Strategy (NCRIS) is funded by the Australian Government to support the growth of national eResearch capacity. NCRIS provides a national approach to investment, funding research infrastructure that supports Australian research and Australian research collaborations world-wide. This infrastructure is intended to serve the Australian research and innovation system broadly. The 2015 Cochran review, the *Status Report on the NCRIS eResearch Capability,* highlighted NCRIS-funded services such as the Australian National Data Service (ANDS) and the Australian Access Federation (AAF) as leading the rest of the world in their approaches to data and federated access (2015). Among other major services under the NCRIS banner are the National Computational Infrastructure (NCI) facility, the Pawsey Supercomputing Centre and National eResearch Collaboration Tools and Resources (NeCTAR).

A Research Infrastructure Review, led by J P Morgan Advisory Council member Philip Clark AM, was established by the Australian Government in 2014. At a recent eResearch Australasia conference Clark is reported to have suggested there will be increasing emphasis on building human capability in the field, highlighting that ‘infrastructure requires both physical and human elements’ (Reid, 2015). While the results of the Clark review have not yet been made available, the government has, in its National Innovation and Science Agenda, committed $1.5 billion for NCRIS over the next decade and has announced that Australia’s Chief Scientist will in 2016 “undertake a process to identify national research infrastructure capability needs to inform where funding is required in future years” (Commonwealth of Australia, 2015, p). The *Status Report on the NCRIS eResearch Capability* indicates there is general concern in the Australian research community with Australia’s ‘overall level of investment in HPC[[3]](#footnote-3) capability at both peak and institutional level’ (2015, p7). It also highlights skills gaps and the need for clear career paths in these emerging fields if the demand for eResearch services is to be met in the future (p47).

At a State level eResearch services and support have been provided by member-based organisations[[4]](#footnote-4). In NSW Intersect has been the largest provider of eResearch services and operates on a subscriber membership model. Implicit inequities in such a model have led to some dissatisfaction, with many members expressing preference for fee-for-service support. For this reason and due to concern surrounding the longer term viability of the Intersect, Macquarie University has recently terminated Intersect membership. At this time the future direction of external eResearch service provision for Macquarie, and perhaps in NSW, is uncertain. While some universities are well on their way to supporting their eResearch activities in-house, others such as Macquarie, are investigating avenues for developing and strengthening institutional capacity. The IT Unit will drive a call-for-tender for data storage and HPC and have flagged plans to develop a suite of services. Where and how other support is provided and services are integrated across the University is an important topic for discussion.

* *International*

In Britain the e-Science Core program initially funded enabling infrastructure in the form of ‘distributed and heterogeneous computational and data resources’ known as the Grid, and large scale eResearch projects (Hey & Trefethen, 2002). In 2006 the funding model was restructured with funding for eResearch now distributed through funding councils and a member-based organisation, JISC (Joint Information Systems Committee). The Joint Information Systems Committee receives funding from all UK higher education providers and from funding councils to provide advice and digital resources, network connectivity, a shared data store facility and conduct research and development projects of benefit to the sector.

The US National Science Foundation (NSF) Office of Cyberinfrastructure is the main strategic and funding body through which US developments have evolved. The NSF-funded TeraGrid project (now the XSEDE project[[5]](#footnote-5)) developed a grid system integrating resources and services between several US supercomputing centres. The NSF jointly funds the Open Science Grid with the US Department of Energy. At the core of this initiative, members of the Open Science Grid consortium (universities and national labs) are able to access compute and storage facilities across the county “at whatever resource is most available”, thus utilising resources that might otherwise have been idle (opensciencegrid.org). The American Council of Learned Societies established the Commission on Cyberinfrastructure in the Humanities and Social Sciences, from which came the 2006 report Our Cultural Commonwealth (ACLS, 2006). In the years since this report Digital Humanities has developed as a practice internationally (and as a field of research in its own right), progressing, amongst other things, digitisation, text analysis, data visualisation and digital mapping.

The European Grid Infrastructure (EGI) foundation coordinates and manages pan-European grid services and infrastructure, while at each country-level National Grid Initiatives manage local eResearch resources. The EGI is currently leading the EGI-Engage project which aims to “accelerate the implementation of Open Science Commons by expanding the capabilities of a European backbone of federated services for compute, storage, data, communication, knowledge and expertise, complementing community-specific capabilities” (egi.eu). The European Union funds a number of multi-nation collaborative approaches to eResearch infrastructure in the humanities, developed under the European Strategy Forum for Research Infrastructures (ESFRI). These include CLARIN-D[[6]](#footnote-6) (Research Infrastructure to make language resources and technology available and useful to scholars of all disciplines) and DARIAH[[7]](#footnote-7) (Digital Infrastructure to Study Source Materials in Cultural Heritage Institutions).

* *Alliances*

The United States and China are currently engaged in a multi-year collaboration to discuss cyberinfrastructure to support research and broaden collaboration between the two nations (china.internet2.edu). Other international partnerships include the G8[[8]](#footnote-8) science ministers who have published a joint commitment to pursuing ‘global research infrastructure, open scientific research data, and increasing access to the peer-reviewed, published results of scientific research’ (gov.uk). The UK Open Research Data Forum has jointly released a statement with the US Committee on Coherence at Scale for Higher Education - the Statement on the Principles of Open Data (2014). Internationally alliances such as the Research Data Alliance and the International Council of Science Committee on Data Science and Technology are driving a collaborative open data agenda.

*5.1.b Fundamentally changing the way we do research*

Across all disciplines eResearch is creating fundamental change in the way research is done and the outcomes it facilitates. Technologies are opening opportunities for cross-disciplinary, cross-institutional and cross-sector collaboration; for faster data collection and analysis on a huge scale; for active and archival storage and data sharing; and, by virtue of the potential these technologies enable, are creating cultural shifts seen in practices such as open data sharing and citizen science.

Humanities researchers are collaborating with computer science departments to preserve, digitise, analyse and share their research. The *Status Report on the NCRIS eResearch Capability* indicates the Australian research community anticipates “future growth of data demand in the HASS disciplines” and “continuing unmet demand for digitisation” (Cochran, 2015 p10). The AURIN (Australian Urban Research Infrastructure Network)[[9]](#footnote-9) project is an example of this. The project is led by the University of Melbourne and involves a wide range of public and private sector collaborators. The project delivers a “one-stop online portal with more than 1,200 multi-disciplinary datasets… and a suite of open-source tools covering spatial and statistical modelling, planning and visualisation” to enable evidence-based decision making around a range of urban management issues (aurin.org). At UCLA the *Event Pulse[[10]](#footnote-10)* project analyses the university library’s broadcast news media archive of more than 200,000 news programs from the last ten years plus social media feeds. Mark-up technology has allowed for analysis of the broadcasts so the project team can “discover, track, visualize, and analyze the underlying forces of world events and the multiple ways they are represented through the media” (cdh.ucla.edu). At the Historical Archive of the Contemporary Jewish Documentation Centre Foundation (CDEC) Milan the *Open Memory Project[[11]](#footnote-11)* uses semantic web technologies[[12]](#footnote-12) to link the names of holocaust victims to data such as place of birth, residence, relatives, place of arrest, arresting officers and deportation details. The project is the first to link holocaust data in this way, creating new opportunities for the exploration of histories and significantly expanding research potential. At Macquarie University the Federated Archaeological Information Management Systems[[13]](#footnote-13) suite of eResearch tools enables digital field data collection, rapid data analysis, data visualisation and storage and data sharing facility, which can be deployed across multiple fields of research.

In medical research, digital data collection tools such as the Australian Institute of Health Innovations WOMBAT (Work Observation Method by Timing Activity)[[14]](#footnote-14) have been developed and employed in a number of hospitals to track, record and analyse practitioner activity. In science, Ocean Networks Canada (ONC)[[15]](#footnote-15) at the University of Victoria has built a mobile app that enables ‘citizen scientists’ to collect and upload data to the ONC data management system. Systems such as these reduce the time to collect and analyse data and in the case of ONC enable efficiencies by involving the non-scientific community in data collection, analysis and description.

Datasets are increasingly characterised as large, international, open and collaborative. Founder and President of Open Knowledge, Rufus Pollock is popularly quoted as pointing out “the best thing to do with your data will be thought of by someone else” (rufuspollock.org). This statement is demonstrated by the sharing of astronomical data at the University of Melbourne, whereby “linking expensive astronomical equipment and providing data mining and curation through grid technologies, the observatory enables astrophysicists to work in large global research teams on terabytes of data. By making this data accessible, the observatory allows some of the stored data to be used up to six times for different pieces of research, often in unexpected ways” (O’Brien, 2005 p66).

The *1000 Genome Project[[16]](#footnote-16)* was possible thanks to technologies that allowed sequencing of 1,000 samples in less than a year - compared to the 10 years it took for the first human genome to be sequenced. Data were then made freely available for scientists to access through Amazon’s cloud computing unit, and Amazon provides fee-for-service access to their EC2 compute services for scientists to further analyse the data. Similarly the *Medicines for Malaria Project[[17]](#footnote-17)* makes its data open for others, paving the way for discoveries in other areas of medicine. Through these practices projects such as these are creating greater possibilities for research outcomes with world-changing impact.

In 2009, European Research Council Scientific Council member Professor Mathias Dewatripont flagged the benefits of open access data as allowing researchers to “work with the existing material, check the results and come up with new ideas”, predicting that “open access for unprocessed data is indeed going to happen in virtually all cases” (2009) . Five years later, in 2014 the European Commission Horizon 2020 Pilot on Open Research Data[[18]](#footnote-18) committed three billion euro in the years 2014-15 to fund research in key areas across Science, Technology and Society. The pilot was established in recognition “that research data is as important as publications” (European Commission, 2013), and with the intention to better understand the infrastructure and the incentives needed to support data sharing and the impact of the barriers researchers face in sharing data. EU Commission policy and research funding programs are expected to evolve as a result of the pilot findings.

The Research Councils UK Common Principles on Data Policy provides a strong message that ‘publicly funded research data are a public good, produced in the public interest, which should be made openly available with as few restrictions as possible in a timely and responsible manner’ (rcuk.ac.uk). The Royal Society report *Science as an open enterprise* (2012) provides a comprehensive picture of the enablers (computational and communications technologies), challenges (requirement for cultural change, “intelligent openness”, limitations on openness) and benefits (collaboration, opportunities for new and accelerated research results) of “data-led science”[[19]](#footnote-19).

The Australian Code for the Responsible Conduct of Research (2007) states it is the responsibility of researchers to make research data ‘available for use by other researchers unless this is prevented by ethical, privacy or confidentiality matters’. The message from most funding providers within Australia and internationally is to *recommend* and *encourage* open access to research data ‘whenever they are not bound by copyright restrictions, confidentiality requirements, or contractual clauses’ (European Research Council, 2014 p2). While the majority of funding agencies are currently exercising a degree of caution by avoiding mandating open access, some such as the Australian Marine National Facility provide research teams with exclusive use of the data collected by the research team for 12 months only. After this time the Facility makes the data open to the broader research community[[20]](#footnote-20).

Monash University is preparing for a time when others follow suit. The university is working with their researchers “to assist in the transition to an environment where data sharing will increasingly be mandated by funders, and where open data becomes a normal and expected part of research” (Splawa-Neyman, Dickson, Kannan, 2015). This is driven not only by an expectation that funding agencies will in future wield an open access ‘stick’, but by the benefits of open access data to the research community. These include increased citations for publications that include datasets (Piwowar and Vision, 2013), time saved by reusing existing datasets, opportunities for world-changing discoveries, academic rigour, business innovation, and better informed policy decisions.

From open access publishing to open data, research is evolving as an open enterprise. Open Science takes this notion of openness within the academy to the broader community. The *Science as an Open Enterprise* report suggests that ‘a realistic means of making data open to the wider public needs to ensure that the data that are most relevant to the public are accessible, intelligible, assessable and useable for the likely purposes of non-specialists’ (The Royal Society, 2012). This approach applies across all potential audiences and usages of data, including government, professions, industry and the public.

There are obvious challenges and potential limitations. Governance and standards, privacy, ethics and commercial competitive practices need to be addressed. In practice however open science is taking shape across different industries and in different forms. The US Materials Genome Initiative for Global Competitiveness (2011), for example, calls for “data transparency and integration” (p6) to meet the aim “not only to allow researchers to easily incorporate their own data into models but additionally to enable researchers and engineers to incorporate each other’s data” (p10). In 2013 the medical device company Medtronic allowed Yale researchers full access to its data in order for them to independently review (with full control over the results) a back surgery device called Infuse. Such access to data and control over the results (which in this case were not favourable to the company) is rare, however it is perhaps an indication of how openness is becoming pervasive across all sectors (Herper, 2013).

One extension of open science, Citizen Science involves the wider community in aspects of research, including data collection and description. Citizen Science is described by Ocean Networks Canada (ONC) as ‘a new way of doing science by involving volunteers who may not have scientific training, but can do research-related tasks like making and describing observation’ (oceannetworks.ca) and by the Australian Citizen Science Association as **‘a partnership between individuals and scientists for investigating pressing questions about the world’ (citizensciencealliance.org).** Citizen Science is also known as public participation in scientific research (PPSR), which the Cornell Lab of Ornithology describes as ‘organized research in which members of the public engage in the process of scientific investigations: asking questions, collecting data, and/or interpreting results’ (birds.cornell.edu).

Example projects include the ONC Coastbuster project where individuals can upload and describe photographs they have taken of debris that has washed up onto the west coast of Canada, or the Digital Fisher project where participants watch and describe what they see in deep sea videos recorded with NEPTUNE Canada underwater cameras. The Citizen Science Alliance claims ‘such projects are a necessary response to the flood of data facing researchers in many fields’.

Citizen Science is gaining strategic attention at government levels. In the second half of 2015 the US government hosted a live webcast forum “Open Science and Innovation: Of the People, By the People, For the People” (whitehouse.gov). The Forum was the fulfilment of a commitment made by the US President to co-develop with key stakeholders a shared vision for crowdsourcing and citizen science. The vision would see the country utilise the ‘idle’ potential of citizens to contribute to research outcomes, to ‘harness the ingenuity of the public by accelerating and scaling the use of open innovation methods’ and to provide students with the skills needed to excel in science, technology, engineering and math (STEM) by giving them access to participate in research projects (Office of Science and Technology Policy, 2015)

In July 2015 Australia’s Chief Scientist provided the opening remarks for the inaugural Australian Citizen Science Conference in Canberra (csna.gaiaresources.com.au/wordpress/). Local projects include Discovery Circle[[21]](#footnote-21), run from the University of South Australia and the Atlas of Living Australia[[22]](#footnote-22) where citizens can add sightings of plants or animals directly to the Atlas, participate in local animal monitoring projects such as Climate Watch or international projects such as the US-based iNaturalist.

*1.1.c Implications for careers and training*

Such fundamental change has and will continue to see demand for new skill sets for researchers and new career pathways for professional staff. The latter are no longer viewed as consultants who are brought in to work on isolated technical components of the research but are recognised as integral partners in the research team. A search of Australian University and eResearch support organisation websites reveals a range of technical and data roles which partner with researchers to deliver on eResearch outcomes:

Technical Managers and Support Officers; Software Engineers and Developers; Data Architects; Systems Administrators; e-Infrastructure Managers; e-Research Officers; High Performance Computing Support; Testers; Data Analysts; Data Support Managers and Data Librarians; Repository Managers; Multi-media producers.

Demonstrating the impact of these technological changes across society, the 2012 Forbes list of “10 jobs that didn’t exist 10 years ago” lists four eResearch/e-Science related roles: Cloud Computing Services, User Experience Design, App Developer and Market Research Data Miner. According to the article, “Library Science is a really hot degree right now… It’s a helpful knowledge set for someone hoping to manage large amounts of data” (Casserly, 2012).

This view is supported by the UK Open Research Data Forum which highlights a ‘major skills gap’ for data scientists and suggests university training should focus on: data literacy for all; the development of generic data specialists, who might be best located as part of a library function; specialists with domain expertise, who should be located in operational units (departments, centres) (2014). It is worth acknowledging here that academic librarians within Australia and overseas have embraced data management and are continually at the forefront of delivering research support using new technologies, from digital publishing to data management to 3D printing. During his presentation at the 2015 Digital Humanities Conference[[23]](#footnote-23), Gale Publishing’s Ray Abruzzi believes most successful digital project partnerships involve the Library. At McMaster University, Canada, the Sherman Centre for Digital Scholarship[[24]](#footnote-24) has almost entirely been funded and resourced by the Library.

Researchers across all disciplines are acquiring basic software development and computational data management and analysis skills. Both Software Carpentry and Data Carpentry are not-for-profit organisations whose volunteer members teach researchers basic skills in these areas. In the case of Software Carpentry, basic programming workshops are delivered to researchers world-wide by volunteer trainers. Data Carpentry focuses on fundamental domain-specific data management and analysis skills for audiences with ‘little to no prior computational experience’ (datacarpentry.org). The University of Melbourne’s Research Bazaar is the training component of the University’s Research Platform Services and has delivered a number of Software Carpentry workshops. The Bazaar focuses on training and skill development through communities of practice ‘where researchers from many different disciplines can come together to share knowledge’ (melbourne.resbaz.edu.au). A critical element to these programs is the fact they are run by researchers:

“Unlike professional software developers, the researchers teaching our courses can remember what it’s like not to understand this stuff, which makes for a much better learning experience!”

The development of these skills enables researchers not only to adapt their research practices in light of existing technologies, but more importantly to adapt to new technologies and develop a language that enables effective collaboration with technologists. Organisations who have been down this path suggest agility, mobility and creativity are attributes that are as, if not more, important than the ability to work with specific technologies. Likewise, collaborative competencies and a learning mindset are critical in this space.

Skill gaps and how these will be met is a key concern for the sustainability of eResearch in Australia. The Status Report on the NCRIS eResearch Capability highlights the importance of establishing clear career pathways for technologists. The report makes clear recommendations that ‘future framework planning consider the continuing need to address both research workforce and technical support skills and expertise, and take up the issue of preferred strategies at both institutional and national levels’ (Cochran, 2015 p9).

*5.1.d Institutional Strategies*

The development of eResearch strategies and support within Universities has progressed at different paces over the last decade. The Queensland University of Technology first presented their approach to developing an eResearch strategy and support in 2008 (Young and Young, 2009), the Victoria University in New Zealand released their eResearch Capability Building Strategy[[25]](#footnote-25) in the same year, while the University of Cape Town has in 2015 recognised eResearch as central to research support as part of their 2015-2025 strategy[[26]](#footnote-26). Others do not address eResearch explicitly in organisational strategies but approach this via a number of research infrastructure and support initiatives.

Commonly, eResearch strategies seek to guide investment in infrastructure and technology, clarify centralised v. decentralised support, develop partnerships between IT, Libraries, Faculty Computing departments and the Research Office, guide the development of skills and careers and provide governance and communications structures.

Advisory groups are common features of organisational approaches. These groups are usually made up of representatives from IT, Library, Research Divisions and Faculties. The groups act as advisories to Deputy Vice-Chancellors of Research and serve as the central coordination and communication point for eResearch. The ANU eResearch Reference Group[[27]](#footnote-27) was set up to establish an eResearch strategy for the University, cultivate a culture of eResearch and to ensure eResearch governance is integrated with the university’s policies and guidelines. The eResearch Coordination Group[[28]](#footnote-28) at UNSW is supported by both the DVCR and the Library. The Group provides a forum for UNSW eResearch activity and a contact point for researchers and external eResearch support services.

In response to funding body requirements, data management plans and policies are also common. These are typically managed by the Library. UNSW Library requires completed data management plans from any researcher requesting allocation of storage on the University’s internal data repository. Others, such as Monash University, do not require researchers complete data management plans but indicate on their data management resource pages ‘the University is likely to consider making a formal data management plan a requirement for applying for internal research funding and for confirming PhD candidature’ (monash.edu.au).

Delivery of eResearch service, advice and support varies across institutions. The scale of support ranges from the provision of data management support and access to data storage and HPC to the establishment of eResearch or Digital Humanities Centres. The latter are often the driving force behind large-scale, high-impact eResearch projects. Monash University, for example, is among a small group of universities leading eResearch in Australia. The University has grown its eResearch Centre[[29]](#footnote-29) from a staff of five in 2008 to its current complement of 35. The majority of those staff are employed from grant funding money on eResearch projects whereby they have been key collaborators and partners on projects, rather than as technical support staff. Anecdotally, Director, Professor Paul Bonnington, claims the capability and expertise provided by the Centre as a research partner was a key factor in the university winning two recent ARC Centres of Excellence (in Integrated Brain Function and Advanced Molecular Imaging).

The Department of Digital Humanities at Kings College London[[30]](#footnote-30) has helped generate over 17 million pounds in research income over the last 15 years. Researchers collaborate on national and international research teams across a range of humanities disciplines as well as addressing eResearch challenges through projects such as PERICLES[[31]](#footnote-31) which aims to address the difficulty of safeguarding digital content in an environment that is subject to continual change.

Those institutions with established eResearch or Digital Humanities Centres have developed and are continuing to develop the in-house capability to drive competitive eResearch practice. Exemplars, as discussed on this and the previous page include Monash University and Kings College. With reference to the breadth of eResearch roles listed on page 9, technical support roles may exist in eResearch or Digital Humanities Centres, in IT departments, in Faculties or Departments (usually employed as contractors), or through a combination of these. External funding enable organisations to employ technical specialists on “soft” money but this practise is potentially unsustainable for the longer-term growth of capability within organisations. This is a challenge given that reliance on grant funding influences the work institutions do and the personnel they hire. Data management support, including the institutional repository, is most often the domain of the University Library. The Research Office also plays a role in the provision of data management advice. Regardless of the model used for service delivery there needs to be cohesion between service providers so users know which service to use and where to go for it.

Given concerns about skills shortages raised in the NCRIS Status Report and the short-term nature of competitive funding, the challenges associated with either developing in house expertise or buying this expertise in are real concerns for individual universities and the sector more broadly. In addition to this, Universities need to consider the type of skills researchers require to work in this space, as described on pages 9 and 10. Training is needed from undergraduate through to Higher Degree Research programs, in addition to the existing research workforce. Kings College delivers a digital humanities teaching program to undergraduates and postgraduate coursework and research cohorts. Other approaches may include giving curriculum credit by pairing up undergraduates with Faculty leaders to solve Faculty digital humanities problems.

The Maryland Institute for Technology in the Humanities has developed Faculty Fellowships that allow researchers to take time out from teaching to develop Digital Humanities projects. The Institute also runs a Digital Humanities Incubator series[[32]](#footnote-32), designed to ‘acculturate’ scholars, librarians and students in the practice. The University of Melbourne Research Bazaar model promotes the development of communities of practice. This approach appears to be popular in the humanities as well as the sciences and works on the basis that researcher leaders learn alongside junior staff and a culture of learning and experimentation is encouraged.

**5.2. Macquarie University eResearch Activity**

Macquarie’s activity to date is summarised below and demonstrates some engagement with eResearch across the University and in collaboration with external partners. A list of projects and activities is also available at appendix 2.

1. Infrastructure

*Data Management and High Performance Computing (HPC)*

The Information Technology unit is driving needed changes in this area. The unit is currently drafting a call-for-tender for new data storage and compute facilities for the University. The absence of adequate data storage and data storage practices has been perceived as a weakness for the University by those in our consultation groups. It has left the University open to risk as data are stored in unreliable, inconsistent and inaccessible ways and curtails the extent to which the University can acquire and access large research datasets.

In parallel to the work being done through the Information Technology unit it will be important the University implement its draft Data Management Policy and the accompanying Data Management Plan Template. These documents were outcomes of the *Seeding the Commons* project (described below under the heading Institutional Projects) and have yet to be integrated into research management practice. The Policy has not been ratified and the Data Management Plan Template is neither widely known about or used. Given the requirement from funding bodies that we clearly articulate our data management plans these documents must be revisited and made operational. Doing so will provide our researchers with much needed guidance regarding their data management responsibilities, and the support and resources available to them.

Coupled with the enhanced data storage described above, high performance computing will position the University to work with and collaborate on analyses of large datasets in significantly reduced timeframes, leading to increased capacity to produce impactful research. The type of capability provided through data storage and computational facilities will enhance our position as a research partner of choice and help us remain competitive in the increasingly large-scale world of ‘big data’[[33]](#footnote-33).

Macquarie Unviersity researchers are encouraged to contact Information Technology to discuss particular requirements to assist them with either infrastructure, software development or other services. The group will formalise eResearch IT support via the OneHelp system and will develop a suite of services for common use by Researchers.

1. Institutional Projects

*Australian National Data Service (ANDS) Projects: Seeding the Commons and Metadata Stores*

The *Seeding the Commons Project* was funded by ANDS and completed in 2014. The project team was made up of staff from IT, the Library, the Research Office, and Faculties, and was supported by staff from ANDS and Intersect. The project addressed the need for data management policy, procedures and related resources. Project outcomes included the data management policy, a data management plan template and a web-based tool-kit (available through the Research Office). As discussed above, when the project concluded there were no plans for the ongoing ownership and management of the documents and as such the policy and template have not been implemented.

The *ANDS Metadata Stores Project* was also funded by ANDS. The project team involved staff from the DVCR Office, IT, the Library, the Research Office and again was supported by staff from ANDS and Intersect. The project enabled the creation of metadata records to describe research data collections and datasets and make them discoverable in the ANDS Research Data Australia Portal. Prior to this project, the University had no comprehensive way for its researchers to describe and make research data collections discoverable. The Macquarie University Contributor page in the portal showcases Macquarie University research by grouping our data collections together.

Both projects were supported by a Steering Committee made up of representatives from the DVCR portfolio, IT, Library and Faculties. Both projects have developed outcomes and enhanced staff skills and knowledge. As such they represent excellent capital from which we can build under the guidance of a strategy.

1. Departmental Projects

*Australian National Data Service Projects (ANDS)*

At a departmental level the University has completed projects with ANDS funding for the **Department of Ancient History Papyri Data Capture project** and the **Biomolecular Frontiers Research Centre’s Glycomics Repository**. Currently funded ANDS projects include the **Biosphere and Climate Dynamics Group’s Major Open Data Collection project** and the **Biological Sciences’ Productivity in Space and Time project**, in collaboration with the University of Sydney and CSIRO.

Macquarie researchers have also collaborated on **Monash University’s Human Chr7 Proteomics Integration Project** and **Griffith University’s Australian National Corpus Project**.

*Intersect*

Intersect has been the largest full-service eResearch support agency within Australia and the key support provider for NSW universities and other research organisations. Intersect has worked with Macquarie researchers on the **Papyri collection**, **Federated Archaeological Information Management Systems**[[34]](#footnote-34), **Australian Institute of Health Innovation’s WOMBAT (Work Observation Method by Activity and Timing)[[35]](#footnote-35)** and the **Department of Computing’s Alveo virtual lab for Human Communication Science**[[36]](#footnote-36). University Librarian, JoAnne Sparks, was until recently a member of the Intersect board. Grant Sayer from Information Technology and Dr Craig O’Neill from the Department of Earth and Planetary Sciences have participated on Intersect committees.

Macquarie recently discontinued its membership of Intersect and other NSW universities are considering their position. The University’s Information Technology Unit has provided assurances that it will continue to support researchers who have relied on the expertise Intersect provided and those with emerging needs in this area. Future provision of data storage and compute will shortly go out to tender under the direction of the IT Unit, and it is anticipated these will be provided via a cloud provider. The IT Unit has consulted with Macquarie researchers regarding the services they have been engaging Intersect to provide and have noted the needs of Macquarie researchers. The Unit is committed to working with researchers to develop strategic offerings and a suite of services for common use by researchers. Researchers are encouraged to discuss their infrastructure and software development requirements with IT.

While Intersect support (software support, testing and training) has been highly valued by groups making use of these services, Macquarie’s engagement with the organisation has largely been ad hoc and institutional membership has not represented value for investment across the University. Furthermore, questions have been raised around the viability of the Intersect funding model and its long-term sustainability as an organisation. The support and services of the IT Unit and strategic guidance are essential to ensure we maximise our eResearch investment in future.

1. Building skills and knowledge

Macquarie researcher Dr Joshua Madin was involved in co-organising the first Software Carpentry[[37]](#footnote-37) teacher training workshop in Australia in 2013. Software Carpentry is a non-profit membership organisation devoted to improving basic programming skills among researchers. The organisation runs ‘train the trainer’ style workshops which provide accreditation to participants to become volunteer trainers at their local University, teaching the Software Carpentry modules. Modules include the Unix Shell, Git and Git Hub, Python, R and SQL. Currently there are three volunteer trainers at Macquarie University - Dr Joshua Madin, Dr Daniel Falster and Dr Dan Warren.

The Department of Biological Sciences Genes to Geoscience Research Enrichment Program[[38]](#footnote-38) is a PhD development program consisting of a series of workshops ranging from coding to teaching skills to career management. Three workshops are delivered to teach programming, graphs and statistics using R programming language. Dr Joshua Madin, mentioned above, is a course trainer.

1. **DISCUSSION**

The consultation and research process has highlighted the importance of strategic and coordinated approaches to eResearch at institutional levels. To inform an effective strategy for Macquarie we seek input from the research community. What direction must the University take to develop data storage and management capabilities, High Performance Computing, build capacity and develop necessary skills? How should these capacities should be managed and governed?

The consultation and research conducted by the eResearch working party has shown the University’s practice thus far to have been uncoordinated and opportunistic in the absence of a guiding strategy. The Library is working with datasets and metadata description, the Research Office hosts the Data Management Toolkit, the Information Technology unit is working on data storage and high performance computing solutions, teams within departments are developing eResearch tools, teaching basic code and working on projects that involve data sharing across institutions. Activities have occurred due to the drive and interest of individual groups and as a result we have seen the activity and progress described in the proceeding section. However the fragmented nature of this approach suggests we are likely to have missed opportunities to progress beyond our current position and we are not harnessing current activity to increase either compliance or innovation. The *ANDS Seeding the Commons* project is an example where once the funded work was complete the outcomes were not implemented.

By comparison, universities such as UNSW and the ANU have established eResearch advisory committees to guide decision making and maximise investment on service memberships and project outcomes. Mature eResearch centres at universities such as Monash and University of Melbourne and Digital Humanities Centres at Kings College and UCLA have driven capacity to win funding, build communities of expertise and contribute to a more robust research landscape.

An institutional strategy for Macquarie University needs to be clear about the role we want to play in eResearch. Progress has already commenced towards short term and essential goals which will assist with compliance and risk management although much will need to be done to ensure necessary cultural shifts accompany our improved data storage facilities. Basic compliance and risk management are underlying and necessary goals however it is the space beyond this where our strategic decision making must focus. In this space our options are to either utilise the advantages of eResearch tools without necessarily contributing to the field or to actively pursue transformative eResearch practices.

The most immediate issues for Macquarie perhaps speak to the former. In the short term the University must address its data storage and management practises, manage the gap left by Intersect, and identify means for responding to existing and emerging eResearch needs across all disciplines. Planned improvements to data sharing and HPC capacity will enable advancement of the University’s eResearch scope. In parallel we need to develop appropriate governance, clear ownership, and implement a University-wide communication strategy. Best practice suggests that central to all of this will be developing collaborative and cross-disciplinary communities of practice. How we address these needs will depend on the resources available.

The question of resources must then extend to the level of eResearch practice required to allow the University to meet its strategic objectives. If we are to produce world-leading research and deliver world-changing impact to what extent do we invest in eResearch infrastructure, tools and people to meet these aims? Where do we focus that investment and what form does it take? How do we ensure we have the right people doing the work that is needed now and who will be able to respond to future challenges? Our response to these questions will determine our direction as either a consumer of eResearch or an active contributor to transformative research practice and outcomes.

This paper aims to initiate discussion by presenting an overview of the eResearch landscape. It has provided examples of how eResearch is creating fundamental changes to the way research is done, and by doing so is opening up exciting possibilities for world-changing research outcomes. It has presented the findings from a consultation process across the University and, while acknowledging the picture is incomplete, for the first time we have brought together in one document a range of eResearch activity taking place at this university (appendix 2). The intention is that the issues and questions raised in this section of the paper will stimulate discussion about, and in turn guide the direction for where Macquarie wants to be in the international eResearch landscape, the resources the University is prepared to commit to this aim and options for getting there.

**We request the Macquarie University research community give consideration to and provide feedback on these questions:**

* In what areas, and how should the University build eResearch capacity to meet the objectives of the *Strategic Research Framework* and the *A Framing of Futures* priorities?
* Where are the opportunities for Macquarie University to harness eResearch to build on the University’s research strengths?
* How and by whom is eResearch direction guided and overseen across the University?
	+ eResearch Committee/Advisory Group?
	+ eResearch Centre?
	+ Other?
* Who needs to champion eResearch support and related activities?
* What action does the University need to take to provide, manage and govern data storage?
* What action does the University need to take to provide, manage and govern High Performance Computing?
* How and by whom is this funded?
* How do we share infrastructure?
* How do we share expertise and knowledge?
* How do we communicate and promote the work Macquarie University researchers are doing in eResearch?
* What policy and practice considerations need to underpin our eResearch activities?
* How do we build and develop a workforce with the expertise required to deliver innovative eResearch practice?
	+ Do we build collaborative projects with internal or external technologists
	+ Do we use an external service provider, similar to Intersect and have the majority of our expertise off the Macquarie University payroll?
	+ Do we hire in external contractors?
	+ Do we develop the required skills amongst our existing workforce?
	+ Do we approach this through a combination of these options?
* Where should this human capability sit within the University structure?
	+ A separate e-Research or Digital Humanities centre?
	+ Within departments or faculties?
	+ External to the University?
* How and in what will they be trained?
* What educational qualifications and background will they have?
* What academic programs are needed to support them them?
* How do we create a learning environment for our staff and students that enables the University to strengthen its eResearch capabilities?
* How do Macquarie University researchers want to collaborate using eResearch?
	+ How do we want to collaborate across disciplines?
	+ How do we want to collaborate other institutions?
* How do we introduce and involve our Undergraduate and Postgraduate and HDR cohort to eResearch?

**Please provide all feedback to Emily Brennan, PVCR Project Coordinator at Emily.brennan@mq.edu.au**

1. **REFERENCES**

American Council of Learned Societies 2006, *Our Cultural Commonwealth*, American Council of Learned Societies, New York

ARC & NHMRC (2007), *Australian Code for the Responsible Conduct of Research*, Australian Government

Casserly, M 2012, ’10 jobs that didn’t exist 10 years ago’, Forbes, 11 May 2012. Available online at <http://www.forbes.com/sites/meghancasserly/2012/05/11/10-jobs-that-didnt-exist-10-years-ago/>

Viewed 1 September 2015

Cochran, Tom 2015, *Status Report on the NCRIS eResearch capability,* Department of Education and Training

Commonwealth of Australia, Department of the Prime Minister and Cabine, National Innovation and Science Agenda, 2015

‘ERC Strategic Issues: Open Access’, *research\*eu focus*, No. 3, April 2009, European Council

European Commission (2013), *Press Release: Commission launches pilot to open up publicly funded research data*, Available online at <http://europa.eu/rapid/press-release_IP-13-1257_en.htm> (viewed 1 October 2015)

European Research Council Scientific Council (2014), *Open Access Guidelines for research results funded by the ERC*, revised December 2014

Herper, M 2013, ‘No more secrets: Medtronic shows how open science might work in the real world’, Forbes, 19 June, 2013. Available online at <http://www.forbes.com/sites/matthewherper/2013/06/19/> Viewed 1 September 2015

Hey, Tony and Trefethen, Anne 2002, ‘The UK eScience Core Programme and the Grid’, *TERENA Networking Conference,* June 2002 Limerick, Trans-European Research and Education Networking Association

McKinsey Global Institute 2011, *Big data: The next frontier for innovation, competition, and productivity*, McKinsey and Company

National Science and Technology Council (2011), *Materials Genome Initiative for Global Competitiveness*, Office of the President of the United States of America, Washington

O’Brien, Linda 2005, ‘E-Research: An Imperative for Strengthening Institutional Partnerships’, *Educause Review*, November-December 2005, pp 64-76

Piwowar HA, Vision TJ (2013) Data reuse and the open data citation advantage. PeerJ 1:e175 [https://dx.doi.org/10.7717/peerj.175 Viewed 1 October 2015](https://dx.doi.org/10.7717/peerj.175%20Viewed%201%20October%202015)

Reid, A 2015, Highlights of the eResearch Australasia 2015 conference, *AARNET News*. <http://news.aarnet.edu.au/higlights-of-the-eresearch-australasia-2015-conference/> Viewed 30 October 2015

Research Councils UK (2015), *RCUK Common Principles on Data Policy*. Available online at <http://www.rcuk.ac.uk/research/datapolicy/> Viewed 15 October 2015

Splawa-Neyman, P, Dickson, N, Kannan, A (2015), Poster Presentation “Imaging Locus”, *ANDS Open Data Showcase*, 19 June 2015, Canberra

The Royal Society 2012, *Science as an Open Enterprise*, The Royal Society Science Policy Centre, London. Available online at <https://royalsociety.org/topics-policy/projects/science-public-enterprise/report/>

The Royal Society 2014, UK Open Research Data Forum Report. Available online at <http://www.researchinfonet.org/wp-content/uploads/2014/07/Jan-2014-Forum-Report.pdf>

UK Foreign & Commonwealth Office (2013), *G8 Science Ministers Statement*. Available online at [https://www.gov.uk/government/news/g8-science-ministers-statement](https://www.gov.uk/government/news/g8-science-ministers-statement%20Viewed%201%20October%202015)

US Committee on Coherence at Scale and UK Open Research Data Forum (2014), *Statement on the Principles of Open Data*. Available online at <http://www.researchinfonet.org/wp-content/uploads/2014/07/Joint-statement-of-principles-June-2014.pdf>.

The White House 2015, Fact Sheet: Empowering Students and Others though Citizen Science and Crowdsourcing, Office of Science and Technology Policy, Washington, 23 March 2015

[Young, Carolyn D.](http://eprints.qut.edu.au/view/person/Young%2C_Carolyn.html) & [Young, Joseph A.](http://eprints.qut.edu.au/view/person/Young%2C_Joseph.html) (2009) A University Support Model for eResearch. In eResearch Australasia 2008, 28 Sept - 3 Oct 2008, Melbourne. (Unpublished)

Available online at <http://eprints.qut.edu.au/28308/>

**Webography**

Citizen Science Alliance, viewed 1 October 2015, <http://www.citizensciencealliance.org/philosophy.html>

Cornell Lab of Ornithology

<http://www.birds.cornell.edu/citscitoolkit/about/defining-citizen-science/>

EGI-Engage, viewed 1 October 2015, <http://www.egi.eu/about/egi-engage/index.html>

Internet2 US-China Collaboration Initiative, viewed 1 October 2015, <https://china.internet2.edu/about/>

Ocean Networks Canada

<http://www.oceannetworks.ca/>

Open Science and Innovation: Of the People, By the People, For the People, viewed 1 October 2015 <https://www.whitehouse.gov/blog/2015/09/09/open-science-and-innovation-people-people-people>

Open Science Grid, viewed 1 October 2015, <http://www.opensciencegrid.org/>

Rufus Pollock (the online home of Rufus Pollock), viewed 1 October 2015, <http://rufuspollock.org/misc/>

**APPENDIX 1: OVERVIEW OF SOME OF AUSTRALIA’S E-RESEARCH SERVICES**

|  |  |
| --- | --- |
| **National Collaborative Research Infrastructure Strategy (NCRIS)** | **Description** The Strategy supports partnerships between the research sector, business, industry and government. Examples of NCRIS funded projects include ANDS and NeCTAR (described in this table) as well as the Pawsey Supercomputing Centre and the Australian Urban Research Infrastructure Network (AuRIN). A list of all currently funded NCRIS projects can be found below. NCRIS network currently supports 27 projects, involving 222 institutions and 1700 staff. NCRIS facilities are used by over 35,000 researchers locally and internationally.In 2014-15, based on recommendations from the National Commission of Audit (NCoA), the government undertook a review of research infrastructure, the results of which have not yet been made public. In the meantime the government has committed $150 million to support existing NCRIS projects remain operational until mid-2016 and allow them to position themselves for the period beyond June 2016.  |
| **Funding Sources**The Australian Government funds NCRIS. Government funding for NCRIS projects in recent years:* 2013 – 2014: $80 million
* 2014 – 2015: $100 million
* 2015 – 2016: $150 million

Projects are funded largely by NCRIS and contributions from State Governments, Universities and research organisations. Initial funds can be leveraged to secure funding from other schemes or sources. The objective of 2015-16 funding is to ensure the facilities currently supported under NCRIS 2013 funding remain operational until mid-2016 and allow them to position themselves for the period beyond June 2016. The Australian Government has committed funding for NCRIS until mid-2017.  |
| **Responsibilities*** supports a national collaborative research infrastructure network to enable Australian researchers to address key national and global challenges;
* provides the Australian membership fees for the European Molecular Biology Laboratory.

Funding under NCRIS is currently guided by the 2015 program guidelines which set out the intention to support currently funded NCRIS projects to remain operational until mid-2016 and allow them to position themselves for the period beyond 30 June 2016.  |
| **Currently Funded Infrastructure Projects** Astronomy Australia Ltd., Atlas of Living Australia, AuScope, Australian Animal Health Laboratory, Australian Microscopy and Microanalysis Research Facility, Australian National Data Service, Australian National Fabrication Facility, Australian Phenomics Network, Australian Plant Phenomics Facility, Australian Plasma Fusion Research Facility, Australian Urban Research Infrastructure Network, Biofuels, Bioplatforms Australia, European Molecular Biology Laboratory Australia, Groundwater, Heavy Ion Accelerators, Integrated Marine Observing System, National Computational Infrastructure, National Deuteration Facility, National eResearch Collaboration, Tools and Resources, National Imaging Facility, Nuclear Science Facilities – Bragg Institute, Pawsey Supercomputing Centre, Population Health Research Network, Research Data Storage Infrastructure, Terrestrial Ecosystem Research Network, Translating Health Discovery.  |
| **Interaction with Macquarie**ANDS Projects Seeding the Commons and Metadata Stores (complete)NeCTAR CloudTERN (Terrestrial Ecosystem Research Network) “connects ecosystem scientists and enables them to collect, contribute, store, share and integrate data across disciplines”. Involved 27 university partners, CSIRO and more than 25 other research organisations, Australian, state and territory government agencies, non-government organisations. (complete)AuScope (ARC CoE for Core to Crust Fluid Systems (CCFS)) |
| **Australian National Data Service** | **Description**The Australian National Data Service (ANDS) was established in 2009 and is funded under the NCRIS to lead the creation of a cohesive national collection of research resources and a richer data environment that will:* make better use of Australia's research outputs
* enable Australian researchers to easily publish, discover, access and use data
* enable new and more efficient research

ANDS’ mission is to transform Australia’s research data environment by making Australian research data collections more valuable by managing, connecting, enabling discovery and supporting the multiple use of this data.  |
| **Funding Sources**ANDS is funded by the Australian Government through the National Collaborative Research Infrastructure Strategy (NCRIS). The current ANDS business plan (2015 – 2016)  |
| **Responsibilities**ANDS is responsible for * making Australian research data collections more valuable by managing, connecting, enabling discovery and supporting the reuse of this data
* enable richer research, more accountable research; more efficient use of research data; and improved provision of data to support policy development

ANDS partners with universities and other research organisations on funded projects, delivers national services such as Research Data Australia repository and Cite My Data, helps build communities of practice and is building the Australian Research Data Commons.  |
| **Interaction with Macquarie**Seeding the CommonsMetadata StoreAt a departmental level the University has completed projects with ANDS funding for the **Department of Ancient History Papyri Data Capture project** and the **Biomolecular Frontiers Research Centre’s Glycomics Repository**. Currently funded ANDS projects include the **Biosphere and Climate Dynamics Group’s Major Open Data Collection project** (<https://projects.ands.org.au/id/MODC14>) and the **Biological Sciences’ Productivity in Space and Time project**, in collaboration with the University of Sydney and CSIRO (<https://projects.ands.org.au/id/AP28>). Macquarie researchers have also collaborated on **Monash University’s Human Chr7 Proteomics Integration Project** (<https://projects.ands.org.au/id/AP32>) and **Griffith University’s Australian National Corpus Project** (<https://projects.ands.org.au/id/NCRIS012>).  |
| **NeCTAR** | **Description**NeCTAR is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy to provide eResearch infrastructure in partnership with Australian research institutions, organisations and research communities. NeCTAR’s focus is on research infrastructure that enables remote access to national facilities through virtual laboratories, eResearch tools, the Research Cloud and a national Server providing a hosting environment for core national eResearch and research infrastructure services.  |
| **Funding Sources**NeCTAR was established through the Super Science project, financed by the Education Investment Fund. The University of Melbourne has been appointed as the Lead Agent. |
| **Responsibilities**Since August 2011 NeCTAR has partnered with Australian research community to develop and operate 11 Virtual Laboratories, 16 eResearch Tools providing online access to domain-specific research tools, a National Research Cloud, a National Server. |
| **Interaction with Macquarie**Macquarie University is lead organisation on the NeCTAR funded UniCarbKB initiative that ‘aims to promote the creation of an online information storage and search platform for glycomics and glycobiology research.  |
| **Intersect** | **Description**Intersect was established in 2008 and has been the largest full-service eResearch support agency within Australia and the key support provider for NSW universities and other research organisations. The agency provides support at the research planning stage (helping researchers scope advanced IT requirements and advising on advanced IT solutions), the research conduct stage (through high performance computing, cloud computing and hosting services, research data management and eResearch tools), and at post-project stage (through data storage archives). Their service extends to training, consulting and advice, and software engineering.  |
| **Funding Sources**Member subscription feesEngineering incomeSupported by Commonwealth and State government investments |
| **Responsibilities**Training, consulting and advice, and software engineering.   |
| **Interaction with Macquarie**Macquarie has recently discontinued its membership of Intersect and other NSW Universities are taking a similar direction. Past projects with Intersect include the Papyri collection and the Department of Computing’s Alveo virtual lab for Human Communication Science, led by the University of Western Sydney. Research teams who also used Intersect to develop eResearch tools (and continued to utilise Intersect support post development) are the Federated Archaeological Information Management Systems (FAIMS) team, and the Australian Institute of Health Innovation in the development of WOMBAT (Work Observation Method by Activity and Timing). |

**APPENDIX 2: SUMMARY OF MACQUARIE UNIVERSITY E-RESEARCH INVOLVEMENT AND ACTIVITY**

**ANDS Seeding the Commons**

|  |  |
| --- | --- |
| Grant Sayer, Information Technology | Project leader and steering committee |
| Vladimir Bubalo, Library | Project Team |
| Maureen Kattau, Library | Project Team |
| Semira Dautovic, Research Office | Project Team |
| Gill Ellis, Faculty of Arts | Project Team |
| Kerry Todd-Smith, Faculty of Business and Economics | Project Team |
| Josephine Morton, Library | Researcher Interviews |
| Professor Jim Piper, DVCR | Project Sponsor  |
| Fiona Burton, Library | Steering Committee |
| Tori Hocking, DVCR Office | Steering Committee |
| Louise Fleck, Research Office | Steering Committee |
| Professor Peter Nelson, Faculties | Steering Committee |
| Professor Mark Wiggins, Faculties | Steering Committee |
| Luc Small, Intersect | Intersect Support |
| Stuart Allen, Intersect | Intersect Support |

Project Overview

<https://projects.ands.org.au/id/SC11>

Project Outcomes

<http://www.research.mq.edu.au/current_research_staff/data_management/managing_research_data/research_toolkit/new_to_data_management>

**ANDS Metadata Stores**

|  |  |
| --- | --- |
| Dianne Hillier, DVCR Office | Project Manager |
| Semira Dautovic, Research Office | Project Team |
| Vladimir Bubalo, Library | Project team |
| Josephine Morton, Library | Project Team |
| Nishan Naidoo, Library Information Technology | Project Team |
| Noel Valenti, Information Technology | Project Team |
| Marcelle Douglas, Information Technology | Project Team |
| Blossom Wong, Information Technology | Project Team |
| Warwick Burdge, Information Technology | Project Team |
| As above (Seeding the Commons) | Steering Committee |
| Stuart Allen, Intersect | Intersect Support |

Project Overview

<https://projects.ands.org.au/id/MS19>

Project Outcomes <https://researchdata.ands.org.au/search/#!/p=1/group=Macquarie%20University/>

**ANDS Macquarie University Glycomics Repository**

|  |  |
| --- | --- |
| Professor Nicolle Packer  | Lead Researcher |
| Dr Matthew Campbell | Researcher, Developer, Data Source Admin |

Project Overview <http://ands.org.au/news/andsnapshot.html>

Project Outcomes <https://researchdata.ands.org.au/glycosuitedb-a-glycan-structure-repository-catalogue/19266>

**Macquarie University Papyri Data Capture**

|  |  |
| --- | --- |
| A/Professor Malcolm Choat | Lead Researcher, Data Source Administrator |
| Dr Trevor Evans | Researcher |

Project Overview <https://projects.ands.org.au/id/DC12C>

Project Outcomes <https://papyri.mq.edu.au/>

**Productivity in Space and Time (ePiSaT)**

|  |  |
| --- | --- |
| Professor Iain Colin Prentice | Project Manager |
| Bradley Evans | Developer |

Project Overview <https://projects.ands.org.au/id/AP28>

Project Outcomes <http://episat-software.blogspot.com.au/>

**ANDS Macquarie University Major Open Data Collection (in progress)**

|  |  |
| --- | --- |
| Dr Ines Hessler  | Project Manager |
| Mr Vladimir Bubalo | Project Team |

Project Overview <https://projects.ands.org.au/id/MODC14>

**Alveo (Above and Beyond Speech, Language and Music), led by UWS**

|  |  |
| --- | --- |
| A/Professor Steve Cassidy | Product Owner |

Project Overview and Outcomes: <http://alveo.edu.au/>

**DADA-HCS (funded by the ARC Special Research Initiative on eResearch)**

|  |  |
| --- | --- |
| A/Professor Steve Cassidy | Project Coordinator |

Project Overview: <http://clt.mq.edu.au/research/projects/dada/>

**FAIMS (Federated Archaeological Information Management System)**

|  |  |
| --- | --- |
| A/Professor Shawn Ross | Project Director |
| Dr Adela Sobotkova | Development Coordinator |
| Dr Brian Ballsun-Stanton | IT Leader |

Project Overview and Outcomes: <https://www.fedarch.org/wordpress/>

**WOMBAT (Work Observation Method by Activity Timing)**

|  |  |
| --- | --- |
| Professor Joanna Westbrook | Director |

Project Overview: <http://aihi.mq.edu.au/project/wombat-work-observation-method-activity-timing>

**ANDS Human Chr7 Proteomics Integration Project (Monash University)**

|  |  |
| --- | --- |
| Professor Mark Baker | Collaborator |
| Professor Nicolle Packer | Collaborator |

Project Overview <https://projects.ands.org.au/id/AP32>

Project Outcomes <http://www.ozhupohpp7.com/home> &

<https://researchdata.ands.org.au/the-proteome-browser/11319>

**ANDS Australian National Corpus (Griffith University)**

|  |  |
| --- | --- |
| A/Professor Steve Cassidy | Collaborator |

Project Overview <https://projects.ands.org.au/id/NCRIS012>

Project Outcomes <https://www.ausnc.org.au/>

**Software Carpentry – volunteer trainers**

|  |  |
| --- | --- |
| Dr Joshua Madin | Volunteer Trainer |
| Dr Daniel Falster | Volunteer Trainer |
| Dr Richard FitzJohn | Volunteer Trainer |
| Dr Dan Warren | Volunteer Trainer |
| Mr Diego Barneche  | HDR Candidate, Volunteer Trainer |

Project overview: <http://software-carpentry.org/>

This list highlights the projects and activities raised during the initial eResearch strategy consultation phase in 2015.

We welcome further input to this list.

Please provide details of eResearch projects or activity to Emily Brennan, PVCR Project Coordinator (emily.brennan@mq.edu.au)

1. Accelerate world-leading research performance; Prepare world-ready higher degree research candidates; Engage as a world-recognised research collaborator of choice; Deliver research with world-changing impact. [↑](#footnote-ref-1)
2. http://mq.edu.au/our-university/ [↑](#footnote-ref-2)
3. High Performance Computing [↑](#footnote-ref-3)
4. eRSA in South Australia, Intersect in NSW, Pawsey Supercomputing Centre in WA (previously iVEC), Queensland Cyber Infrastructure Facility, Tasmanian Partnership for Advanced Computing, V3 Alliance in Victoria [↑](#footnote-ref-4)
5. https://www.xsede.org/ [↑](#footnote-ref-5)
6. http://de.clarin.eu/en/about/overview [↑](#footnote-ref-6)
7. http://dariah.eu/about.html [↑](#footnote-ref-7)
8. Britain, Russia, Germany, Japan, Italy, Canada, France, USA [↑](#footnote-ref-8)
9. http://aurin.org.au/ [↑](#footnote-ref-9)
10. http://www.cdh.ucla.edu/projects/event-pulse/ [↑](#footnote-ref-10)
11. http://www.cdec.it/ [↑](#footnote-ref-11)
12. The World Wide Web Consortium (W3C) describes Semantic Web technologies as those that “enable people to create data stores on the Web, build vocabularies, and write rules for handling data. Linked data are empowered by technologies such as RDF, SPARQL, OWL, and SKOS” [↑](#footnote-ref-12)
13. https://www.fedarch.org/wordpress/ [↑](#footnote-ref-13)
14. https://aihi.mq.edu.au/project/wombat-work-observation-method-activity-timing [↑](#footnote-ref-14)
15. http://www.oceannetworks.ca/ [↑](#footnote-ref-15)
16. http://aws.amazon.com/1000genomes/ [↑](#footnote-ref-16)
17. http://theodi.org/blog/medicines-for-malaria-sharing-data-on-drug-discovery-key-to-disease-control [↑](#footnote-ref-17)
18. https://www.openaire.eu/opendatapilot [↑](#footnote-ref-18)
19. “the use of massive datasets to find patterns as the basis of research” (The Royal Society Report 2012) [↑](#footnote-ref-19)
20. http://mnf.csiro.au/Policies/Outputs-and-outcomes-from-research-voyages.aspx [↑](#footnote-ref-20)
21. discoverycircle.org.au [↑](#footnote-ref-21)
22. ala.org.au [↑](#footnote-ref-22)
23. http://dh2015.org/schedule-overview/ [↑](#footnote-ref-23)
24. scds.ca/ [↑](#footnote-ref-24)
25. https://ecs.victoria.ac.nz/foswiki/pub/EResearch/Resources/vuw\_eresearch\_strategy.pdf [↑](#footnote-ref-25)
26. http://www.eresearch.ac.za/sites/default/files/image\_tool/images/140/GwendaThomasPresentation\_final.pdf [↑](#footnote-ref-26)
27. https://services.anu.edu.au/planning-governance/governance/anu-eresearch-reference-group [↑](#footnote-ref-27)
28. https://research.unsw.edu.au/units/eresearchunsw [↑](#footnote-ref-28)
29. https://platforms.monash.edu/eresearch/ [↑](#footnote-ref-29)
30. http://www.kcl.ac.uk/artshums/depts/ddh/index.aspx [↑](#footnote-ref-30)
31. http://www.pericles-project.eu/ [↑](#footnote-ref-31)
32. http://mith.umd.edu/research/project/digital-humanities-incubator/ [↑](#footnote-ref-32)
33. “datasets whose size is beyond the ability of typical database software tools to capture, store, manage and analyse” – although it is acknowledged “this definition is intentionally subjective and incorporates a moving definition of how big a dataset needs to be in order to be considered big data” (McKinsey 2011) [↑](#footnote-ref-33)
34. https://www.fedarch.org/wordpress/ [↑](#footnote-ref-34)
35. https://aihi.mq.edu.au/project/wombat-work-observation-method-activity-timing [↑](#footnote-ref-35)
36. http://alveo.edu.au/ [↑](#footnote-ref-36)
37. http://software-carpentry.org/ [↑](#footnote-ref-37)
38. http://www.gg.mq.edu.au/ [↑](#footnote-ref-38)