Submission

2016 National Research Infrastructure Roadmap Capability Issues Paper

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

Yes:

- Advanced manufacturing including infrastructure to support Industry 4.0 and fabrication facilities for novel materials
- Space/ satellite infrastructure
- Development of sustainable technical capacity for to support the development and maintenance of current and future generations of key research infrastructure
- National clinical trials infrastructure
- Quantum Technologies

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

Generally, governance standards are appropriate. One of the challenges is equitable access which is sometimes predicated on having funds to buy a seat at the table, albeit nationally or internationally.

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

Yes, this is a critical issue. It is important that Australian researchers have access to world-class research infrastructure no matter where it is located.

The challenge for Australia is to manage this access as cost effectively as possible. For example, the cost of access for Swinburne to the Hawaii-based Keck telescope is millions of dollars per year and is expected to increase. A model where universities in conjunction with the Australian government co-contribute is more appropriate.

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

National facilities should be developed where one or more of the following conditions apply:

- The infrastructure is specific to the needs of Australia and cannot be replicated elsewhere (e.g. national environmental research infrastructure)
- Australia has unique social, geopolitical characteristics or natural advantages that create a compelling case for investment (e.g. SKA)
- The cost of national development is more cost effective than the costs associated with international access

- Australia can develop skills and expertise that will provide a competitive advantage in research and innovation
- There are additional spill over benefits (e.g. industry development or transformation)

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

The operation of research infrastructure is inextricably linked to the availability of the research workforce skills and expertise needed to operate the infrastructure. The utilisation of the infrastructure by researchers is heavily dependent on this operational workforce. We would go further and suggest that, along with equipment upgrades, the support of available human expertise is an essential infrastructure need identified as highly critical for the support of research and to advance Australian innovation. Expert skills, not otherwise committed to specific funded projects, and associated with operation and interpretation of equipment and data is managed in an ad hoc and non-continuous manner at present. This is a hard problem, but supporting this in a sensible way would be a bold new vision for infrastructure support in Australia.

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

Skilled technicians govern how well we use our infrastructure: they maintain and manage key equipment and also train researchers in how to use these resources. For many current NCRIS capability areas, there are too few Facility Fellows which limits access and use. The provision of additional technical support means that more researchers and also industry users could be made aware and trained in the technical capabilities and operational requirements of the equipment. By appropriately funding these expert operators (facility fellows/expert scientists) our national research infrastructure can assist in training and skills development by providing access for research users to specialised expertise and advanced techniques for optimal usage of the infrastructure.

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

The development of researchers trained in using the infrastructure is a key responsibility of research institutions. However, the full employment costs of the technical specialists (or infrastructure facility fellows) cannot be met by the research revenue from funding agencies such as the ARC and NHMRC via the competitive peer reviewed grants schemes because those schemes do not fully fund the cost of access to the research infrastructure.
Much of the existing technical workforce is employed on 12-month contracts which do not support stability of the workforce. Consistency of funding support is required – for much infrastructure, the budget is forecast annually with no budget commitment guaranteed for outyear funding. This means that facilities cannot offer contracts for longer than 12 months at a time. Short term contracts are also a disincentive for those seeking careers as technical specialists. To ensure that these capabilities are updated and remain available this infrastructure gap needs to be addressed. These technical specialists should be seen as part of the infrastructure.

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

While merit based access is an important principle, in some situations this has the potential to restrict access to researchers who have established track records, with researchers earlier in their career or trialling highly creative or innovative approaches potentially disadvantaged. It may also discriminate against industry-oriented research which is directed towards more commercial outcomes that are less traditional. Access should provide for a spectrum of activities and should not be dependent on the ability to pay.

Broad principles of open access should be applied to research infrastructure as well as research content wherever possible as the tools may be as valuable to other sectors of society. This is a major issue for developing linkages with organisations outside of universities and increasing industry engagement with research. The National Research Infrastructure Roadmap should include a statement on FAIR access with a requirement for publicly funded services to provide some level of access, even if it is limited.

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

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

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

Standards are important to enable confidence in the quality of the research infrastructure and are important in how research outcomes are used. ISO9000 quality system is required to provide confidence that the infrastructure is managed appropriately. Additionally, regulatory standards are necessary to ensure a safe operational environment and instil public confidence.

One of the challenges for much infrastructure is that the cost of achieving commercial grade standard may be substantially greater than the research standard, i.e. millions cf hundreds of thousands of dollars. This makes it difficult to take research outcomes to the market.

In addition, interoperable metadata standards and recognised schemas and classification systems should be adopted or where unavailable, developed for all databases and collections supported as national infrastructure. Effort should be made to ensure Australian terminology and taxonomies are developed while also aiming for international compatibility.

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

Such models will be dependent on the nature of the infrastructure.

Question 13: In considering whole of life investment including decommissioning or defunding for national research infrastructure are there examples domestic or international that should be examined?

There are a number of first generation synchrotrons around the world that have been decommissioned and repurposed and how this was handled could be used as a model.

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

The ARENA 2036 (University of Stuttgart) and the Open Hybrid Lab Factory (University of Braunschweig) in Germany which have both attracted significant industry investment.

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?

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

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?

Generally, the capabilities identified within the consultation paper are appropriate. However, we offer the following observations:

- The consultation paper notes the importance of health data however the lack of coordination, data linkage, governance and access framework to clinical registry data, biobanks, 'omics data and patient data already limits the ability of researchers and health practitioners. This is a problem of national importance that is already nationally recognised, but yet there appears to be no imperative to address this issue. There is also a shortage of trained biostatisticians which is equally a research infrastructure issue as for the case of physical infrastructure.
- There is a requirement for a nationally coordinated approach to clinical trials which enables participant trial recruitment and management, as well as the development of infrastructure to support digital clinical trials. Medical research is continually plagued by the unnecessary replication of pre-existing databases as well as repeated requests for the same information from medical files. A national network of accessible electronic medical files in addition to databases of volunteers available for medical research is needed. Such efficiencies have been made across Scandinavia, improving the quality of their clinical trials.
- Infrastructure at the interface of biological/ life sciences and physical sciences and engineering, for example 'lab on a chip', quantum biology and biomedical engineering infrastructure needs to be considered. Infrastructure in these areas also has the potential to improve our understanding and treatment of communicable and non-communicable disorders as well as stimulating new industry development.
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Environment and Natural Resource 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?

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

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?

Advanced Physics, Chemistry, Mathematics and Materials

Question 21: Are the identified emerging directions and research infrastructure capabilities for Advanced Physics, Chemistry, Mathematics and Materials right? Are there any missing or additional needed?

Australia's physical, chemical, mathematical, material and engineering sciences are widely acknowledged as being at or above world standard. We support the areas identified and offer the following points to clarify or emphasise areas of priority:

Quantum Technology

The Issues Paper addresses recognises precision measurement as an emerging area, however, this represents only one aspect of the broader field of Quantum Technologies – an emerging area of global significance in which Australia can be highly competitive. In recent years the UK has committed to a £270M investment in quantum technologies, including £120M to establish of four research hubs in the areas of Quantum Sensors and Metrology, Quantum Enhanced Imaging, Networked Quantum Information Technologies and Quantum Communication. Further, the European Union has also recently announced a €1b Quantum Technologies Flagship program.

Both the UK and EU have identified Quantum Technologies as a key area of future industrial growth and these programs aim at bringing the university based research into practical real world technologies. The European Quantum Manifesto identifies four key priority areas listed below:

1. Quantum Communication (Ultimate security sharing/communicating digital information)
2. Quantum Simulators (Understanding and developing functional materials - superconductivity/magnetism, quantum chemistry and quantum biology)
3. Quantum Sensors (Precision measurement devices for inertial navigation, gravity sensing applications and atomic clocks for GPS)
4. Quantum Computing (Solving computational problems that are presently intractable on classical computers)

Australia is a major international research presence and our strengths are well aligned with the four areas identified in the EU Flagship program. The National Research Infrastructure Capabilities take a more holistic approach to Quantum Technologies, encompassing each of these aspects. A proposed model of infrastructure organisation is to establish Quantum Research and Innovation Hubs and Spokes, as has occurred in the UK. Key to the success of this is the need for highly skilled personnel, with enough technical expertise to understand the research, who can translate these developments to a commercial environment.

Advanced manufacturing

Advanced manufacturing is neglected as a key capability area in its own right the Issues Paper. Its importance for Australia is recognised by the Australian Government through the establishment of an Industry Growth Centre and the Innovative Manufacturing CRC.

The While fabrication is recognised as a capability area of importance, additive manufacturing, precision manufacturing, pilot scale prototyping, robotics, automation, design and CAD are also critical to the future of an Australian advanced manufacturing sector. Appropriate infrastructure, platforms and networks are critical to successful utilisation.

The digital transformation of manufacturing is recognised as Industry 4.0, representing the fourth wave of industrial transformation. It establishes a fully integrated value chain which is enabled by cyber-physical production systems, the Internet of Things and the management of big data. In the new manufacturing future, new technologies can be rapidly and flexibly incorporated into the production environment.

Australia has recognised the importance of Industry 4.0 and has established the Prime Minister's Industry 4.0 Taskforce, of which Swinburne is a member. This is an important step in ensuring Australian industry is globally connected to Industry 4.0.

However, we also need to ensure that we develop the necessary platforms to support Industry 4.0 where we have the potential for competitive advantage based on our science and engineering excellence. One example is the creation of an Industry 4.0 Platform for automated manufacturing of composite products has been designed to be versatile and agile. It is based on a Virtual Smart Factory (VSF) platform that can be expanded, and adapted cost effectively to include other technologies and practices on the one system such as large scale 3D Printing, 5 Axis Machining and new robotic equipment. Such infrastructure is necessary to demonstrate the integration of cyber physical systems in a representative manufacturing environment. It will inform and influence the technical description of Industry 4.0 operational standards that is urgently required for Australian Manufacturers to link into global supply chains.

Swinburne, with industry, is working to develop such a platform, as part of its Factory of the Future. Many other Australian institutions are also actively engaged in Industry 4.0. We require a nationally coordinated approach, similar to the US's National Network for Manufacturing Innovation.

Question 22: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

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?

Please refer above

Understanding Cultures and Communities

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

The emerging directions and infrastructure capabilities are generally appropriate however there are important infrastructure resources for digital humanities that are not recognised in the Paper including TrISMA, a national-scale infrastructure project to track public social media activities across Australia, and Australian Policy Online(APO), which provides an online open access repository hosting a variety of digital content supporting public policy and practice. Importantly, APO serves as a resource for a wide range of grey literature essential for many disciplines which is otherwise hard to find, evaluate and manage over the long term including policy and practice resources, reports, government documents, discussion papers, evaluations, and data.

Relative to science capability areas, the costs associated with the development and maintenance of these types of infrastructure is modest, the potential uses and scope for expansion are substantial, yet there is no dedicated funding source. The costs are supported through modest funding on a semi-regular basis from ARC LIEF and institutional support. However, this limits the relevance and potential of these national resources. Recognition and support for APO as national infrastructure would allow a major expansion of the repository which is already interoperable with other systems such as Trove, World Catalogue. There is also the potential for the APO database to become an international collaboration and mode for grey literature collecting in other regions such as Africa, Asia, Europe and North America.

Question 25: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

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?

<u>**National Security**</u>

Question 27: Are the identified emerging directions and research infrastructure capabilities for National Security right? Are there any missing or additional needed?

Question 28: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

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

<u>**Underpinning Research Infrastructure**</u>

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

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

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

<u>**Data for Research and Discoverability**</u>

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?

One aspect that in Swinburne's view is not explicitly mentioned is the *real-time* nature of data processing. Whereas cloud infrastructure and supercomputing facilities are well equipped to cover a significant amount of the "offline" data processing needs, due to their geographical location, they are less suited to complex, large-scale real-time data processing. Therefore, there is a need to identify solutions to provide data networks with suitable real-time bandwidth capacity to close this gap.

Key to many research activities will be to facilitate searching and processing *across* multiple data sets. This will require the definition of standardized data formats for better interoperability, standards around *data quality*, and (meta-)tool support for the (semi-)automated generation of analysis tools.

Question 34: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

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?

Data is increasingly generated faster than it can be stored, processed and provisioned, and this is unlikely to be addressed by technology alone. Therefore, it will be important to identify and support *holistic* approaches for the entire life-cycle of data that, besides processing and storage, also include guidelines and processes for data compression/reduction and discarding of out-of-date data.

Existing supercomputing facilities generally age very quickly and hence need to be either upgraded or replaced in 5 to 6 year timespans. In order to provide as seamless and continuous access as possible to such facilities (and upgrades of a majority thereof at the same time), we recommend rolling upgrade plans of these facilities (as well as their networking infrastructure) so that a state-of-the-art facility becomes available every 2 years.