Submission Template
2016 National Research Infrastructure Roadmap
Capability Issues Paper

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Questions

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

A new capability area is **Engineering Science and Technology Validation**. For example, pilot-scale validation of emerging process engineering science and technology for the resources sector, and for oil and gas specifically, could unlock massive economic value for Australia by speeding up the sector's innovation cycle, which has a current average lag time of 25 years. Currently, the high cost of implementation and the risk of failure constitute the primary barriers to the adoption of such innovation. A specific example supported by The University of Western Australia is a micro-scale liquefied natural gas (LNG) plant for open-access research. Such open-access pilot scale facilities do not exist in Australia and are scarce worldwide. Pilot-scale research facilities would bridge the large gap between the development and demonstration of an innovative technology on the laboratory scale, and the deployment of that technology on industrial scales. A micro-LNG plant for technology validation in Western Australia represents a research infrastructure that would support an innovation ecosystem extending across the Australian university sector and CSIRO (National Resource Sciences Precinct), and would be supported by the WA Government, and key LNG industry players such as Chevron, Shell and Woodside.

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

The University of Western Australia supports the Government's continued investment into two 'Tier 1' supercomputing capabilities in Australia – one at the **Pawsey Supercomputing Centre** in Western Australia and one at the National Computing Infrastructure (NCI) facility in Canberra. However, there needs to be a stronger alliance between Pawsey and NCI to ensure: coordination of facility upgrades for continuity of service; coordination of merit allocation schemes; and the sharing of resources including training and support.

The University has some concern over incorporated governance models, as adopted by Bio Platforms Australia for example. Such models can provide insufficient

influence over investment decisions or opportunities for co-investment by universities, who are key stakeholders/end-users of these facilities. Such a governance model further engenders a business service model that is not conducive to sharing of intellectual property between national nodes, as well as creates pricing tensions.

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

The University of Western Australia supports national investment to assist with access to facilities internationally, that otherwise would not be available in Australia and for which there is a strong demand.

The University of Western Australia supports national investment in sharing expertise in international facilities with Australian counterparts. In the first round of NCRIS, travel and access funds were provided by various capabilities to encourage national movement of people to share expertise and access facilities. Such funds, provided at a modest level, were extremely effective in creating research mobility to seek out nationally unique capability. The next level of such schemes is being championed currently by EuroBioimaging, a European consortium led by the European Molecular Biology Laboratory (EMBL). Under its Global Bioimaging initiative, in which the AMMRF and NIF are key partners, EuroBioimaging is funding an 'exchange of experience' workshop as well as staff exchanges, but currently there is no Australian funding to support these initiatives.

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

Insufficient Australian demand and high cost for moderate to low national benefit.

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

Yes. Deep specialisation, high complexity and a wide range in the research infrastructure needed by many multidisciplinary research projects challenges not only the adequate provision of facilities, but also expertise.

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

The University of Western Australia agrees that there should be a national discussion on career pathways for research infrastructure scientists. At present, such scientists are commonly academics in universities who regularly face difficulties in career progression because of their core facility duties. In addition, they are professional staff with extremely limited career progression options (perhaps one or two levels on professional salary scales over their career), despite their highly specialised and valuable skill set.

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

National infrastructure needs to be tightly coupled and well integrated with local infrastructure, and institutions should take responsibility for the implementation of a national approach to the production and management of infrastructure ready researchers and technical specialists.

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

The principles outlined in Section 3.5 are appropriate.

Question 9: What should the criteria and funding arrangements for defunding or decommissioning look like?

Defunding or decommissioning of facilities should be staged to allow for alternate arrangements to be explored to address the needs of the user, as well as to transition the skills, knowledge and experience of those who operate the facility. Defunding should be considered when the facility only provides local access and benefit; or where the technology has moved on and has been replaced by alternative techniques; or when the cost has decreased so much as to put the infrastructure within the scope of the ARC LIEF scheme.

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

To develop and maintain connected national research infrastructure, it is essential that support is available from the federal government. This support can be leveraged through co-investment from state and territory governments, government agencies, granting bodies, universities and, where appropriate, industry. But ongoing investment from the federal government as the "foundation investor" is key to providing the confidence for funding from other stakeholders.

The provision of an additional $1.5 billion over 10 years from the federal government to support the operational cost of established research infrastructure is welcome. However, there also needs to be funding to **invest in capital expenditure** to ensure that facilities remain current and state-of-the-art. This is particularly concerning for supercomputing 'Tier I' facilities which are in need of capital refresh every 4 years. For the Pawsey Supercomputing Centre, this capital refresh will need to be committed by 2017 or the Centre will need to close by the end of 2018.

In some instances, consideration should be given to making it possible to lease instruments where equipment rapidly becomes obsolete or is very expensive to fully maintain. Leasing presents advantages in smoothing out capital expenditure profiles, keeping instruments more up to date, and assisting with achieving appropriate

maintenance. The current 'purchase and maintain' model has a challenge in that full maintenance contracts are often prohibitively expensive (5-10% of purchase price), and the national approach to maintenance of instruments and facilities is known to vary widely from none to full 'platinum' contracts.

Question 11: When should capabilities be expected to address standard and accreditation requirements?

The University of Western Australia believes that the national expectations about accreditation should be flexible, recognising that the need varies and the burden of achieving accreditation is usually high.

UWA has accreditation from the US Centre for Disease Control for its NCRIS Metabolomics Australia vitamin D assay. It also has accreditation with the International Atomic Energy Agency for its uranium isotope particle analysis.

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

The NCRIS program has not only made access to new infrastructure possible, it has enhanced the performance of much existing infrastructure originally funded through other schemes via the creation of an integrated national network of facilities and expertise. This governing principle of distributed but interconnected expertise has served the nation exceptionally well, particularly the more geographically isolated parts of it. This principle has also created the national critical mass necessary for wider international engagement. For example, through the AMMRF, UWA staff are engaged with the European Commission Horizon 2020 EuroBioimaging project, a program that provides physical user access to a broad range of state-of-the-art technologies in biological and biomedical imaging for life scientists. This program, headquartered at the world-renowned EMBL in Heidelberg, Germany, is widely acknowledged to be modelled on the AMMRF. Such international engagement, facilitated through national engagement, represents a major benefit of the national infrastructure program.

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

See response to Question 10.

Health and Medical Sciences

Question 15: Are the identified emerging directions and research infrastructure capabilities for Health and Medical Sciences right? Are there any missing or additional needed?

The Population Health Research Network (PHRN) is the only NCRIS capability hosted by The University of Western Australia and it remains an important national asset to help in our understanding of health and disease. Linked health data was pioneered

by Western Australian and remains an essential part of Australia's health and medical research infrastructure, with the unique combination of infrastructure developed by the PHRN providing new opportunities for Australia to conduct world leading research leading to improved health outcomes.

However, Western Australia remains under serviced in a number of areas of research infrastructure for the Health and Medical Sciences that is relevant today, and much of this infrastructure will evolve significantly over the next ten years. In Western Australia the most significant gap in imaging is the current complete absence of dedicated **human research medical imaging** infrastructure. This absence of infrastructure is contributing in part to the declining performance of Western Australia in medical research, and is a high priority to be addressed. It is critical that such infrastructure is nationally integrated through a capability such as the National Imaging Facility.

UWA houses a node of the National Imaging Facility and strongly supports the current facility in having provided superior national access to a network of state-of-the-art capability, expertise and capacity in a range of medical themes, including oncology, neuroscience and mental health, cardiovascular, musculo-skeletal and biomaterials. This includes the opportunity to translate from small-animal pre-clinical to large animal pre-clinical to human, as well as the capacity to support multi-centre trials. The UWA has specialised in preclinical flagship MRI, which has been successful, but much more imaging infrastructure is required in Western Australia, and the uptake of imaging science and the culture of multi-user access needs to continue to evolve and grow. The National Imaging Facility is well placed to continue the development of imaging science in Western Australia through national connectivity and integration.

The Issues paper has omitted an extremely important emerging technology that is needed to support research in structural biology with application to the Medical Sciences, specifically, **cryo-electron microscopy**. Recent commentary in the journal "Nature" describes the impact of cryo-electron microscopy as nothing short of a revolution, identifying single particle cryo-tomography as the most significant development for structural biology since X-ray crystallography. Thanks to recent hardware and software breakthroughs, these tools can now reveal the hidden machinery of the cell with unprecedented, near-atomic resolution. This provides information about how molecules involved in disease might be targeted with strategically designed drugs.

In the coming decade, researchers across Australia will require increasing access to cryo-eletron microscopy, which requires not just an instrument, but a whole ecosystem to provide an end-to-end solution across the cycle of these complex experiments. To achieve this successfully, a national approach is needed. Mid-range machines can be used to collect high – but not the highest – quality data, and to identify suitable samples to be examined on openly accessible, state-of-the-art

instruments. A national approach is also required to tackle the data management challenges associated with this capability. The Australian Microscopy and Microanalysis Research Facility is well-placed to implement such an approach. Given the exceptional success of the structural biology community who use synchrotron radiation supported by smaller in-house instruments, a similar support and access model for the bimolecular cryo-electron microscopy would be of high value.

Question 16: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Section 5.3.5 states that *"in order to maximise clinical utility through agreed data specifications, 'omics data should be collected using well defined and broadly applicable clinical and industry standards. This will require alignment of research facilities with diagnostic pathology groups to develop National Association of Testing Authorities (NATA) accredited research units. National research infrastructure in all 'omics areas should adopt international standards as they develop."* We recognise that local efforts in this area can be very effectively supported by international engagement, and international effort around standardising methods is growing. Key is the empowerment of local expertise and its integration nationally. An example at UWA is the collaboration between the US Centre for Disease Control and the US National Institute of Standards and Technology on Vitamin D commutability, aimed at validating NIST-produced Vitamin D reference materials for clinical tests. Metabolomics Australia at UWA has been invited to participate in this study, which is likely to be expanded to include other steroids and hormones. Support for such engagement will be important to see transfer of knowledge to Australia.

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?

Infrastructure in the Health and Medical Sciences area remains often fragmented, subject to variable business models that favour clinical use over research, and prone to duplication. The University of Western Australia supports the NHMRC's initiative in **Advanced Health Research and Translation Centres** as participants in governance models to provide regional coordination of research infrastructure.

Environment and Natural Resource Management

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?

The blue economy is a significant and growing part of Australia's broader economy, with our oceans expected to contribute $100 billion per annum by 2025. To achieve this potential, Australia needs significant investment into marine orientated infrastructure to meet the challenges of sovereignty, security, safety, food, biodiversity conservation, urban development, resource allocation and climate variability. The world-leading Integrate Marine Observing System (IMOS) and

Terrestrial Environment Research Network (TERN) facilities are providing invaluable and unprecedented data-streams of real significance and application to the wider coastal zone and deep ocean. However, presently in Australia there is a substantial gap in rigorous observations and resulting data-streams of shoreline conditions, costal erosion, variability and trends around the continent, and so there is a clear need for investment in a **national coastline observatory facility**.

UWA consistently ranks amongst the world's top 50 in Life and Agriculture Sciences (ARWU rankings) received a 5 in both Biological Sciences and Plant Biology (ERA 2015) and is the primary affiliation of 4 of the 9 Australian plant scientists in the Thomson Reuters highly cited researcher list (2015). It headquarters the ARC Centre of Excellence in Plant Energy Biology, and houses the West Australian Centre of Excellence in Natural Resource Management, the (former) Future Farm Industries CRC, and the GRDC-funded Australian Herbicide Resistance Initiative (AHRI). Plant science itself is rarely mentioned specifically in the NCRIS roadmap, even though this research area is vital to underpin the future of agricultural R&D and environmental management. Plant scientists are consumers of a wide range of NCRIS facilities, including omics, data, and characterization. Research to address precision and smart agriculture and to take laboratory innovation into field settings will need aligned infrastructure (most notably phenomics) and also a greater focus in other NCRIS facilities that focus on data, data integration and 'omic sciences to better support the specific requirements of plant science. For example, there is the need in the Roadmap for the expansion of scope and geographical location of **plant phenomics facilities** to aid agricultural development and new knowledge generation across Australia.

An example of the alignment of NCRIS local capability and local expertise at UWA is Metabolomics Australia and the ARC Centre for Excellence in Plant Energy Biology, in providing data in various plant models, typically centred around growth of plants in low phosphate environments or areas with salinity. This has recently expanded to include Terpene analysis in collaboration with researchers from CSIRO in WA. Terpenes are involved in the defence responses of plant to external stimuli, but are also an emerging class of compounds being evaluated for health benefits in humans. The potential of terpenes as natural product supplements in humans represents an additional opportunity not adequately exploited to date. These initiatives would not be possible without locally available expertise provided through NCRIS.

UWA partnered with AuScope in the original round of NCRIS on Secondary Ion Mass Spectrometry that is heavily used for geochemistry. Geochemistry did not feature in the Issues paper, but future support in this area by capabilities such as AuScope will be important. Tools for high precision isotopic analysis of minerals have evolved enormously in recent years and are essential to understanding the mineralization processes that underlie Australia's resources industry. As an example, our geologists require access to new-generation secondary ion mass spectroscopy (SIMS) to remain

at the top of their field. This type of analysis is key to understanding the mineralisation processes that underlie Australia's resources industry. In particular, use of new ion sources with an order-of-magnitude increase in brightness promise massive improvements in lateral resolution with no decrease in sensitivity. This will be of particular use to the zircon dating community, who will be able to access new isotopic systems to determine the age of minerals, allowing, for example, better dating of lunar crustal events. It will also contribute to work in nuclear safeguarding with the International Atomic Energy Agency (IAEA).

Advanced Physics, Chemistry, Mathematics and Materials

Question 23: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Advanced Physics, Chemistry, Mathematics and Materials capability area?

The detection of gravitational waves announced in 2016 has marked a new era of gravitational wave astronomy. **Gravitational wave detectors** are the most sensitive measuring instruments every created and Australian scientists have played a significant role in their development, with many practical 'spin-off' innovations leading to new technologies (e.g. the gravity gradiometer for detecting new mineral ore deposits). In order to further refine gravitational wave detection to determine their positon in the sky, a world array of detectors is needed to triangulate the signals and the Gingin site in Western Australia would be of international significance because its data would determine the resolution of the entire world array. A large scale gravitational wave observatory is needed at Gingin and would build upon existing gravitational wave infrastructure at this site. With an expected lifetime of at least 30 years the gravitational wave observatory would become an international partnership that complements the SKA project and draws on the Pawsey Supercomputing Centre for data services.

The Australian National Fabrication Facility (ANFF) provides research infrastructure to support research and development activities in advanced manufacturing to meet the practical challenges in all of the National Science and Research priorities. The facilities exist to allow the fabrication of complex structure at the cutting edge of materials science that allow researchers to test new physical and chemical theories, and to build prototypes of new devices that are able to launch new products for commercial development. The suggestion to enhance the fabrication focus on packaging and integration capabilities will directly align with the activities of the WA ANNF node. Infrared sensing technologies and on-chip micoelectromechanical systems are the unique capabilities at UWA which are world-leading, and have significant demand for access from industry and international partners.

Understanding Cultures and Communities

Question 26: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Understanding Cultures and Communities capability area?

The University of Western Australia supports a National digital humanities capability which focuses on reuse, integration, interoperability and the collating of data, as well as providing a platform for building tools and techniques. This capability should do more than simply providing better access to cultural collections and making them more discoverable. Some specific examples of additional Digital Humanities capability include:

- Open data – collecting institutions (and other data providers) should expose their metadata and digital objects in formats that can be reused by research infrastructure services (using appropriate AusGOAL licenses). This would include the International Image Interoperability Framework for images; metadata in formats that can be consumed by Linked Data services; and texts in formats that are suitable for text-mining and text analysis (the HathiTrust in the U.S. is an important example of this).
- Knowledge graph – for linking and integrating metadata from disparate sources. This would include vocabulary and ontology services; Linked Data services; and visualisation services. The HuNI Virtual Laboratory has already made a start in this area.

National Security

Question 29: Is there anything else that needs to be included or considered in the 2016 Roadmap for the National Security capability area?

See response to Question 18 on national coastline observatory facility.

Underpinning Research Infrastructure

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

See response to Question 2 and Question 10 on supercomputing.

In terms of national digitisation capability the Issues paper contextualises digitisation to mean a form of preservation of vulnerable samples and collections. But there is also a need for a **digital preservation capability** for future-proofing digital and digitised objects. This could take the form of a national source of specialist knowledge but there may well also be a need for digital preservation infrastructure. Presently few institutions have implemented any preservation services for their digital collections, such that the format migration or conversion to a standardised, long term preservation format is to the standards recommended by the National Archives of Australia.

Data for Research and Discoverability

Question 35: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Data for Research and Discoverability capability area?

Microscopy and microanalysis are producing ever larger data files due to the increasing richness of data obtained from contemporary techniques, e.g., the increased digital and spectral resolution of modern detectors, and the transition from the probing systems in two or three dimensions toward the routine acquisition of 4D and 5D data arrays, where compositional and time-resolved information are superimposed onto spatially resolved data sets. In addition, microscopy techniques are increasingly generating internationally significant data, warranting sharing and re-use.

The AMMRF has developed a plan for a national approach to data management. Success with it will require infrastructure to support data acquisition and high-speed data transfer, secure storage that allows sharing in a controlled way (through authentication or registration) and the capacity to undertake cloud-based data analysis on stored data. The AMMRF has collated data and informatics needs nationally from all of its nodes and would provide a good central resource for communication on this front. Most importantly, successfully achieving a national data solution requires node-based data and informatics engineers to implement solutions and to provide expert advice and support to AMMRF users. The university would like to see support of these requirements incorporated into any new capabilities for Data for Research and Discoverability.

Other comments

Whilst the Issues paper often points to the benefits of integration, we wish to emphasise that a main benefit of the national infrastructure framework to UWA has been the extent to which it has facilitated interconnection of people, which has in turn facilitated the research endeavour in multiple ways:

- Created increased local awareness of what infrastructure is available nationally, with resulting increased access of interstate infrastructure by UWA researchers and increased access of local infrastructure by interstate researchers;
- Increased the level of expertise in infrastructure available locally and nationally; and
- Reduced duplication of infrastructure nationally, and reduced the level of competition amongst cognate facilities.

Importantly, in many instances, these benefits have flowed on to non-NCRIS infrastructure, representing an important further leverage of the NCRIS program.