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UNIVERSITY OF TASMANIA SUBMISSION TO THE NATIONAL RESEARCH INFRASTRUCTURE CAPABILITY ISSUES PAPER

SEPTEMBER 2016

Introduction

The University of Tasmania welcomes this opportunity to provide comments on the National Research Infrastructure Capability Issues Paper (the Issues Paper). World leading research requires an appropriate, high quality and well maintained research infrastructure and a coordinated approach to providing such infrastructure at local, regional and national scale is essential for a country such as Australia. In this context, we welcome the federal government's announcement of a $1.50 billion, ten-year commitment to the National Collaborative Research Infrastructure Program (NCRIS) – such long term planning and commitment is an essential underpinning for the support of research excellence, the development of researchers and the delivery of research which makes a signature contribution to the nation's social, cultural and economic agenda.

The University of Tasmania is a participant in a number of current NCRIS facilities.

It leads the Integrated Marine Observing System (IMOS), a large and successful national research infrastructure of which the University is justifiably proud. IMOS is the only NCRIS capability led from Tasmania and the only one led by a University outside the Group of Eight. This highlights the distinctive role played by the University of Tasmania in marine, climate and Antarctic science, both nationally and globally. A separate submission has been provided by IMOS, and is fully supported by the University of Tasmania as lead institution.

The University is a partner in AuScope, related to the Very Long Baseline Array and the GPS/geodesy facilities. The University-owned and operated AuScope Very Long Baseline Array is one of the largest and most productive research infrastructure operations at the University.

Through the Tasmanian Partnership for Advanced Computing, the University supports a regional node of the national e-Research infrastructure encompassing data storage and services, cloud computing and virtual laboratory infrastructure.

The University of Tasmania as the only university on the nation's only island state, fulfils a number of special roles in respect of the research contributions it offers to support both the land and marine environments of Tasmania, and the unique cultural heritage of the state.

We agree that both federally and at institutional level, research infrastructure must be prioritised, planned and resourced in a collaborative manner. As part of its commitment to good practice, the University has developed its own Five-year Research Infrastructure Priority Plan, to ensure that all research infrastructure commitments are strategically considered at a "whole of institution" level and within a wider state context.

In constructing this response to the Issues Paper, the University has sought responses from across all academic domains to ensure the broadest possible input at this critical stage in development of the 2016 National Research Infrastructure Roadmap. We have also contributed to regional discussion groups and through joint partner discussions. We have responded below to selected questions in the Issues Paper which reflect the main issues and interests for the University community.

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Responses to Questions:

Question 1: Are there other capability areas that should be considered?

The capability area of **Advanced Earth Sciences** should be recognised specifically at dot point 3. Earth Sciences have recently gained recognition by the Australian Chief Scientist's office as having a distinct, modern tenor as an integrative science with particular relevance to the Australian nation. Likewise, recognition of Earth Sciences will build on national strengths already recognised through the Excellence in Research for Australia (ERA) process. A decadal plan for Earth Sciences is being prepared by the Academy of Sciences, National Committee for Earth Sciences, and a submission from this group will be important in this respect.

A separate submission will be made by the National Marine Science Committee (NMSC) related to national research vessel capability. The Australian Maritime College at the University operates a Training Vessel (TV) Bluefin which currently serves primarily as a seafaring training vessel but also as a vessel for research in coastal habitat mapping, seafloor mapping, etc. There is a need within Australia for coverage of its coastal zones with vessels of >20 m, and currently south-eastern Australia is lacking in capability. In this NMSC submission it is proposed to have replacement vessels and operating time for a national coordinated alliance of research vessels that cover Australia's extensive and valuable marine estate in order to fully realise the significant benefits from our blue economy. The University supports this proposal.

Of particular relevance to climate modelling and to Tasmania we also recommend addition of:

- **An Antarctic observing system**. The announced ice breaker and over-snow research capability as part of the Australian Antarctic Strategy and 20 Year Action Plan will provide new means to access remote regions of Antarctica, but does not address the observing infrastructure required to make long-term observations in deep field regions. Australia has a poor record of maintaining long-term Antarctic observations away from the main research stations, primarily due to lack of dedicated funding. An Antarctic observing system is required to underpin both one-time and long-term data acquisitions, such as mapping large uncharted regions beneath the ice and on the continental margin, make continuous measurements of ocean water temperature, drill through 3km of ice to sample ice-bed properties and place instrumentation at this interface or sensing of the interior properties of the continent. Infrastructure needs span the marine and terrestrial environments. Further, large volume data transfer is presently unavailable from deep field Antarctica without recourse to prohibitively expensive commercial satellite systems or similarly expensive flights for manual download. Developments in remote system automation are required, including of long-range autonomous underwater vehicles for polar region conditions. The ocean and ocean-ice components of an Antarctic observing system are in scope for an expanded IMOS.
- **An airborne remote sensing capability**. We welcome the priority of satellite remote sensing in the current report but note that current or likely future satellite platforms are unable to sample with the spatial resolution or sensor flexibility of airborne platforms. Antarctica, like the Australian mainlaind, is vast and a flexible airborne remote sensing research capability is required to span the gap between point-wise, continuous ground-based measurements and regional-scale, episodic satellite measurements. Autonomous platforms provide particularly exciting opportunities to work over large distances, collecting very high resolution datasets

over key regions, such as ice sheet grounding lines where sampling at up to 100m scale is required over thousands of kilometres of ice sheet. The benefits of such a capability extend to the Australian mainland and offshore regions.

- **Guardianship of our cultural heritage through Digital Humanties research**: The development of national support for a digital portal(s), for the significant physical cultural artefacts which Universities hold across Australia must be considered as an urgent priority. No one institution can develop the infrastructure needs to utilise state of the art digitization technologies to capture and expose the rich research opportunities which the Australian university cultural collections offer and consequently make them available to wider academic and cultural audiences. The development of a national plan for digital humanities which provides for example, regional nodes which specialise in particular digitisation facilities and resources to create a national framework.

Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure?

The eight governance principles listed are all considered appropriate. However, we suggest possible inclusion of ninth and tenth principles, namely 'evidence driven decision making' (9th principle) and 'independence of decision making' (10th). The 10th in particular underpins all good governance models and should be explicitly stated in the governance of a large national research infrastructure program.

In terms of NCRIS governance, NCRIS needs to review and manage the NCRIS areas. The key element from a governance aspect is that the NCRIS areas are **performing** to the specified expectations of their respective strategic research communities. NCRIS should ensure that the **utility** of the NCRIS investments still meets the needs of Australian research programs and priorities.

NCRIS needs to adopt a long term perspective and manage research infrastructure on a five to 10 year basis. It also means, for example, moving away from the current approach of one year contracts, which leads to high levels of overhead and loss of key expert technical expertise, and in some ways low levels of accountability and to less than strategic decision making.

NCRIS needs to promote arrangements that facilitate alignment of proposals such that resources can be supported in a coherent way. An example is where researchers place bids into the Australian Research Council (ARC) for ARC Discovery projects that also need NCRIS areas to support their projects, or where landmark facilities like the Marine National Facility *RV Investigator* or *RV Aurora Australis* are needed. The current arrangements mean that researchers would apply to ARC for funds, and independently apply for funds for an NCRIS facility or ship time and be separately assessed on the merits again – multiple proposals, multiple review systems, and different timelines of funding announcements/schedules. In a world of limited resources, the ARC project may be funded, and the ship-time bid may not be funded or vice versa. Similar things could occur for access to other large research facilities, such as synchrotrons, astronomical observatories (such as for Gemini) or for high performance compute time at the National Computational Infrastructure (NCI).

The challenge is to get the funding bodies to work together so that, for example, successful funding proposals from ARC also lead to the required resources for the project from the associated infrastructure guardians. The National Science Foundation (NSF) in the United States and National Environment Research Council (NERC) in the United Kingdom both manage the allocation of research funds and infrastructure access in a properly coordinated and aligned way. Australia

should have a similar system which will lead to optimal outcomes and alignment of research outcomes.

Question 3: Should national research infrastructure investment assist with access to international facilities?

High quality national research infrastructure is critical for Australia's participation and leadership capacity in international research community and scientific organisations. For example, Australia has been and is represented at the highest international bodies in Geodesy (former president of the International Association of Geodesy, current Chair of the International Global Navigation Satellite Systems Service, current Chair of the committee responsible for implementing the next generation (Very-long-baseline interferometry (VLBI) network), which are exclusively organised as best-effort organisations. It is present on the steering committee of the Global Ocean Observing System (GOOS) via IMOS. These international leadership positions need to be recognised and must be accompanied by commitments for contributions to international working groups and hosting operations and analysis centres as part of the Australian research infrastructure.

Assistance with subscriptions for and access to international facilities should constitute an important part of Australian infrastructure investment. Such access is vital for promoting international collaborations, showcasing the capabilities of Australian researchers and research outcomes, and providing Australian researchers with access to state-of-the-art infrastructure currently unavailable in Australia. The list of supported international infrastructure should be continuously assessed and updated based on availability of infrastructure within Australia. Where it is impractical or cost-ineffective to provide national infrastructure capacity, access to international infrastructure needs to be managed equitably at a Government level and the procedures for accessing this support should be transparent. Where support is only required for an individual researcher or small group, the home institution should provide the support but be linked into the national coordinating body.

As part of access to international facilities, the current Australian system would benefit from a more co-ordinated and strategic approach. At the present time, University researchers apply to the ARC under the Large Infrastructure, Equipment and Facilities (LIEF) scheme. The LIEF scheme typically has an annual budget of some $30 million, and access via subscriptions to large international researcher facilities, such as Gemini or the ships under the International Ocean Discovery Program (IODP), consumes something of the order of 25-30 per cent of the LIEF budget on an annual basis. There should be an international science consortia scheme run within Government that has funds in excess of say $50 million per annum (to be determined) to cater for access by Australian researchers to international research facilities on a competitive basis. In this way, Australian researchers will have access to world-leading facilities, gain expertise and establish unique collaborations with other international scientists. If this approach was taken, the ARC LIEF scheme could be re-designed to more properly distribute infrastructure spending across the University sector.

Question 4: What are the conditions or scenarios where access to international facilities should be prioritised over developing national facilities?

Where possible, cutting-edge research infrastructure should be available in Australia. Access to international facilities should be considered where necessary, and in some cases while similar infrastructure is being developed in Australia. Permanent reliance on international infrastructure should only be considered in exceptional circumstances where the costs of such infrastructure on a national scale are clearly prohibitive.

Access to international facilities should also occur where costs of access to national facilities would exceed the typical support allocated to designated NCRIS program areas. For example, where the costs of a ship specifically for drilling in the deep ocean exceed the program expenditure.

A separate budget for access to and subscriptions for international research facilities and consortia is also urgently required. As noted above, such subscriptions, including the Integrated Ocean Drilling Program (IODP), Gemini Program and Australian Synchrotron are funded from the ARC LIEF program, consuming up to 25-30 per cent of the LIEF budget. Being subject to competing priorities within the application process is not helpful for long term planning for Australian scientists requiring long term participation in international consortia – this could be overcome through establishment of a separate international consortia funding pool.

Question 5: Should research workforce skills be considered a research infrastructure issue?

A skilled research workforce is essential to maximise effective use of national research infrastructure. However, this is a shared cost with research institutions also having a mandate and responsibility to provide a highly skilled research workforce.

It is essential to recognise highly qualified technical and scientific support staff as part of the infrastructure as they are required for optimal utilisation of the infrastructure. For example, the Australian synchrotron and geospatial infrastructure utilise cutting-edge technology and current results show clear technique-specific systematic errors which can only be resolved by understanding the complete system, from operation through analysis. Technical and support staff who understand not only the instrumentation, but also play a role in the science programs ensure the maximum return from infrastructure investment as they provide the crucial bridge between infrastructure design and usage and researcher functions.

A well-developed workforce with rich technical skills will need to dovetail with the development and sustainment of infrastructure. In some cases key, skilled personnel may need to be considered as an integral part of the infrastructure; hence, as infrastructure develops, training and skill development in specific roles will need to progress in parallel with the deployment and usage of physical infrastructure. A connected strategic conversation with research training providers is needed to optimise the recruitment, retention and development of technical capability and capacity long term.

Question 6: How can national research infrastructure assist in training and skills development?

Skills development will occur by implementing schemes that allow access to infrastructure specifically for training purposes. The 'next wave' program run by the Marine National Facility (MNF) is an exemplar; the MNF has policies and procedures in place that explicitly address training the next generation of blue water marine scientists *and* voyage leaders as part of the annual cruise planning assessment under the transit voyage opportunities or piggy-back cruise options.

Question 7: What responsibility should research institutions have in supporting the development of infrastructure ready researchers and technical specialists?

In both specific and general terms, research institutions should be providing opportunities to access infrastructure through Honours, Higher Degree by Research (HDR) and early career researchers, as well as routes for established researchers to engage in up-skilling and further professional development. Hence, the training and professional development opportunities for all researchers, and skilled technical professional staff should at the very least provide familiarity with major

national infrastructure such that these current and future users are keen to undertake advanced training as appropriate to the field and the system ensures diversity and equity of access. The more technically enabled staff we have as a nation, the better the outcomes from our national infrastructure and the better placed the nation is to take a lead in innovation and be competitive across the international research community.

Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?

To some degree, access principles may need to be determined at a facility level. However as a general principle, access should be given first to research users on a competitive application basis and secondly on a paid subscription basis. We strongly recommend that access to facilities should be tied, wherever possible, to major grants programs – the requirement to apply for both grant/program funding and separately for infrastructure access is both costly and inefficient and can lead to poor quality outcomes and a poor return on investment.

As a general principle we note that limited access and under-utilisation of large infrastructure usually go hand in hand. More funding towards coordinated access programs is required at all levels. The governance of programmes supported as part of NCRIS also bears examination; strong governance and independent strategic oversight is the primary enabling director of both effective utilisation and research outcomes of national significance and impact.

Question 10: What financing models should the Government consider to support investment in national research infrastructure?

The NCRIS-type funding model has been hugely successful as a research and science activity enabler. In the 21st century, there are numerous benefits from a whole-of nation approach. Without doubt this style of support should be expanded. The Government might also consider a funding model that provides for expert teams to use subsets of the infrastructure to build national and indeed internationally significant datasets, e.g. the US EarthScope model for continent-imaging dovetails with the Australian Uncover initiative. Such planning leads to world-class integrative fundamental science.

When allocating funding to support and enable research infrastructure, it is critical that sufficient resources are provided to maintain the continuity of long-term time series which form the foundation on which new and innovative research findings are based, whilst also maintaining pathways for future upgrades to keep up with international developments. For example, the power of observational programs to provide crucial information about climate change and sea-level lies in continuous time series spanning from decades up to a few centuries (e.g. historical tide gauge observations coupled with next generation satellite altimeter measurements, validated by IMOS for the Southern Hemisphere). The benefits of these programmes to the nation are only being fully realised now.

Another critical dimension for Australia, is the building and taking part in a global network of infrastructure programs as part of this nation's responsibility to be an effective partner in international science. Where Australia is able to, it should commit resources.

Such programs, for example, relate to measuring the ever changing shape, gravitational field and rotation of the restless Earth which relies on a homogeneous, compliant global network of geodetic sensors and observatories. Co-location of multiple instruments, utilising the specific knowledge and

expertise of different research groups, as well as coordinating global observations is essential. It is therefore absolutely crucial to secure long-term operations funding for components of significance for Australia and its environs, such as infrastructure for earth sciences, astronomy, oceanography, etc., where Australia can contribute to international science. Pathways for future upgrades of infrastructure need to be made possible, to maintain an appropriate presence with the rest of the world. Equally, strategic participation and role sharing will ensure that Australia has access to key research infrastructure opportunities it could not afford to explore independently.

The opportunity for Australia to join with other Southern Hemisphere partners, e.g. New Zealand, and offer an aligned 'Pacific research voice' is also worthy of more detailed consideration within NCRIS and across a number of government departments concerned with defence, environment, development and economic competitiveness in key sectors.

It should also be recognised that some needs for national research infrastructure are perennial and essentially indefinite; a good example of this is the need for open and data discovery and management systems. A cohesive, integrated, and consistent national approach to open data and data management will optimise the value of Australian research data, and is required in perpetuity.

Question 12: Are there international or global models that represent best practice for national research infrastructure that could be considered?

Some sound principles which should apply to national research infrastructure are:

- *Merit-based access for all Australian-based researchers on the basis of independently peer-reviewed proposals. Where Australian researchers can access strategic international facilities on a similar basis, Australia should reciprocate for those nations.*
- *A balance between developing infrastructure, targeting new and innovative research programs and maintaining support for underpinning infrastructure which provides fundamental reference data and/or continuity in important long-term time series/measurements.*
- *Infrastructure is both the equipment and the technical and support staff who are experts in its development, operation and maintenance and exploration capabilities. Technical and support staff who understand not only the instrumentation, but also play a role in the science programs ensure the maximum return from infrastructure investment as they provide the crucial bridge between infrastructure and researcher.*

These core principles are evident in the development, delivery and access to national infrastructure in the United States, United Kingdom, European Union and New Zealand.

Question 14: Are there alternative financing options, including international models that the Government could consider to support investment in national research infrastructure?

As noted above, a shared model of supporting long-term research infrastructure needs could be considered on an international basis. International subscription programs do exist in science, such as the IODP and Gemini program, but are limited. Another example, Antarctic and Southern Ocean research is expensive and international coordination will be important to maintain next generation equipment, especially in the most remote regions, in a cost-effective manner. The Council of Managers of National Antarctic Programs is one existing framework that would allow such coordination in partnership with the Scientific Committee for Antarctic Research.

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Health and Medical Research

Question 17: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Health and Medical Sciences capability area?

Current capabilities are focused on the basic biomedical sciences and high-tech equipment needs and less on the equally important translational research and clinical practice outcomes. What is increasingly needed are mechanism for coalescing and aggregating researchers and clinicians into co-located space and new training facilities within/adjoining hospitals/health centres to enable more effective translational health outcomes research. NCRIS might give some attention to consideration of a series of connected regional centres of excellence each with specialist infrastructure provision to better support the capture of critical mass to enable effective translational research. The University would welcome the opportunity to contribute to these discussions especially in domains such as clinical translational medicine [CTM]. For example, at a national level in the United States, United Kingdom, Germany, Australia, Brazil, and Singapore, institutes have been established that create a strong link with industry and cut across various areas of science and medical practice to advance translational dynamics. Australia should evaluate these models and establish its own fit for purpose variant.

Environment and Natural Resources Management

Question 18: Are the identified emerging directions and research infrastructure capabilities for Environment and Natural Resource Management right? Are there any missing or additional needed? (Environment and Natural Resource Management)

In a marine context, there is a critical need for IMOS to be sustained and enhanced in observation of biological systems, including in inshore coastal systems where the majority of human impacts on marine systems occur. IMOS recognises this need and is heading in this direction. It is well positioned to respond if adequate resources are available. Given pressure on marine resources, the vastness of the nation's marine estate and its importance to our economy, some rethinking of the quantum of funding to marine observing is warranted so that biological / ecological systems can be adequately observed.

A national research centre for marine biosecurity is also worthy of consideration given the need for such a centre has been articulated strongly in several government reviews which have also recognised the risk and lack of targeted investment in a domain of national economic significance. A model wherein NCRIS pump primed the infrastructure development of a national centre is deserving of further attention and the University would welcome the opportunity to support NCRIS in developing such a conversation.

In Section 6.2.1 Atmospheric Observations, the Issues Paper has the statement:

The Marine National Facility's (MNF) RV Investigator is a step change in multi-disciplinary, blue water research vessel capability. This national facility is however oversubscribed in the proposal phase by a factor of three to four times the available sea time. There is extraordinary pent up demand for this facility and the services that it provides. The MNF only operates 180 days per year, instead of the 300 days that was promised and planned for in the original operations. The extra 120 days of deployment of the ship would provide improved access for the research community and allow multi-year proposals. Better coverage of the Australian coasts could be achieved by a range of smaller, coastal vessels distributed around Australia, and these vessels should also be operated as part of the

larger MNF facility. The United States of America operates a coordinated scheme using such a model.

In Section 6.2.2 Marine environment, the Issues Paper says:

"To maintain Australia's world leadership in marine science, particularly in the Southern Ocean and the Antarctic, ocean observation and monitoring, blue water research and related data modelling and simulation capabilities need to be sustained"

It would be more appropriate to say needs to be enhanced substantially, in particular for the observational programs such as IMOS. For example, IMOS provides the cornerstone investment for Australia's participation in the global Argo float program. Continued uncertainty and downward pressure on IMOS funding, coupled with funding reductions in climate science programs that have provided co-investment, means that Australia has reduced the number of Argo floats that we deploy on an annual basis. The Argo array around Australia will soon not have the required Argo data density for Australia's major blue-water monitoring program.

In Section 6.2 Desirable New Capabilities, the Issues Paper says:

"There are several areas of existing national capability that should be built up,…"

We suggest that the following areas could be built up:-

- *The number of ship days for the MNF RV Investigator (up to 300 days); Sustaining and enhancing IMOS, including Australia's contribution to the Argo array; Support for the software infrastructure needed to create a cohesive national climate model. Australia's main climate model capability is currently ACCESS (Australian Community Climate Earth System Simulator) largely created by Commonwealth Scientific and Industrial Research Organisation (CSIRO) and used in the Australian CMIP6 simulations, and widely used by university researchers.*
- *The software that makes up the ACCESS model is really an infrastructure that needs to be managed and deployed on Australian computing facilities. Support needs to be provided to keep the software up to date, to keep the agreed variants of the model available for researchers to use and experiment with. While such infrastructure can be resource intensive, it then provides a framework that the researchers can operate within, and consequently there are significant savings to be had from reduced duplication, accelerated outcomes, and a cohesive community with a single focus and single facility to work with. Co-benefits also result from greater access by research organisations, students, etc. Governance is a critical component of such a facility, and must have a high level of engagement from the research community in the design and development of the model physics, thus providing the pathway for research to operational outcomes, of improved model skill and performance.*

The University is also a strong advocate for national investment in a nodal infrastructure framework to enable the development of Digital Humanities across all Australian universities where it relates to the digitization of, and open access to rare physical collections of national cultural significance. NCRIS is encouraged to initiate the national Digital Humanities Project drawing on international best practice to ensure that the guardianship of some of this nation's most significant cultural collections is adopted as a priority. Further comment is offered in the relevant section below.

Section 6.2.4 Solid Earth, does not seem to recognise the importance of marine geology and marine geophysics for understanding the solid earth. In comparison, the Marine Environment section was completely water and biology focused. Earth Sciences is practiced in the marine environment and as a research community we should be recognising the need to integrate the onshore and offshore activities. In terms of the infrastructure, the new and upcoming offshore capabilities represented by the RV Investigator (with more sea-time) and the new Antarctic icebreaker, means that it could be possible to have a better integration of the offshore and onshore geology and geophysics.

Additionally, Australia could use these platforms to augment our current investment in international programs such as the Integrated Ocean Drilling Program (IODP) – which typically address climatic and oceanographic research questions, globally.

Other emerging directions for consideration are in the broad field of geosciences which should include micro- and nanoscale characterisation of solid earth materials. The existing AuScope infrastructure needs to be expanded to include such infrastructure as a National Facility rather than the current model where individual universities host such infrastructure without a national framework.

A further recommended emerging capability is that of autonomous systems which form an emerging direction across both Environment and Natural Resource Management, Advanced Physics, Chemistry, Mathematics and Materials and Understanding Cultures and Communities (in terms of interaction of areas of society and cross-disciplinary research). This is identified as a growth area for IMOS.

Question 19: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond? (Environment and Natural Resource Management)

The international research infrastructure projects that Australia should engage in include International Ocean Drilling Program (https://www.iodp.org/), International Continental Drilling Research Program (http://www.icdp-online.org/home/), and the astronomy programs, such as the Square Kilometre Array (SKA), Gemini, Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO), ESO, etc.

Other international research infrastructure includes:

CMIP6 collections (Coupled Model Inter-comparison project phase 6). Climate change is a key issue for Australia and globally. The Conference of the Parties meeting 21 in Paris committed the world's countries to reviewing emission targets every five years and also placed adaptation to climate change squarely on the agenda of governments. One of the tools that sits at the heart of climate change science is the CMIP6 simulations which covers a very broad range of simulations used to inform the attribution of the climate change to human influence and also to inform projections of future climate change, and also to look at near term projections (on decadal scale). The CMIP6 collections are also used for impact studies on a regional scale, and also to inform policy around mitigation.

CMIP6 simulations are contributed to by many nations around the world and distributed. Australia needs to be part of this underlying global collaboration around hosting and distributing these simulations to and from the nations of the world. Australia's explicit involvement would support

Australia's researchers in climate and climate change science. The expected size of the CMIP6 collection is likely to be between 100-1000 petabytes.

Question 20: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Environment and Natural Resource Management capability area? (Environment and Natural Resource Management)

Establishing a National Research Facility for enabling high-pressure and high-temperature experimental research into the properties of solid earth materials would be an important step towards maintaining the current strengths and developing future capabilities in Advanced Earth Sciences.

Other emerging trends include the ongoing and systematic observation of ecological and biological components of Australia's marine estate. Ad hoc measures point to rapid change in many ecosystems, and observations are needed to quantify change, understand the underlying mechanisms, and to identify appropriate responses. This is identified as a growth area for IMOS.

Understanding Cultures and Communities

Question 24: Are the identified directions and research infrastructure capabilities for Understanding Cultures and Communities right? Are there any missing or additional needed?

As noted above, The University of Tasmania strongly endorses a national strategy and infrastructure framework to develop a National Digital Humanities Platform. The University's own experience with the Faculty of Arts and Humanities collaborating with the Port Arthur Site Management Authority, has demonstrated the cultural and economic benefits that arise from such humanities-based partnerships. In this example the collaboration resulted in new visitors' exhibits at Port Arthur, increased tourism, financial return through the sale of new products related to the exhibition and the launch of a new academic programs on understanding Australia's heritage.

A national strategy is needed to build a digitally literate workforce and build cultural awareness. Examples such as our own Port Arthur collaboration, and many drawn from publically available case studies in the 2014 United Kingdom Research Excellence Framework (REF) assessment exercise demonstrate the measurable increase in tourism and related economics benefits that can arise from such collaborations.

Likewise, the University also supports free digital access to the nation's cultural and historical collections. GLAM Peak Australia, where the University Library is represented by the Council of Australian University Librarians (CAUL), have outlined current barriers to unlocking the value of the nation's physical special and rare cultural collections: lack of national coordination and funding for large-scale digitisation of materials, lack of interoperable systems or tools to discover and access holdings, reduced funding for the national Trove platform, copyright laws which have not kept up with digital technologies, https://uoncc.files.wordpress.com/2016/05/glampeak-election2016.pdf.

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Underpinning Research Infrastructure

Question 30: Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?

We note that the National eResearch Collaboration Tools and Resources (NeCTAR) is not identified as underpinning research infrastructure despite having 8000 registered users and supporting a suite of virtual laboratories that span several NCRIS areas and also serving the larger research community. The Nectar Cloud and its associated virtual laboratories is underpinning the analysis and discovery science of many Australian researchers. Of the eResearch areas, NeCTAR has the greatest reach and supports more Australia researchers than any other service. The cloud is at the heart of the infrastructure that researchers need to collaborate both in Australia and internationally.

Question 31: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond? (Underpinning Research Infrastructure)

Scientific research is inherently unpredictable and, more and more, world-altering change in research technology occurs on short timescales.

The Issues Paper should acknowledge that the rapidly changing landscape of research reflects a policy that is highly adaptive and ready to manage such change. This policy must be able to adapt to situations where the life cycle of new developments is much shorter than ten years. The national research infrastructure funding model should be ready for emerging directions of research over and above what is listed in this document, should they arise.

Question 32: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Underpinning Research Infrastructure capability area?

We are only at the start of the "data deluge". All indications are our storage systems are under considerable pressure to continue to grow expansively and rapidly to meet future needs. The considerable growth in size of datasets will also have considerable impact on the delivery of data to national and international partners. Access to highly functional data delivery services (compute and network) and novel ways of visualising and delivering data efficiently are quickly becoming a weak link in the data discovery and access chain. While this has been addressed to some extent in the document, the extent of the issues we face in the future appear underestimated.

Question 33: Are the identified emerging directions and research infrastructure capabilities for Data for Research and Discoverability right? Are there any missing or additional needed?

The aspects of data management discussed relating to trusted data and integration/collaboration (also grouped in the "Ideal research data system" diagram) should come together under the general heading of Data Governance with an output of accessible, trusted data capable of integration across disparate systems. The Industry sector has embraced this concept with considerable success over the past decade. Particularly in the area of international collaboration, an analysis of efforts at integration and access to research data would likely reveal mixed success where those most successful have applied good data governance and those least successful have not. This limits timely access to trusted data primarily through insufficient attention to data provenance and licensing, integration and data quality assurance.

Concluding comments

Availability of cutting edge research infrastructure, access models and the balance between Australian versus internationally located research facilities are important issues to settle as the nation enters this ten year period of funded NCRIS facilities. It is essential that the Roadmap provide guidance, not only on the physical infrastructure to be funded, but also on the above-mentioned issues.

The University of Tasmania has welcomed the opportunity to engage in the national debate and is pleased to be given this opportunity to provide input to the development of the 2016 National Research Infrastructure Roadmap.

Any questions can be directed in the first instance to:

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