

Draft Final National Digital Research Infrastructure
(NDRI) Investment Plan: Recommendations for
Investment by the NDRI Working Group

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Preamble

The 2021 National Research Infrastructure (NRI) Roadmap (the Roadmap) identified the needs and priorities for future Australian Government investment into the nation's NRI capabilities, as delivered via the Department of Education's National Collaborative Research Infrastructure Strategy (NCRIS).

The Roadmap recommended the development of an NDRI Strategy and that the Australian Government should deliver step change investment into "cutting-edge NDRI", among other NRI priority areas. To deliver upon these findings, the NDRI Strategy was developed under the auspices of the NRI Advisory Group and was published in July 2024. To guide the implementation, the NDRI Working Group was formed, made up of eminent Australians with field-specific expertise drawn directly from Australia's NDRI and broader NRI landscape, to provide expert advice and recommendations for potential NDRI investments.

Since mid-2024, and guided by their Terms of Reference, the NDRI Working Group, with support from the Department of Education, have undertaken several rounds of open and invited consultation with NDRI stakeholders. In the Targeted Discussions, stakeholders were invited to share their views on questions relating to key areas of interest within the nation's NDRI ecosystem. Additionally, two public consultation surveys were administered. These were the NDRI Investment Plan Consultation Survey, where all stakeholders were provided the opportunity to provide their comments on the same questions as posed in the series of Targeted Discussions, and the NDRI Investment Plan Environment Scan Survey, where stakeholders were invited to provide suggested solutions to meet the needs of Australia's NDRI landscape. These consultations were supported by further discussions with several national and international NDRI experts.

The recommendations for NDRI investment outlined in this document are informed by all stakeholder inputs and are presented alongside indicative investment amounts. This document is presented as a draft and to the community for comment.

NDRI and Aboriginal and Torres Strait Islander Peoples

In alignment with the NDRI Strategy, these recommended NDRI investments are presented with the acknowledgment that Australia's NDRI has a significant role in promoting and sustaining, ethical and responsible Aboriginal and Torres Strait Islander peoples research, across all disciplines and methodologies. Investments in Australia's NDRI ecosystem should provide appropriate support and governance structures to enable Aboriginal and Torres Strait Islander peoples' equitable participation within the NRI ecosystem, including employment. Efforts should be made to ensure that relevant NDRI investments are led by Aboriginal and Torres Strait Islander communities, particularly via community representative organisations. This will help ensure that Aboriginal and Torres Strait Islander peoples maintain governance over their data and that its uses are respected, as per the CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) Principles. Importantly, raising the awareness of the CARE Principles amongst NDRI users and more broadly across the research community, and ensuring that NDRI facilities put in place the necessary systems and processes, will ensure that existing and new Aboriginal and Torres Strait Islander data held on NDRI is used appropriately. For more information on the CARE Principles, refer to the following link: www.gida-global.org/care.

Summary of Recommendations for NDRI Investment

Specific Investment Areas	Indicative maximum investment
Outcome 1: Underpinned by Training Frameworks for Researchers and NRI Workforce	
Skills Development/Fellowship Scheme for NRI Staff	\$25 million
Skills Development for NRI Users	\$15 million
Uplift in Aboriginal and Torres Strait Islander NDRI Capabilities	\$15 million
Notional allocation total of up to	\$55 million
Outcome 2: Responsive to Technological and Societal Shifts	
Compute Capability for AI/Machine Learning (ML)	\$25 million
Software Capability for AI/ML	\$20 million
Other Responses to Societal Shifts	\$10 million
Notional allocation total of up to	\$55 million
Outcome 3: Consistent in its Standards for Data Collection, Curation and Access	
Improvement of Data Quality	\$15 million
Improvement in Data Mobility	\$15 million
Development and/or Enhancement of Data Repositories	\$85 million
Notional allocation total of up to	\$115 million
Outcome 4: Integrated Across Levels of Computing and Data Infrastructure	
Delivery of HPC Capability	\$100 million
Development of an Integrated, National HPC Facility	\$15 million
Notional allocation total of up to	\$115 million
Outcome 5: Cybersecure, particularly for National-Scale Data and Computing	
Delivery of a National Trust and Identity (T&I) Capability	\$30 million
Cybersecurity Uplift Program	\$15 million
Support for Cutting Edge T&I and Cybersecurity Development of Data/Compute/Software Platforms	\$10 million
Notional allocation total of up to	\$55 million
Outcome 6: Maximised by Openly Available Research Software Tools	
Schemes for Merit Allocation of Research Software Engineers	\$35 million
Development and/or Enhancement of Software Repositories	\$20 million
Notional allocation total of up to	\$55 million
INDICATIVE TOTAL AVAILABLE BUDGET	\$400 million

The notional allocations for each outcome area are indicative only. The notional allocations across all outcomes exceed the indicative total available budget.

Outcome 1: Underpinned by Training Frameworks for Researchers and NRI Workforce

Opportunity:

Supporting Australia's NDRI workforce will enhance the quality of the nation's research.

Challenge:

Without a highly skilled NDRI workforce, Australia will not reach its full potential.

Approach:

Governments should work with NDRI providers to address staff shortages and expand workforce training opportunities.

Overview:

The increased importance and uptake for NDRI by various user communities creates growing demand for a diverse and highly specialised expert workforce that is able to maintain and operate NDRI to maximise the value of capital investment. Global shortages are driving a highly competitive global environment for digital experts, such as research computing specialists, research data specialists and research software engineers. In this environment, Australian NDRI critically relies on appropriate training and career pathways within the nation's NDRI ecosystem.

The widening user base of NDRI, across various research disciplines and sectors, (for example, reaching into the use of data to develop policy) is growing the needs and expectations for training opportunities in the digital skills necessary to ensure that NDRI resources are used to their full potential. Though many training opportunities already exist, they are often not easy to find and/or accessible to the user base.

Considerations for implementation:

Workforce was a key focus of the consultations. Common themes in the responses included:

- The need for staff with specific expertise in research infrastructure who understand domain needs, and the importance of accreditation, recognition and career pathways for these staff.
- Strategic placement of technical specialist positions in the NRI and NDRI ecosystem.
- Communities of practice to share knowledge, promote best practice and stay current with emerging trends and technologies, especially artificial intelligence (AI).
- Incorporating ethical, legal, and social implications of new technologies.
- Partnerships with universities and technology firms for access to accredited short courses, and early access to cutting edge tools.
- National training programs for both foundational (for example, digital literacy, cybersecurity awareness, etc.) and specialist NDRI skills.
- Fostering global partnerships through face-to-face secondments and replicating overseas models where appropriate.
- Training in appropriate governance, collection and sovereignty for Aboriginal and Torres Strait Islander data.
- Research communities are at different levels of maturity in NDRI and this needs to be considered when offering skill development.

- While many skills are cross-cutting, some are discipline specific, or more important to some disciplines than others.

Specific Investment Areas for Outcome 1

Skills Development/Fellowship Scheme for NRI Staff

Notional allocation of up to \$25 million

Researchers rely on a wide variety NDRI staff including data curators, analysts, and archivists; metadata experts; as well as research software engineers, and system administrators that support and manage the underlying hardware. Ensuring the long-term sustainability of Professional Support Staff is critical to an effective NDRI system. Creating the best environment for these staff should include development and/or educational opportunities including through the sharing of capability, career pathways and advancement, and ready and appropriate recognition. As many of the staff are employed through institutions, much of this work will involve driving changes in culture across institutions. This should include specific consideration for research communities still building maturity in NDRI.

Staffing investments are also discussed in Outcomes 3, 5 and 6.

Skills Development for NRI Users

Notional allocation of up to \$15 million

It is also critical that users of NDRI have the skills to make the best use of the capabilities provided to them. Training approaches could involve improving general digital research infrastructure literacy across cohorts and across disciplines, while tailored training could improve researchers' computational workflows and overall use of NDRI. This should include specific consideration for research communities still building maturity in NDRI.

Uplift in Aboriginal and Torres Strait Islander NDRI Capabilities

Notional allocation of up to \$15 million

Establishing or uplifting data-related capability in Aboriginal and Torres Strait Islander communities is essential to ensuring communities can effectively communicate their stories and advocate for their needs. This can be achieved by training and up-skilling people from those communities who own and/or manage data, and researchers seeking to use it. Technical skills comprising data literacy need to be developed and should include data creation, collection, access, analysis, interpretation, dissemination, reuse, review and retirement.

Investments into Aboriginal and Torres Strait Islander communities should be directed via representative community organisations, to ensure the needs of community are met and to enable collective benefit for communities.

Outcome 2: Responsive to Technological and Societal Shifts

Opportunity:

NDRI technological advancements support Australian researchers to perform unprecedented research.

Challenge:

Rapid advances and societal shifts can lead to obsolete and ineffective digital resources.

Approach:

Coordinated, expert-informed strategic planning should underscore Australia's future NDRI system.

Overview:

Advances in digital technologies can enable Australian researchers to now deliver outcomes that may have not been (practically) possible in the past. The strategic uptake of new and emerging digital tools within the NDRI ecosystem will support all researchers to access state-of-the-art capabilities to conduct innovative and pioneering research. These research outcomes may offer unprecedented benefits for all Australians while aligning with the nation's strategic interests.

Considerations for implementation:

Consultations explored current and future trends in digital infrastructure. Common themes included:

- AI models will play a crucial role in software and NRI.
- The best use of AI will need dedicated and skilled expertise and experience that intersects with the NRI workforce.
- Upskilling of users of AI and its outputs will be critical to ensure ethical development, deployment, and governance of AI models within NRI, addressing concerns around bias, transparency, and responsible use.
- A national library of open science AI models that can be used by researchers would be useful.
- Graphics processing unit (GPU) alongside central processing unit (CPU)-based software and workflows will be an increasingly important capability. This joint capability will be essential for processing large datasets and running complex simulations.
- Large and complex data sets, covering social, economic, environmental data are increasingly accessible for research analysis to gain understanding of human and societal behaviours.
- Public attitudes are changing and there is an imperative to respond to public demand for transparency, privacy, and informed consent. Management and utilisation of high performance compute (HPC) resources should seek to balance optimal performance and energy efficiency. This extends to any technological investments into NDRI capabilities, which should ensure sustainability measures are upheld.
- While quantum is an emerging technological advancement, it is still nascent from an NDRI perspective, and is not a recommended priority in this NDRI investment plan.

Specific Investment Areas for Outcome 2

Compute Capability for AI/Machine Learning (ML)

Notional allocation of up to \$25 million

HPC and AI/ML are poised to become one of the cornerstones of NDRI. To make the most of these assets, it is important to adopt a holistic approach supporting the convergent use of HPC and AI infrastructures. This requires more interaction between the HPC and AI communities to discuss common issues, such as how to organise the provision of large-scale, on-demand computing resources to boost AI/ML developments; or how to support skills development and training so that the next generation of data scientists can make the most of the new technology. Data handling is another crucial aspect. Fast access to relevant data and safe storage of large sets of data and algorithms needs to be organised, in compliance with General Data Protection Regulations (GDPR) and following the FAIR (Findable, Accessible, Interoperable, and Reusable) Principles as well as the CARE Principles.

Software Capability for AI/ML

Notional allocation of up to \$20 million

Australia must develop a capability to be able to take advantage of and critically assess the usefulness and potential impact of AI/ML tools. This capability must be underpinned by data management and pre-processing in addition to appropriate trust and identity (T&I), and cybersecurity settings. A strong capability will include resources for model development and training, model evaluation and validation, deployment, monitoring and management, explainability and interpretability.

Potential investments include multidisciplinary efforts involving teams of AI researchers and domain experts on the development and piloting of resources and models that can be the basis of future research infrastructure investments.

Other Responses to Societal Shifts

Notional allocation of up to \$10 million

Given the accelerating availability of real-time data and advanced analytics, there are opportunities to address new questions, via new methods, in all disciplines. We recognise particular imperatives for investment in the humanities, social sciences and galleries, libraries, archives and museums (GLAM) research communities to ensure that these research communities have access to appropriate research infrastructures. A key challenge for the social sciences, arts and humanities sectors is forward planning and support to link local infrastructures to enable better utilisation of assets. This includes development of novel societal observational instruments and related resources and will complement initiatives falling under the other Outcomes. An evidence-based understanding of individuals, communities and populations requires a broad range of data, appropriated curated, including administrative data held by governments and other public entities, and transaction data such as transport usage and consumer data. We also recognise the importance of developing more environmentally sustainable NDRI, including initiatives such as reducing the energy consumption of compute and data storage.

Outcome 3: Consistent in its Standards for Data Collection, Curation and Access

Opportunity:

Ensuring Australia's growing volume of research data is as FAIR as possible will offer benefits to researchers.

Challenge:

Increasing volumes of research data are being generated that are not FAIR/CARE compliant.

Approach:

A sector-wide data management framework that supports FAIR/CARE compliance nationally.

Overview:

Enabling Australian researchers to re-use and re-analyse high-quality datasets will maximise the efficiency of the nation's collective research efforts. Supporting Australia's NDRI to generate (and manage) datasets that are as FAIR as possible will support researchers, from all disciplines, to have more capability to dedicate efforts towards other aspects of their research. This will help achieve an overall increase in the nation's research productivity. Greater standards of collection, curation and access will also ensure that unnecessary 'data debris' is minimised.

Australia's researchers should also uphold the CARE Principles for Indigenous Data Governance when handling, managing, and analysing Aboriginal and Torres Strait Islander peoples' data. The CARE Principles represent the crucial role of data in advancing innovation efforts while respecting the purpose behind the data and the right to self-determination for Aboriginal and Torres Strait Islander peoples.

Considerations for implementation:

Data was one of the cornerstones of the consultations. Common themes of the feedback included:

- Develop robust and culturally responsive comprehensive data governance frameworks that ensure data is managed ethically and securely, adhering to FAIR and CARE Principles.
- Data governance frameworks should consider persistent identifiers (PID), metadata standards, point of data acquisition requirements, long term data storage or preservation, appropriate access guidelines, etc.
- Seamless data sharing between institutional, national, and international resources is needed.
- National curated data repositories with pathways from various disciplines, tools for proper record creation coupled with systems that encourage researchers to use the repositories are needed. These capabilities would need dedicated and skilled staff to manage data and train users. These can serve as best practice examples for data management.
- Data science support for researchers to implement best practice in relation to data management and governance would be helpful.
- Support is needed for initiatives that implement the FAIR and CARE Principles, in particular for Indigenous Data Governance.

Specific Investment Areas for Outcome 3

Improvement of Data Quality

Notional allocation of up to \$15 million

Access to and use of data, together with full contextual metadata, stimulates and empowers collaboration within and across disciplines. Access to data also empowers other activities, such as informing policy development. Consequently, access to high quality data is a fundamental driver of excellence in research and innovation. The enabling power of data also represents an investment in future research opportunities, both to extend the scope and timeline for responding to as yet unposed science questions and collaborations, and to test the validity of future hypotheses.

System wide definitions of data systems, categories and standards are critical. Many discipline areas will likely have unique data requirements leading to needs in terms of their data. Importantly, these definitions will inform T&I and cybersecurity treatment required, data locations, curation and retention policies and approaches, essential and optional metadata requirements, policies, etc. NCRIS facilities could be the first adopters of these definitions with the goal of expanding their application to other institutional research infrastructures or data in due course.

Supporting researchers with data management early in their projects (for example, developing data management plans, implementing metadata standards, improving storage practices) will improve long-term prospects for data preservation and reuse. Dedicated funding streams for both infrastructure and Professional Support Staff are also necessary to enable researchers to accomplish this work.

Decisions regarding data should as much as possible be machine actionable, especially at times well after the data creation/collection. All these developments will ensure that data can readily comply with FAIR and CARE Principles.

Improvement in Data Mobility

Notional allocation of up to \$15 million

To maximise the use and availability of data, it is critical that data can be readily moved to appropriate locations such as a HPC capability or into a national data repository where it is shareable with researchers. Mobility also allows mirroring of data as needed. Appropriate location of data ensures data integrity and preservation, ready collaboration and fit for purpose access arrangements.

Development and/or Enhancement of Data Repositories

Notional allocation of up to \$85 million

Across the ecosystem, national support and coordination of data repository and preservation platforms, as well as underlying software and storage systems, is necessary for long-term management and maximising the value and impact of research funding.

Data, and potentially software, repositories enabled to gather discipline data from a variety of sources such that it is appropriately available to researchers in Australia as an important capability. These data resources should have staff to support both the effective management of the data and its use by researchers, and have clear and appropriate access policies. An environment should be created where skills can be retained and career paths be provided. Systems also need to be in place

to support users and potential users of the capability to ensure appropriate use and maximum impact of the use of the data.

Data management should include effective long-term curation plans including strategies to develop systems to monitor and report on the use of data such that informed decisions can be made about whether data is kept, therefore providing a means by which the amount of data kept can be lowered over longer periods.

Investments in this space should demonstrate strong respect, alignment and reflection with the principles of culturally appropriate data management, including the CARE Principles. Investments should also consider direct engagement with Aboriginal and Torres Strait Islander community organisations to support the delivery of this investment area. This will help ensure that any investment is Aboriginal and Torres Strait Islander community-led and is suitable for meeting the needs of community.

Data availability is also discussed in Outcomes 4, 5 and 6.

Outcome 4: Integrated Across Levels of Computing and Data Infrastructure

Opportunity:

A seamlessly integrated NDRI ecosystem will support Australia's researchers.

Challenge:

Researchers have rapidly expanding NDRI demands but may lack expertise to use data efficiently and effectively.

Approach:

Pursue integrated access to different tiers of compute and shared data.

Overview:

Recent technological advances have revolutionized modern research practices across domains. Research programs and instruments, as well as digital health records, cultural artifacts and environmental monitoring, now produce vast amounts of high-quality data. Global trends are pushing for this data to be readily available and indeed sharing of data presents the possibility of even greater impacts and insights in many cases. To remain globally competitive Australia must have the compute capability to take advantage of the opportunities that these data present. This is even more pressing with the rise of AI/ML models where new data is created from existing data resources, and defining the appropriate use of both the models and the data generated, will be critical for Australian research and security.

Considerations for implementation:

Computation was a key component of the consultations. Common responses included:

- A globally competitive high performance computing capability is critical for Australian research.
- Investment into architectures that can be dual use for both AI and non-AI applications would help maximise flexibility.
- GPU architectures are required for research challenges.
- Platforms that bring data and compute together will be critical in some research endeavours.
- Skilled specialists who can assist users in fine-tuning workflows and algorithms are essential. These specialists enable efficient use of cutting edge supercomputing resources.
- Any design of new hard infrastructure should take full account of current and future sustainability requirements at the design phase.
- There is a lack of a national strategy for computing with multiple HPC providers across the Australian research sector each employing different workflows and access processes.
- Integration under a single strategy is needed to develop an integrated, national Australian HPC capability.

Specific Investment Areas for Outcome 4

Delivery of HPC Capability

Notional allocation of up to \$100 million

The increased complexity and size of datasets and computational workflows has resulted in a growing demand for both CPU and GPU computing, large-scale parallel computation, and secure environments for the analysis of sensitive data. Investment in HPC should ensure that a world leading capability is available to as broad a cross section of the research community as possible. Such a capability would need appropriate storage capacity to facilitate computation especially in disciplines with large datasets. New HPC capabilities should also be mindful of the environmental impacts of the facility and have plans to minimise these impacts.

Development of an Integrated, National HPC Facility

Notional allocation of up to \$15 million

Increased harmony and interoperability across Australia's NDRI will streamline research processes for end-users. The creation of mapped pathways for researchers to transition between disparate levels of infrastructure and across different fields of research will save Australia's researchers time, effort and resources and should increase overall research productivity nationally.

The new integrated, national facility would seek to unify existing Tier-1, selected Tier-2, cloud, and potential commercial cloud research HPC where appropriate, to bring strategic leadership and integrated operational management to the national, collaborative HPC ecosystem. This would include:

- Unified governance of merit-based access and service-delivery to support access to the right compute at the right time in a single national HPC environment.
- A strategic point of view on:
 - The appropriate national mix of CPU vs GPU (and other frontier) hardware to support and advance Australia's research interests.
 - Appropriate risk management of sovereign capability (hardware, software, people), value-for-money and public-private mix.
 - Co-location (where relevant) of data and compute, and data movement (where relevant).
 - The investments in hardware, NDRI staff and NDRI users needed to maintain national HPC at the appropriate level.
 - Enhancing international and national relationships in HPC and AI for the betterment of Australian research.
- A capability where scarce HPC and AI skills can be retained, where career paths can be provided and, more broadly, where skills, knowledge and expertise across the system can be uplifted.

Outcome 5: Cybersecure, particularly for National-Scale Data and Computing

Opportunity:

Enforcing Australia's NDRI cybersecurity protects nationally valuable and sensitive digital resources.

Challenge:

Cybersecurity threats are growing as research data sensitivities increase.

Approach:

NDRI providers should support assessment and mitigation of cybersecurity risks, underpinned by system-wide T&I solutions.

Overview:

Providing secure arrangements for researchers to generate, access and analyse data will always be an essential element of Australia's NDRI. These datasets (for example, sensitive and nationally valuable datasets) require ongoing and enhanced protection against ever-increasing cyber threats. By providing cybersecure NDRI, researchers can use this research infrastructure with confidence while establishing and maintaining trust with the broader Australian community that they serve.

Systematic T&I services and access management frameworks will be fundamental to delivering secure access to high value digital resources. These will help in standardising and simplifying access to national and institutional compute/storage resources and analysis/research software tools and environments, while also simplifying transition between platforms and tiers. These frameworks will also promote the secure connection of Australian datasets with related international datasets.

Considerations for implementation:

T&I and cybersecurity are foundational aspects of all NDRI and hence there was considerable response to this topic in the consultations. Common themes in the responses included:

- There are no fully integrated T&I services across the NDRI landscape. Currently, the system can identify most academic and some government users, but it lacks the capability to specify which resources they can access, such as embargoed data or analytical and computing platforms.
- There is limited monitoring or compliance checking on institutions that conduct sensitive or classified research in Australia as to whether they meet any current existing safeguards.
- Development of enhanced federated identity management systems that allow seamless and secure access to multiple resources across institutions, enhancing collaboration while maintaining security is needed. Such a system needs to address researchers who might be from outside the "normal" research environments.
- Any system needs to support the creation of secure environments for sensitive data, while supporting open access for less sensitive research outputs.
- Comprehensive training programs to educate researchers and staff on best practices for cybersecurity, including threat detection and response are critical.
- NRI providers need to be able to assess their security posture and vulnerability so that they can identify and address potential security gaps in the infrastructure.

- Cybersecurity communities of practice that are focused on research infrastructure to enable the community to collaborate/coordinate their cybersecurity posture are essential.
- Cybersecurity measures should comply with international standards and best practices, facilitating international collaborations and data sharing.

In alignment with the NDRI Strategy, the implementation of the following investment areas should be delivered in cooperation with the various stakeholders within the Australian Government, to ensure a whole-of-government perspective is maintained. These include the Australian Government's Department of Defence and Department of Home Affairs, as well as the nation's security agencies, such as the Australian Signals Directorate.

Specific Investment Areas for Outcome 5

Delivery of a National T&I Capability

Notional allocation of up to \$30 million

Australia must have T&I infrastructure, policies and services that enable seamless and consistent access across the system that are aligned with global T&I frameworks and initiatives. As well as ensuring that the right people access research data, this will support the movement between levels of computing and infrastructure, and prevent inefficiencies in resource utilisation and where appropriate ensure that research software is T&I aware/capable from the outset. The nature of the infrastructure, policies and services would be developed through an assessment of the current state of T&I across the same and in consultation with the community.

This capability would ensure that scarce T&I skills can be retained (and career paths be provided) and made available to NRI providers to help them implement national T&I blueprints and more broadly uplift T&I skills, knowledge and expertise across the NRI system.

Discipline specific approaches will be required depending on their data and community needs. Development of discipline/domain specific community-lead tailored T&I solutions will underpin FAIR and facilitate CARE Principles. For example, where sensitive data is concerned, specific requirements for research partners, communities, and institutions will be needed.

It will be critical to extend the T&I fabric beyond “edu.au” to Federal, State and Territory Governments, publicly funded research organisations, medical research institutes and industry partners (such approaches could involve federating more broadly with other organisations using appropriate technology and approaches). Additionally, extending the T&I fabric beyond “edu.au” to communities which may or may not have formal organisations and/or structures, for example, Aboriginal and Torres Strait Islander communities, will be vital for data access management and access to NRI more broadly.

Cybersecurity Uplift Program

Notional allocation of up to \$15 million

Increasing the cybersecurity posture of NDRI facilities, and NRI more broadly, along with cybersecurity education for researchers is essential to protect sensitive data, researchers’ intellectual property and Australia’s prosperity that derives from commercially valuable research outputs. Facilities and researchers need more support for securely managing and accessing research systems/platforms, sensitive data, as well as access to security resources, and information about best practices to secure research data.

This program would work with all NRI and NDRI facilities to uplift their cybersecurity posture using a partnership model that includes institutions and key organisations, including but not limited to the Australasian Higher Education Cybersecurity Service, Council of Australasian University Directors of Information Technology, Australian Cyber Security Centre, Australian Signals Directorate, etc. The program would build communities of practice for disciplines/domains with a view to agreeing and adopting appropriate fit for purpose international standards to uplift cybersecurity, along with access to cybersecurity intelligence, training, benchmarking, reporting and self-assessment tools to enable an ongoing improvement of cybersecurity across the system and researchers.

Support for Cutting Edge T&I and Cybersecurity Development of Data/Compute/Software Platforms

Notional allocation of up to \$10 million

Disciplines may have their own unique T&I and cybersecurity requirements that are fit for purpose for their community and/or require alignment with international discipline initiatives. These requirements can be bespoke/cutting edge and extend beyond the remit of what could be reasonably expected or delivered by a T&I capability or addressed by a cybersecurity uplift program. Enabling NRI facilities to have access to resources to help address bespoke discipline specific requirements will address specific use cases, as well as serve as a 'healthy hothouse' for developing cutting edge T&I and cybersecurity solutions that could in the future be applicable more broadly. Priority should be given to helping the humanities, social sciences and GLAM communities, the Aboriginal and Torres Strait Islander communities and the health/medical community.

Outcome 6: Maximised by Openly Available Research Software Tools

Opportunity:

Supporting research software tools as critical NDRI capabilities ensures efficient and effective research conduct.

Challenge:

Software is critically important, yet its place in NDRI is not well defined.

Approach:

Research software tools should be recognised with equal importance to NDRI computing, data and networking capabilities.

Overview:

Software has become an essential component of modern research, enabling insights and collaborative practices that underpin scientific progress and innovation. National-level support will enhance the ability of Australia's NDRI to create, house, operate, and provide research software tools to all users while also nurturing the careers of NDRI's research software engineers. Recognising the importance of research software will augment the ability of software creators to develop and validate their work, amplify the reach of collaborative efforts, and ensure that the diverse needs of research software users can be better addressed.

Considerations for implementation:

The consultations specifically explored software and its delivery to researchers. Common responses included:

- Software tools should be visible, findable and scalable. This could be done through creating centralised software registries with appropriate access arrangements, developing citation/attribution mechanisms aligned with academic incentives, and promoting open licensing models.
- Ongoing maintenance for research software infrastructure is critical.
- Research software engineer roles are critical across the research sector to support team-based research.
- A multidisciplinary research software developer merit allocation scheme would be a cross-cutting national capability that could build on best practice domain training providing short-term skills transfer and capacity building, while sharing knowledge from one organisation to the next.
- Comprehensive training programs to build skills in software development, maintenance, and usage among researchers (either as users or producers of software) would be useful.
- AI models will be a core part of the future software landscape.

Specific Investment Areas for Outcome 6

Schemes for Merit Allocation of Research Software Engineers

Notional allocation of up to \$35 million

Research software engineers are a fundamental part of the research landscape and their availability to a range of research activities is critical to ensure world leading research. A software engineering capability where experts in software engineering collaborate with research domain experts, data experts, and systems/hardware experts will help ensure among other things high quality data management plans, well-engineered research software, highly efficient code for analysis and compute and robust and reproducible research outcomes.

Access to research software engineering capacities could help enhance general coding capabilities, improve the integration of authentication and authorisation infrastructures, improve cybersecurity of research software, optimise research code, introduce the use of AI large language models (LLMs) into research programs, drive cross discipline sharing of capability, etc. There may be several different avenues to deliver on this investment area, all of which could be considered, but clear, merit-based access processes will be key to any scheme.

These schemes should focus on software as re-usable research infrastructure, in strategically important areas of national significance.

Development and/or Enhancement of Software Repositories

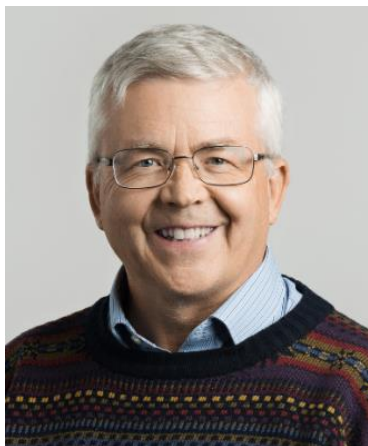
Notional allocation of up to \$20 million

Many disciplines rely extensively on software in their research. This software must be written, appropriately annotated, maintained and updated as required. Additionally, often these capabilities are shared meaning training and support must be offered and delivered. Investment in resources to ensure these capabilities are available to Australian researchers is important to ensure a world class research environment.

Software requirements are also discussed in Outcomes 2, 3, 5 and 6.

Appendix 1: NDRI Working Group Member Biographies

Chair: Emeritus Professor Joe Shapter



Having received his PhD in Reaction Dynamics from the University of Toronto in 1990, Professor Joe Shapter moved to Australia in 1996 and joined Flinders University. He later served as Dean of the School of Chemical and Physical Sciences for 6.5 years. He headed involvement in both the Australian Microscopy and Microanalysis Research Facility (AMMRF) and the Australian National Fabrication Facility (ANFF) and was SA Director for AMMRF.

Joe joined the University of Queensland in February 2018 and served as a Pro-Vice-Chancellor (Research Infrastructure), responsible for the strategic leadership of the University's research infrastructure. He is also a Senior Group Leader at the Australian Institute of Bioengineering and Nanotechnology.

Joe served as a member of the 'Frontier Technologies' Expert Working Group for NCRIS and was involved in writing the 2009 roadmap for science funding. Joe has provided summaries of nanotechnology to the Australian Chief Scientist and was consulted by the Commonwealth Government in building the National Enabling Technologies Strategy (NETS). He has also served on the Australian Academy of Science National Committee for Materials Science and Engineering. Joe is currently serving on national boards in the research and research infrastructure areas. Other positions at Flinders included Associate Dean (International) in the School of Chemical and Physical Sciences. He is a Fellow of the Royal Australian Chemical Institute (RACI).

Joe has published 350+ refereed articles on novel nanomaterial production, nanometre scale of these materials and their applications in, for example, sensors or solar cells.

Joe has a long history of involvement in tertiary education which has been recognised with several awards. He held an Office of Learning and Teaching (OLT) National Teaching Fellowship which explored "Developing Tailored Study Plans for the New Higher Education Environment: 'Letting Go of Control'". He also served as Associate Dean (Teaching and Learning) in the Faculty of Science and Engineering at Flinders University.

Professor Liz Sonenberg



Liz Sonenberg is the Pro-Vice-Chancellor (Systems Innovation) and a professor in the School of Computing and Information Systems at the University of Melbourne. Her Pro-Vice-Chancellor role is across the Chancellery Research and Enterprise portfolio and the portfolio of the Chief Operating Officer. Across these roles her responsibilities include oversight of the maturing of the array of business systems that support the University research enterprise, and guiding the University's strategic digital and data agenda, governance, and policies. Previously, at the University of Melbourne she has been Head of the Department of Information Systems and Dean of the Faculty of Science. Across her career she has graduated 21 PhD students, attracted over \$2.5m of national competitive grant income, and had considerable industry engagement in funded research.

Liz's research focus is on human-centered AI, especially mechanisms to support human decision making in hybrid teams comprised of humans and AI systems. Her contributions are in the design of agent-based architectures and reasoning mechanisms that are sufficiently expressive to be suited to specified tasks in various domains, but also tractable, and hence able to be embedded in software.

Liz was the recipient of the Distinguished Research Contribution in the 2020 Australasian AI Awards and is currently a member of the international Standing Committee of the One Hundred Year Study on Artificial Intelligence (AI100). She has held several senior positions at the University of Melbourne, been a director of five small companies associated with the University and held Advisory Board roles in various Commonwealth funded national research infrastructure initiatives. Furthermore, was a member of the Board of the International Foundation for Autonomous Agents and Multiagent Systems from 2002 to 2008, and in 2004 was program co-chair of the Third International Joint Conference on Agents and Multi Agent Systems hosted in New York.

Liz holds a Bachelor of Science and Doctor of Philosophy from Monash University.

Mike Hill



Mike Hill is the Head of First Nations Strategy and Engagement at Amazon Australia and a Partner Solutions Architect at Amazon Web Services (AWS). Mike also currently serves as the Deputy Chair of SJ Makerspace, a not-for-profit association, which Mike co-founded.

Mike has pioneered significant initiatives while working at Amazon. The Amazon Australian Reconciliation Action Plan was developed under Mike's leadership and provides a structured approach to advancing Amazon's reconciliation efforts. Mike also built the AWS Partner Network Indigenous Partner Practice. The practice supports Indigenous-owned IT service providers and service vendors to grow as businesses. Furthermore, Mike chairs the Australian and New Zealand Indigenous Employee affinity group which supports First Nations employees and promotes cultural awareness within Amazon.

Through his volunteer work at SJ Makerspace, Mike strives to promote the teaching and learning of STEM subjects to youth in the Serpentine-Jarrahdale area. Mike has several responsibilities at the association, including board recruitment and induction, grant applications, marketing strategy, and administration and budget management.

Mike has a Master of Business Administration from the University of Western Australia and a Bachelor of Science (Geographic Information Science) from Curtin University of Technology. Mike has over 15 years of experience in the data and geospatial industry and is an AWS Certified Solutions Architect, Cloud Practitioner, and DevOps Engineer.

Emeritus Professor Robyn Owens AM



Robyn is an Emeritus Professor in the Australian university sector and the former Deputy Vice-Chancellor (Research) of the University of Western Australia (UWA). She has over 30-years' experience working as a teacher, researcher, and university leader, focusing on strategy and national policy.

Robyn has a BSc (Hons) from UWA and a MSc and a DPhil from Oxford, all in Mathematics. She worked at l'Université de Paris-Sud, Orsay, continuing research in mathematical analysis before returning to UWA to work as a research mathematician.

Through her role as Pro-Vice-Chancellor (Research & Research Training) at UWA, Robyn led the development and research training of over 1900 research students. Before taking up that position, she was Head of the School of Computer Science & Software Engineering at UWA from 1998 until the end of 2002.

Robyn has lectured in Mathematics and Computer Science at UWA, and Electrical Engineering and Computer Science at Berkeley, as well as for shorter periods in Thailand and New Zealand. Her research has focussed on computer vision, including feature detection in images, 3D shapes measurement, image understanding, and representation. Her work has been acknowledged with several international awards, including the 2010 UK Rank Prize.

Robyn is an elected Fellow of the Australian Academy of Science, the Australian Academy of Technological Sciences & Engineering, and the Australian Computer Society. She is a graduate of the Australian Institute of Company Directors and of the Vincent Fairfax Ethical Leadership Program. She currently sits on the Senate of Murdoch University. In 2023, Robyn was recognised for her significant service to science in the fields of computer visions and mathematics by receiving an Order of Australia (AM) in the 2023 King's Birthday Honours List.

Robyn is also the Independent Chair of the ACCESS-NRI Board.

Richard Northam



Richard Northam is the Director of North Pier Pty Ltd, a consulting firm that specialises in Information Technology in Higher Education and Research. Richard currently serves on the board of the Australian Access Federation Ltd as an independent director and was previously its company secretary.

Richard has had a long association with NCRIS in a number of senior roles including the Director of National Engagements at Australian National Data Service (ANDS), the Director of the Research Data Services (RDS) Project, and as the Node Manager with the Research Data Storage Initiative (RDSI) project. He later served as a Director on the boards of the RDS Project and National eResearch Tools and Resources (Nectar) Project. In the 18 months before the formation of the Australian Research Data Commons (RDSI), Richard played a key role as a trusted facilitator and co-ordinator of discussions between the Executive Directors of ANDS, RDS and Nectar and acted as a conduit between the governing bodies. He served briefly as the Interim Executive Director of RDSI after its formation.

Richard took a key leadership and authorship role to make the case among the NCRIS community and the Australian government that Trust and Identity for research is an important element of the making the National Research Infrastructure ecosystem more connected, accessible by Australian and global researchers, and importantly safe and secure. The Australian Access Federation has since been formally recognised as an NCRIS facility to lead Trust and Identity for the NCRIS system.

Before working inside the NCRIS system, Richard was the CEO of the Council of Australian University Directors of Information Technology (CAUDIT). In this role, he was instrumental in building an awareness among the CIO community at universities of both the importance and the need for institutional information technology groups to engage with and support the needs of researchers and the NCRIS system. In the early years of NCRIS, he led a series of study tours of CIO's, researchers and departmental representatives to the UK, Europe, Canada and the USA to build global connections and seek out best practice examples of eResearch projects and initiatives. Before CAUDIT, he was the Director of IT at University of New South Wales at the Australian Defence Force Academy, and held a number of senior positions within the Australian Public Service, including a stint working at the Australian Parliament House supporting the IT needs of ministers and senators.

Richard holds a Bachelor of Engineering (Electronics) and is a Senior Member & Certified Professional of the Australian Computer Society. He has a keen interest in craft brewing and is the co-founder of the Frogs Hollow Brewing Company. He lives and works on the far south coast of New South Wales, Australia.

Professor Elanor Huntington



Elanor Huntington is the Executive Director of Digital, National Facilities and Collections at CSIRO and a Professor of Quantum Cybernetics at the Australian National University (ANU).

Elanor leads the data-focused research, development and digital capability of CSIRO and is the Executive Sponsor of the Secure Australia and Region Challenge as well as the lead for CSIRO's relationship with the Department of Defence.

Elanor is a Fellow of the Australian Academy of Technology and Engineering and participates in the Academy's governance taskforce, diversity and inclusion committee, and the Reconciliation Action Plan (RAP) committee. Elanor is also an Honorary Fellow of Engineers Australia.

Before joining CSIRO, Elanor held roles across Australia's research landscape, including Dean of the College of Engineering and Computer Science at ANU, Chair of the extended Group of Eight (Go8+) Engineering Deans, and Program Manager in the ARC Centre of Excellence for Quantum Computing Technology.

Elanor holds a PhD in experimental quantum optics and a Masters in Information Technology.

Appendix 2: NDRI Working Group Terms of Reference



Australian Government
Department of Education

National Digital Research Infrastructure (NDRI) Working Group

Terms of Reference

Last Update: August 2024

Purpose

These Terms of Reference (ToR) describe the role of the Working Group (WG) responsible for developing a NDRI Investment Plan (NDRI IP), to be finalised by early 2025.

Context

As in the 2021 National Research Infrastructure (NRI) Roadmap, NDRI is defined as: digital research infrastructure components that are collectively managed and operated as coordinated facilities and services for research institutions and users across the country because they are so nationally significant, or large in scale, complexity or cost that they cannot be offered by a single institution or facility.

The NDRI IP will advance the 6 outcomes of the NDRI Strategy endorsed by the NRI Advisory Group (NRIAG) on 12 July 2024.

- Outcome 1: Underpinned by training frameworks for researchers and NRI workforce.
- Outcome 2: Responsive to technological and societal shifts.
- Outcome 3: Consistent in its standards for data collection, including attribution, curation, and access.
- Outcome 4: Integrated computing and data infrastructure.
- Outcome 5: Cybersecure, particularly for national-scale data and computing.
- Outcome 6: Maximised by openly available research software tools.

The NDRI IP will be guided by the current NRI Principles and NRI Investment Principles and should position Australia's researchers to undertake and apply world-class research. It is anticipated that the NDRI IP will be completed by the NDRI WG, endorsed by the NRIAG, and submitted to the Department of Education (the Department) in early 2025. The Department will then progress it to the Minister for Education for decision, in consultation with the Minister for Industry and Science.

Objectives

The WG will provide expert advice to the Australian Government and the NRIAG on the highest priority investments required, ensuring Australia has a strong NDRI capacity to support world class research. The WG will be informed by strong engagement with research and user needs, and the NDRI IP should be forward looking and set out the expected research and user needs up to 10 years from now. The NDRI IP will encompass the full life cycle of relevant NDRI. It should consider longer term investment.

The investments identified should:

- position Australia and its research communities as a world leader in research that relies on NDRI.
- consider whether Australia should make investments that explicitly focus on developing world leading NDRI capabilities, including but not limited to:
 - the utility of an expanded and integrated national computing capacity
 - the benefits to Australian research and industry from high performance computing capacity
 - options for international partnerships and collaborations.
- set out how future investment will prioritise the maintenance and/or development of:
 - key skills, such as research software engineering data analytics, and emerging capabilities.

- set out the potential impact on Australia’s research capacity and outcomes of differing levels of additional National Collaborative Research Infrastructure Strategy (NCRIS) investment, against various potential levels of funding:
 - a high level of investment from NCRIS, plus co-investments
 - a medium level of investment from NCRIS, plus co-investments, which represents a lower investment but is beyond the urgent minimum
 - a low level of investment from NCRIS, plus co-investments, which represents an urgent minimum investment.

The WG should not assume all current arrangements continue, therefore the NDRI IP should:

- consider options for reorganising or enhancing governance about:
 - the speed of decision making within and across integrated NDRI investments
 - the speed and efficiency of support provided to research communities and other NDRI users.
- consider the need to create new NDRI or build on existing NDRI.
- consider the benefits to the translation and commercialisation of Australian research.

Membership and Responsibilities

The WG is an advisory body. The Minister for Education, in consultation with the Minister for Industry and Science, will make decisions on funding from NCRIS to implement the NDRI IP.

The WG will consist of at least 6 members, including a Chair. The Chair will have main responsibility for maintaining communication with the Department and for coordinating the work of the WG. Combined, the WG members will have:

- knowledge and expertise in relation to planning and conducting leading edge research, and how NDRI support for research can be maximised.
- knowledge of Australia’s NDRI system.
- deep knowledge and expertise in relation to the individual components of Australia’s NDRI system and ability to apply that knowledge to improve the system.
- deep knowledge of emerging technologies that will improve NDRI components.
- deep knowledge of workforce and skills issues relevant to NDRI.
- knowledge of potential co-investing organisations.

The term of membership is from inception of the WG until the final NDRI IP is submitted to the Department.

Members are obliged to declare conflicts of interest. The WG will maintain a register of material interests, update that register at each meeting and manage conflicts through standard protocols.

The WG will ensure broad cultural perspectives are presented for significant decisions and issues. The WG will particularly ensure that the IP is respectful to First Nations cultures and knowledges, and promotes and sustains ethical and responsible First Nations research across disciplines and methodologies (AIATSIS Code of Ethics for Aboriginal and Torres Strait Islander Research, CARE Principles for Indigenous Data Governance) as well as working towards commitments to improve the outcomes of First Nations peoples (Closing the Gap, Priority Reform 4).

Meetings

The WG will meet as needed and should use a consensus-driven approach to decision making. A quorum will consist of the Chair, and two other members.

Deliverables and process

The WG will produce the NDRI IP in line with the following process:

- *Initial consultation* – a blend of open and targeted consultation on advancing the objectives of the IP.
- *Call for potential investments* – potential NDRI providers, identified through the initial consultation, will be invited to submit costed outlines of how they could provide research infrastructure that would advance the objectives of the NDRI Strategy.
- *Drafting and testing* – gathering and incorporating feedback on the initial draft NDRI IP from the NRIAG and through other consultations.
- *Consultations on the draft final NDRI IP* – a blend of open and targeted consultation on how well the draft final IP will advance the objectives of the NDRI Strategy.
- *Submit* - Finalise the NDRI IP, including recommended funding level, seek endorsement from the NRIAG, and submit to the Department.

Appendix 3: NRI Principles and NRI Investment Principles (from the 2021 NRI Roadmap)

NRI Principles

- NRI maximises the capability of the research and innovation system to contribute to economic outcomes, national security, social wellbeing and environmental sustainability.
- Research infrastructure is collaborative and planned in a way to provide a network of capabilities that serve the national interest and are aligned with government priorities.
- NRI includes people, skills and knowledge, data, processes and equipment.
- NRI resources are focused to achieve maximum impact in national priority areas.
- NRI is managed to deliver maximum impact as efficiently as possible. Synergies with complementary and related capabilities drive an ecosystem of support for researchers.
- NRI is widely accessible to researchers and industry across Australia. Barriers to access are as low as practicable.
- NRI enhances participation of researchers in, and provides access to, the international research system.
- NRI is respectful to Indigenous cultures and knowledges, and adopts the principles of Indigenous self-determination, leadership, impact and value, and sustainability and accountability as outlined in the AIATSIS Code of Ethics for Aboriginal and Torres Strait Islander Research.

NRI Investment Principles

- Funding for investment in NRI is in areas of national significance that can demonstrably support Australia's research and innovation system.
- Investment should balance the long-term nature of NRI development, together with changes in national priorities and identified gaps in the research and innovation system.
- Investment should produce NRI that facilitates and enhances industry and international engagement.
- Investment cases describe the intended impact and reflect the resources and governance needed to develop and manage world-class research infrastructure capability. These include the equipment, processes, data, skills and knowledge needed to deliver maximum value.
- Investment encourages and leverages opportunities for co-investment from states and territories, university, public and private sectors.
- Investment supports the development of a cohesive suite of NRI that strives to create an ecosystem of seamless services for researchers.

Appendix 4: NDRI Strategy on a Page Summary

Vision

User-centric design must lie at the heart of Australia’s NDRI system.

Australian researchers, from all disciplines, should have access to cutting-edge, sovereign NDRI capabilities to continue delivering world-class research and innovation.

<u>Outcome 1</u> UNDERPINNED BY TRAINING FRAMEWORKS FOR RESEARCHERS AND NRI WORKFORCE	<u>Outcome 2</u> RESPONSIVE TO TECHNOLOGICAL AND SOCIETAL SHIFTS	<u>Outcome 3</u> CONSISTENT IN ITS STANDARDS FOR DATA COLLECTION, CURATION AND ACCESS	<u>Outcome 4</u> INTEGRATED ACROSS LEVELS OF COMPUTING AND DATA INFRASTRUCTURE	<u>Outcome 5</u> CYBERSECURE, PARTICULARLY FOR NATIONAL-SCALE DATA AND COMPUTING	<u>Outcome 6</u> MAXIMISED BY OPENLY AVAILABLE RESEARCH SOFTWARE TOOLS
<p>Opportunity: Supporting Australia’s NDRI workforce will enhance the quality of the nation’s research.</p> <p>Challenge: Without a highly skilled NDRI workforce, Australia will not reach its full potential.</p> <p>Approach: Governments should work with NDRI providers to address staff shortages and expand workforce training opportunities.</p>	<p>Opportunity: NDRI technological advancements support Australian researchers to perform unprecedented research.</p> <p>Challenge: Rapid advances and societal shifts can lead to obsolete and ineffective digital resources.</p> <p>Approach: Coordinated, expert-informed strategic planning should underscore Australia’s future NDRI system.</p>	<p>Opportunity: Ensuring Australia’s growing volume of research data is as FAIR as possible will offer benefits to researchers.</p> <p>Challenge: Increasing volumes of research data are being generated that are not FAIR/CARE compliant.</p> <p>Approach: A sector-wide data management framework that supports FAIR/CARE compliance nationally.</p>	<p>Opportunity: A seamlessly integrated NDRI ecosystem will support Australia’s researchers.</p> <p>Challenge: Researchers have rapidly expanding NDRI demands but may lack expertise to use data efficiently and effectively.</p> <p>Approach: Pursue integrated access to different tiers of compute and shared data.</p>	<p>Opportunity: Enforcing Australia’s NDRI cybersecurity protects nationally valuable and sensitive digital resources.</p> <p>Challenge: Cybersecurity threats are growing as research data sensitivities increase.</p> <p>Approach: NDRI providers should support assessment and mitigation of cybersecurity risks, underpinned by system-wide trust and identity solutions.</p>	<p>Opportunity: Supporting research software tools as critical NDRI capabilities ensures efficient and effective research conduct.</p> <p>Challenge: Software is critically important, yet its place in NDRI is not well defined.</p> <p>Approach: Research software tools should be recognised with equal importance to NDRI computing, data and networking capabilities.</p>

Implementation

An independent NDRI Working Group will develop an NDRI Investment Plan to implement the NDRI Strategy. The NDRI Investment Plan will be underpinned by stakeholder engagement and guided by the NRI Advisory Group. The Investment Plan will be funded, implemented, and monitored through NCRIS.