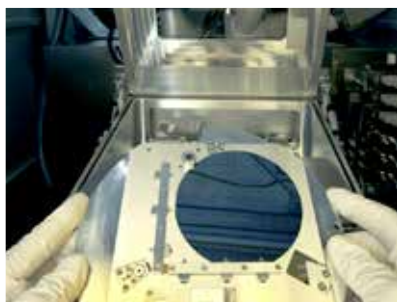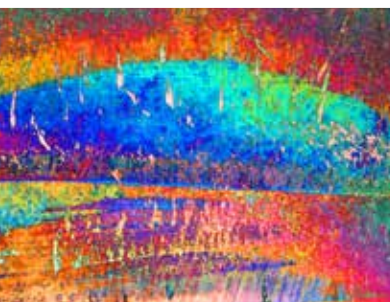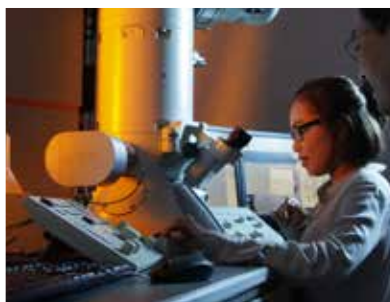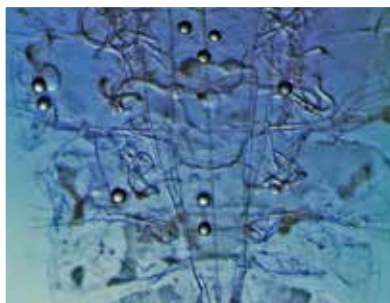**Australian Government**

FACILITIES FOR THE FUTURE
UNDERPINNING AUSTRALIA'S RESEARCH AND INNOVATION

Government Response to the 2016 National Research Infrastructure Roadmap
Research Infrastructure Investment Plan

Government Response to the 2016 National Research Infrastructure Roadmap Research Infrastructure Investment Plan

National research infrastructure (NRI) comprises the nationally significant assets, facilities and services that support leading-edge research and innovation. It is accessible to publicly and privately funded users across Australia, and internationally.

The Australian Government is committed to ensuring that Australia stays at the forefront of advanced science, research and innovation in what is an increasingly competitive global environment. A modern and world-class NRI system will drive advances in technology and knowledge that boost productivity, create jobs, and deliver economic growth.

> *Research infrastructure is a critical platform for the research sector that supports in excess of 150,000 jobs[1], which in turn supports countless more jobs, including in small businesses, across almost every sector of the economy.*

That's why the Government commissioned the development of the *2016 National Research Infrastructure Roadmap* (Roadmap), by an expert group led by Australia's Chief Scientist, Dr Alan Finkel AO. The Roadmap built on the recommendations of the 2015 Research Infrastructure Review, chaired by Mr Philip Marcus Clark AM, which highlighted the need for excellent research infrastructure to support excellent research. Released in May 2017, the Roadmap identifies the NRI that Australia needs to meet its long-term future research needs and goals. The Roadmap made nine recommendations and identified 36 NRI priorities to position NRI for the next decade.

The Government has considered and responded to these recommendations through the Research Infrastructure Investment Plan (Investment Plan). Capitalising on this opportunity to remain at the forefront of global research, the Government has committed almost $2.2 billion to 2028–29 to refresh and enhance infrastructure and provide vital operational funding in line with the Roadmap's nine focus areas and the nation's research priorities. This significant investment will ensure Australia's researchers and businesses have the cutting-edge equipment and infrastructure to keep Australia on the forefront of research across health, environment, manufacturing and emerging technologies, such as quantum computing and nano-technology.

New expenditure in the 2018-19 Budget of around $1.9 billion for the National Collaborative Research Infrastructure Strategy (NCRIS), builds on the Government's commitment under the National Innovation and Science Agenda (NISA), which together comprise the most comprehensive investment in NRI by any Australian Government. New investments include:

- $1.5 billion for equipment and capabilities to ensure researchers have access to the most advanced infrastructure
- around $400 million to support critical operating funding for facilities, and scoping of potential new cutting-edge capabilities

A further $70 million was committed in the 2018-19 Budget for the Pawsey Supercomputing Centre to upgrade its High Performance Computing (HPC) capability.

1. Measured in person years of effort

These investments build on the $189 million of investments made in 2017-18 responding to the Roadmap priorities, specifically:

- $70 million for the National Computational Infrastructure for HPC replacement to ensure that our nation remains a world-leader in data analysis and predictive modelling, and

- $119 million for the strategic partnership with the European Southern Observatory (ESO), giving Australian astronomers competitive access to a suite of the world's best optical astronomy research infrastructure.

Critically, this investment will create approximately 500 new jobs over the next ten years, including for STEM graduates. It will provide cutting-edge NRI for over 40,000 users (nationally and internationally) from universities, industry, Government and research agencies of these facilities. This drives further employment in support industries, such as high-tech construction, advanced manufacturing and scientific endeavours. This virtuous cycle will continue to grow the economy, encourage innovation and support businesses of every size.

This substantial additional funding will support:

- access to new generation microscopes to observe the world at a scale not seen before

- imaging equipment that will allow us to delve into the previously unknown inner workings of animals and the human body

- further understanding of the largely unexplored frontiers of our oceans, through expanding the operations of the RV *Investigator* by an additional 120 days a year

- construction of advanced fabrication facilities to design and manufacture the next generation of devices at the nanoscale to be at the forefront of the quantum computing revolution and harness the opportunities of space, through building CubeSats and other space-based instruments

- expansion of the Southern Hemisphere's unique nuclear capabilities to drive world-leading advances in biotechnology, agricultural, chemical and material sciences

- expansion of Australia's pioneering approach to environmental and ecosystem data collection and analysis.

Recognising the Roadmap's recommendation to urgently address national HPC, an additional $140 million has been committed to upgrade and purchase new supercomputers for Australia's two Tier 1 HPC facilities: the National Computational Infrastructure facility and the Pawsey Supercomputing Centre.

The public benefit of the Government's research infrastructure commitments cannot be overstated:

- **better management of the Great Barrier Reef** – remote sensor data on a range of ocean conditions and events, including coral bleaching, is helping to preserve the health of the Reef. Tourism and fishing in and around the Reef is worth about $6 billion annually and supports around 69,000 Australian jobs.

- **improving agricultural returns** – utilising genomics to increase wheat yields, an export industry worth $6 billion in 2016-17, and enhance biosecurity measures, such as recently detecting an active rotavirus in pigeons, which without identification would have had devastating impacts for Australia's $5.6 billion poultry industry.

- **increasing identification of cancer** – enabling earlier identification of cancer and through less invasive means, such as an Australian developed blood test to improve bowel cancer detection (almost 15,000 new cases are diagnosed annually in Australia); and supporting the melanoma framework datasets that are comparing the genetic code of normal cells and melanoma tumours to identify all the mutations present. A 2017 study calculated the economic impact of melanoma diagnosis and treatment in Australia at $201 million per annum.

- **developing patents and next generation devices with industry** – supporting research in the transformation of material structures for application in sensors, medical devices, nanophotonics and nanoelectronics—such as the Vaxxas Nanopatch TM to deliver needle free vaccines.

- **improving weather forecasting, especially extreme events** – in addition to improving everyday weather forecasts for the public, productivity of the offshore resource industry has been significantly enriched through superior cyclone forecasting.

- **improving cyber security** – advanced fabrication facilities provide Australia with a significant competitive advantage in quantum computing developments with implications for cyber security research.

The Government will continue to work closely with the research sector and experts on identifying strategic priorities and future planning for NRI facilities, including landmark facilities. It will develop roadmaps and investment plans for NRI on a regular basis to ensure a strategic whole-of-government approach is taken to future investments.

The response to the Roadmap and Investment Plan will ensure that Australia's NRI needs are addressed in a strategic and measured way and our NRI system is maintained and strengthened in areas of national benefit, including agriculture, health, defence, environment and advanced industries.

Objective: A well-supported and strong NRI system that underpins research and innovation

A strong NRI system is necessary to deliver the research excellence that drives innovation across the economy and creates jobs. NRI facilities are also melting pots for collaboration – they bring together researchers from across broad disciplines, catalysing relationships and supporting cross-disciplinary research.

High-quality and accessible NRI is a prerequisite for attracting international innovators and companies, driving Australia's reputation for scientific and research excellence. It attracts, develops and exports a highly skilled workforce, including the next generation of researchers. It encourages strong long-term industry and research partnerships, both domestically and internationally, which provide a conduit for knowledge to support industry to deliver future jobs and economic growth.

A consolidated approach—understanding NRI needs

The Investment Plan provides a strategic, whole-of-government view to investing in Australia's NRI system. It was developed following the Government's detailed consideration of the Roadmap, including nearly 500 written submissions and consultations with over 580 stakeholders.

This was supplemented with targeted information collected from existing NRI hosts and other experts on infrastructure requirements, having regard to existing and future research infrastructure needs and Government priorities, such as Australia's Science and Research Priorities. Other important considerations included engagement and collaboration, support for Government activities, research excellence and funding urgency.

The Investment Plan was developed in consultation with Innovation and Science Australia (ISA) and the Commonwealth Science Council, and drew on advice from facilities.

Consistent with the objective of achieving a strategic and consolidated approach to the NRI system, investments will primarily be made through the National Collaborative Research Infrastructure Strategy (NCRIS) program, managed by the Department of Education and Training.

The investments identified in this Plan complement the significant funding the Government has already committed to NRI through NCRIS and direct appropriations to departments, agencies and publicly funded research agencies (PFRAs).

A detailed response to each of the Roadmap's nine recommendations is at **Attachment A**.

Policy landscape

This Investment Plan aligns with Government policies across many portfolios, most notably Health, Defence, Jobs and Innovation and Education. In addition, it will be a key plank in supporting the vision laid out in *Australia 2030: Prosperity through Innovation*. The strategic plan was released by ISA in January 2018 and provides a long-term roadmap for increasing Australia's innovation performance.

The 2030 Plan highlighted the need to continually invest in research infrastructure to maintain Australia's high quality research and recommended that secure, long term funding for NRI be committed.

Investment in NRI has benefits across the economy. For example, the Blue (Ocean) Economy currently contributes $47 billion per annum to the overall economy and is predicted to grow to $100 billion by 2025. The Blue Economy gains significant benefit from marine science and from innovative research and development—ranging from the more efficient exploration of new resources, effective monitoring and prediction of ocean state, ensuring sustainable management of fisheries, and providing for targeted and effective environmental management of Australia's many unique marine assets. Similarly, investment in the Integrated Marine Observing System (IMOS), the Research Vessel (RV) *Investigator* and the National Sea Simulator (SeaSim) are helping Australia to better understand the current state of the Great Barrier Reef, and how to best manage it into the future.

Case Study

Bioplatforms Australia (BPA) enables world class research in the life sciences by investing in state-of-the-art infrastructure and associated expertise in the fields of genomics, proteomics, metabolomics and bioinformatics. For example, genomics is the study of genomes—the entirety of our DNA, and was a major focus of the 2030 Strategic Plan. It noted that genomics and precision medicine will play an increasing role in improving health outcomes. Through next generation gene sequencing, BPA is working to integrate genomic medicine into healthcare to create personalised, precision medicine. This aim is to shorten diagnosis time and enable early intervention.

Investments in BPA will also include state-of-the-art genomics infrastructure to support the world's largest coral genomics sequencing project, which will help researchers understand the genetic makeup of corals and how they might respond to climate change.

The Government's Investment—driving Australia's R&D into the next decade

The Government's commitment of $2.2 billion to 2028–29, builds on its commitment of over $2.3 billion in 2015 under the NISA:

- $1.5 billion over 10 years, indexed, for operational costs of facilities under NCRIS
- $520 million operating funding for the Australian Synchrotron
- $294 million for Australia's commitment to the Square Kilometre Array (SKA).

As recommended in the Roadmap, this new investment is aligned to the nine focus areas, which were developed based on input from stakeholders. Investing in these areas will strengthen Australia's economy, benefit our communities and improve our global competitiveness.

The Roadmap recognised and re-affirmed the key priorities of NRI investment to date. Investments are therefore directed primarily into existing NRI facilities to secure and expand their capacity. The facilities comprise nodes, partnerships and joint ventures that represent most Australian universities and many research institutes, businesses and state and territory governments. Investments largely fall into four categories:

- Funding to **maintain current capability**, such as replacing ageing equipment and buildings, including a new building for the National Collections held by CSIRO.
- Funding to **expand existing capabilities** to current and next generation technologies, such as through BPA.
- **Expand merit-based access** to existing facilities, for example the RV *Investigator*.
- **Scoping studies** to explore potential new NRI activities, including the role of Government funding in supporting 'green-fields' projects.

Over the five years from 2017–18, the Government's investment includes $572.2 million to support the most critical and urgent priorities in NRI. The new funding will provide Australian researchers with critical infrastructure to ensure our research system is world-class and the cornerstone for innovation and enable productivity growth. The table below outlines the investments against the nine Roadmap focus areas over the next five years, and the next twelve years, noting that funding in the later period will be subject to the next roadmap.

Roadmap Focus Areas	Proposed Investments*	Value of Investment ($m)	
		2017–18 to 2021–22**	Total to 2028–29
Digital data & eResearch platforms	Funding will ensure a regular upgrade cycle for maintaining Australia's Tier 1 HPC capability, across both the Pawsey Supercomputing Centre (Pawsey) and the National Computational Infrastructure. In addition, a scoping study will be undertaken to explore opportunities for enhanced capabilities over the horizon. Investments will enable critical upgrades to virtual laboratories, research cloud storage and data security, providing a strong basis for the increasing volume of complex computing demands across government, research and industry.	219.0	911.1
Platforms for Humanities, Arts and Social Science (HASS)	Funding will enable greater integration and modern accessibility of datasets available through the Australian Urban Research Infrastructure Network (AURIN) and the Atlas of Living Australia. Investments will ensure the preservation of the National Collections maintained by CSIRO through the construction of a new and purpose-built building to consolidate the housing of existing national insect, wildlife and plant collections to ensure their long term preservation. A scoping study will be undertaken to identify the technology platform and capabilities needed to establish HASS and Indigenous research platforms.	53.4	112.0

Roadmap Focus Areas	Proposed Investments*	Value of Investment ($m)	
		2017–18 to 2021–22**	Total to 2028–29
Characterisation	Investments in maintaining and modernising instrumentation at AMMRF and NIF to strengthen characterisation capabilities and move towards next generation microscopy and imaging capabilities. Investments to maintain the capabilities at the National Deuteration Facility (NDF) and Centre for Accelerator Science (CAS) to ensure these critical Australian Nuclear Science Technology Organisation (ANSTO) managed facilities continue to deliver their services to industry and researchers.	68.3	169.3
Advanced Fabrication & Manufacturing	Investments in new instruments at the ANFF will enable Australia to not only undertake world-class R&D but also rapid prototyping of next generation equipment and application of the technology for industry and commercialisation. A scoping study will be undertaken to explore the precision measurement capability need to position Australia as globally competitive, especially in quantum capabilities and instrumentation. Next generation measurement capability is required for characterisation, validation and qualification beyond what is currently domestically available.	36.5	106.6
Advanced Physics & Astronomy	Government has previously made strategic investments in long-term research infrastructure. Of note, is the 10-year Strategic Partnership between Australia and the European Southern Observatory (ESO), which provides astronomers in Australia with competitive access to a suite of the world's best optical astronomy research infrastructure, including their eight metre telescopes. As part of the Government's Roadmap response a level of additional funding is committed for Australian Square Kilometre Array Pathfinder (ASKAP) operations. Funding will ensure that current capabilities are maintained and necessary replacement and maintenance of the ANSTO-hosted Australian Centre for Neutron Scattering.	47.3	150.0

Roadmap Focus Areas	Proposed Investments*	Value of Investment ($m)	
		2017–18 to 2021–22**	Total to 2028–29
Earth & Environmental Systems	Investments through the Intergrated Marine Observing System (IMOS) and the Terrestrial Ecoystem Research Network (TERN) will ensure data streams are maintained through equipment upgrades and the latest technologies are utilised, such as using advanced sensors and autonomous vehicles. Additional funding improves IT platforms maintained by AuScope with priority towards Earth imaging, subsurface observatory and spatial representation to improve the discovery, development and management of Australia's minerals, energy and groundwater resources. Funding provided ensures the full utilisation of the RV *Investigator* delivering an additional 120 days of merit-based access. Work will also be undertaken with key stakeholders to develop a national coastal vessel capability beyond 2021–22. Scoping studies to explore requirements for a more advanced climate and environmental prediction through an enhanced ACCESS model and establishment of a national environmental prediction system will also be undertaken.	60.5	309.4
Biosecurity	Investment opens up merit-based access to the Australian Institute of Marine Science hosted SeaSim for researchers. Funding will enable a fulsome scoping study of gaps and opportunities to network and leverage existing operational-focussed biosecurity investments for researchers.	0.4	75.5
Complex Biology	Investments enable upgrades to next generation sequencing, mass spectrometry, cryo-storage, phenotyping and virtual laboratories that will drive new medical treatments, reduced future medical costs and facilitate emerging opportunities in biomedicine, medical technology, agribusiness and environmental conservation. Funding provides critical infrastructure maintenance costs for next generation capabilities for agriculture research, including investment in next generation imaging and modelling. Studies are funded to scope the investments needed to maximise the broad range of biobanks across Australia and in synthetic biology to drive the next discoveries.	53.4	216.2

Roadmap Focus Areas	Proposed Investments*	Value of Investment ($m)	
		2017–18 to 2021–22**	Total to 2028–29
Therapeutic Development	Investments enable significant advancements in underpinning infrastructure available to drive clinical trials and facilitate Australia's next breakthroughs in biotechnology and pharmaceuticals. Funding improves underlying infrastructure to link more health and population data collections, which will have significant benefit for policy and research outcomes.	33.7	128.2

* As noted in the Roadmap, it is acknowledged that facilities have benefits across a number of focus areas. Facility funding has been allocated consistent to their primary alignment in the Roadmap.

** Includes investments in 2017–18 Budget and and Mid Year Economic and Fiscal Outlook (MYEFO) complementing the recommendations in the Roadmap, e.g. ESO, NCI and Pawsey.

Note: Facility level funding breakdowns to 2021–22 is at **Attachment B**.

Scoping studies will be developed in collaboration with key stakeholders and will explore technical requirements, implementation approaches and potential co-investors. Outcomes of scoping studies will be considered in future investment plans.

Co-investment

Recognising the wide benefit and use of NRI, over $1 billion in co-investment in NRI facilities was realised from various sources over the last decade—primarily industry, universities, state and territory governments and research institutes. It is expected that co-investment will continue to support the operations of existing NRI facilities. This support takes many forms, including provision of rent in-kind to cash contributions for the cost of the technical staff who operate and maintain the essential equipment.

Additional co-investment will be generated as a result of this stable, long-term commitment from Government, which is vital to continuing to expand the capabilities of the NRI facilities.

International

Australia is part of an intricate web of research infrastructure that spans the globe. This network allows transfer of knowledge, staff and skills, with Australian researchers using overseas facilities and Australian facilities reciprocally hosting international researchers. NRI facilities provide great opportunity for international engagement and are necessary for a range of existing arrangements. They provide Australia with access to forums that may otherwise be unavailable. For example, TERN has seven Memoranda of Understanding (MOU), and international partnerships with countries including the United States of America, Japan, Singapore and Canada. These MoUs support Australian's leadership role in terrestrial ecosystem research infrastructure and progress goals of data comparability and contributions to international research.

Internationalisation of some facilities is also necessary, where the cost and complexity of infrastructure is such that no one country can provide support. As such, Australia buys access to some overseas infrastructure, where it is not cost efficient or possible to establish the capability in Australia. For example Australian astronomers have competitive access to optical telescopes at La Silla and Paranal ESO Observatories in Chile, through Australia's Strategic Partnership with ESO.

Consideration of access and membership to international facilities will continue to be reviewed as part of future roadmaps and investment plans, to complement, augment or replace investments in domestic facilities to ensure Australian researchers have access to world-class infrastructure.

Addressing new scientific and technical requirements— ongoing refreshment of investment priorities

Acknowledging technology and scientific changes over time, new roadmaps for NRI will be developed every five years to refresh the ten-year vision of the NRI system and strategic priorities for research, in consultation with the wider research sector. Investment plans will be developed every two years to reaffirm and update investment activities. The Government will seek advice to ensure eminent experts across the NRI sector are informing Government decision making.

Development of the next Investment Plan will commence in 2019, with drafting of the next Roadmap to begin in 2021.

Attachment A

2016 National Research Infrastructure Roadmap Government Response

Recommendation	Government Response
Recommendation 1 Adopt nine focus areas and their priorities to strengthen our economy, advance societal benefit, improve our competitiveness, and build on our existing national capability. These focus areas complement the National Science and Research Priorities and the Industry Growth Centres. They are: Digital Data and eResearch Platforms; Platforms for Humanities, Arts and Social Sciences (HASS); Characterisation; Advanced Fabrication and Manufacturing; Advanced Physics and Astronomy; Earth and Environmental Systems; Biosecurity; Complex Biology; and Therapeutic Development.	**Agreed** The Government notes the nine focus areas and the priorities outlined in the Roadmap recognising their importance in strengthening Australia's economy, advancing societal benefit, improving our competitiveness and building on existing national capability.
Recommendation 2 Establish a National Research Infrastructure Advisory Group to provide independent advice to Government on future planning and investment for a whole of government response to national research infrastructure.	**Agreed in-principle** The Government will continue to seek expert advice from relevant experts as needed to provide strategic advice to Government on the national research infrastructure system, including current and emerging trends, to support future planning and investment.
Recommendation 3 Develop a Roadmap Investment Plan that will actively engage with all levels of Federal and State government, universities, industry, philanthropy, research institutions and research agencies. The investment plan must take a portfolio based approach and consider the business case for focus areas including analysis of funding sources for capital and operational needs, access rules, outreach programs and international engagement.	**Agreed** The Government announced the development of the investment plan in the 2017–18 Budget. The plan will be released outlining the current investments and investments over the next decade. As part of the 2018–19 Budget, the Government is committing over $390 million over 2017–18 and the forward estimates through the Investment Plan to address remaining current NRI capital and operational gaps and to begin to make strategic investments to position Australia's research and innovation system for the next decade.

Recommendation	Government Response
Recommendation 4 Address the needs of complementary initiatives such as the newly established Medical Research Future Fund (MRFF) and the Biomedical Translation Fund (BTF). These will increase demand for research infrastructure and must be considered as an integral part of any roadmap investment plan.	**Agreed** Expert advice will assist Government on an ad hoc basis to ensure investments appropriately support Government policy, including in the areas of health, advanced manufacturing and agriculture.
Recommendation 5 Recognise that a skilled workforce is critical to national research infrastructure. Ongoing commitment to training and career progression, not only by the facilities and projects but also by the universities and research institutions that harness them, is essential.	**Noted** The Research Infrastructure Investment Plan recognises the importance of a skilled workforce and highlights the need to work with research organisations and universities to continue to develop other trained technicians and career pathways for researchers.
Recommendation 6 Recognise that existing landmark facilities such as the Australian Animal Health Laboratory (AAHL), Australian Synchrotron, the OPAL Nuclear Research Reactor, and the Marine National Facility (RV Investigator) will require ongoing investment.	**Noted** Government notes that ongoing funding is being considered for these facilities for their current operational arrangements and enhancements will be considered as part of future prioritised investment.
Recommendation 7 Implement a coordinated approach to International engagement to optimise the benefits of international memberships and partnerships, including access to global facilities and participation in strategic collaborations.	**Agreed** The Government notes the need to consider investment in international facilities and memberships reflecting the cost of domestic infrastructure and the international nature of modern research. Advice from experts will be important to assist Government to continue to optimise domestic and international investments.
Recommendation 8 Increase awareness to ensure optimal utilisation of national research infrastructure through outreach activities with both national and international collaborators and the end users of research such as industry, government and business.	**Noted** The Government will continue to work with facilities to build and enhance awareness and outreach activities. Advice from experts will help identify ways Government can support awareness raising.
Recommendation 9 Urgently address National High Performance Computing (HPC) needs coupled with a review of existing governance arrangements to ensure future positioning is strategic and accessible.	**Agreed** The Government committed funding in 2017–18 to fund upgrades to Australia's two Tier 1 HPC Facilities—National Computational Infrastructure (NCI) and Pawsey Supercomputing Centre.

Attachment B

NRI Investment Breakdown for the next 5 Years

Funded Activity	Planned Investment ($m) 2017–18 to 2021–22
New Investments	
NRI Facilities	
Atlas of Living Australia (ALA)	2.1
AuScope	1.5
Australian Centre for Neutron Scattering (ACNS)	7.0
Australian Microscopy and Microanalysis Research Facility (AMMRF)	14.4
Australian National Fabrication Facility (ANFF)	36.2
Australian Phenomics Network (APN)	2.1
Australian Plant Phenomics Facility (APPF)	2.6
Australian Telescope National Facility (ATNF – ASKAP)	1.3
Australian Urban Research Infrastructure Network (AURIN)	7.4
Bioplatforms Australia (BPA)	48.1
Centre for Accelerator Science (CAS) – ANSTO	0.2
Coastal Vessels	Post 2021–22
eResearch Project	72.2
Integrated Marine Observing System (IMOS)	22.0
Marine National Facility (MNF): RV Investigator	31.2
National Collections (CSIRO)	43.0
National Computational Infrastructure (NCI)	6.3
National Deuteration Facility (NDF) – ANSTO	0.1
National Imaging Facility (NIF)	53.6
National Sea Simulator	Post 2021–22
Population Health Research Network (PHRN)	4.4
Therapeutic Development	29.3
Terrestrial Ecosystem Research Network (TERN)	5.1
Scoping Studies	
Biobanks	
Biosecurity	
Enhance ACCESS (Australian Community Climate and Earth-System Simulator)	
Optimising the value from HPC through enhanced model performance	
Humanities, Arts and Social Science (HASS)—Indigenous platforms	3.2
National Environmental Prediction System	
Precision measurement	
Synthetic Biology	
Existing Investments	
European Southern Observatory (ESO)	38.9
National Computational Infrastructure (NCI)	70.0
Pawsey Supercomputing Centre (Pawsey)	70.0

Attachment C

Current National Research Infrastructure—Summary

NRI Facility	Functionality
Australian National Fabrication Facility (ANFF)	Provides micro, nano and advanced materials fabrication facilities for Australia's researchers. Capabilities are spread across eight Nodes and include (i) nanofabrication; (ii) high-resolution electronics; (iii) nano-biotechnology; (iv) optics, photonics and lasers; (v) surface science and microfluidics; (vi) optoelectronics; (vii) advanced materials fabrication; and (viii) MEMS device and compound semiconductor growth.
AIMS – National Sea Simulator (SeaSim)	Is a world-class marine research aquarium facility for tropical marine organisms in which scientists can conduct cutting-edge research not previously possible in Australia or internationally. SeaSim provides ultra fine control over many environmental variables including light, temperature, acidity/pCO2, salinity, sedimentation and contaminants, including the ability to replicate seasonal and diurnal cycles.
Atlas of Living Australia (ALA)	Is a partnership of organisations that have stewardship of biological data and expertise in biodiversity informatics, including museums, biological collections, community groups, government and natural resource managers. The ALA delivers web based infrastructure to capture, aggregate, manage and analyse all classes of biodiversity data and associated spatial layers for use by research, industry, government and the community.
Australian Urban Research Infrastructure Network (AURIN)	Is a national collaboration delivering eResearch infrastructure to empower better decisions for Australia's human settlements, and their future development. It provides secure, seamless access to an extensive range of data/metadata from a multitude of agencies including government, industry and academia. Capabilities include operation of five main services: Metadata Platform; Application Program Interface; Secure Access Portal; AURIN Map; and Workbench.
AuScope	Is designed to enable progressive construction, refinement and ongoing enhancement of an online live, four-dimensional Earth Model for the Australian Continent and its immediate environs. Key components include: (i) Geospatial; (ii) Earth Imaging and Structure; (iii) AuScope Grid; (iv) Earth Composition and Evolution; and (v) the Simulation and Modelling program. Capabilities include: GRID data access system; SAM (simulation, analysis and modelling) network; geophysical education observatory; Earth imaging and sounding; National Virtual Core Library; geochemistry laboratories; geospatial laboratory; inversion laboratory; geohistory laboratories and various geospatial technologies.
Australia Research and Education Network (AREN), eduroam and CloudStor (AARNet)	AARNet operates AREN and provides high-speed, high-quality and resilient broadband between instruments, facilities, campuses and institutions using dedicated national and international digitial infrastructure that interconnects the Australian research sector through the global NREN community to the global research sector. Other services include eduroam (global wireless network access in the research and education sector) and CloudStor (enables AARNet members to quickly and securely transfer, synchronise, share and store files).
Australia Telescope National Facility (ATNF)	Comprises three radio telescopes which can be linked together to form the Long Baseline Array (LBA). Telescope capabilities include (i) high resolution; (ii) large field of view; and (iii) single-dish radio.

NRI Facility	Functionality
Australian Access Federation (AAF)	AAF is Australia's leading identity broker, enabling access to online resources for the Education and Research sector. It facilitates trusted electronic communications. Facilities and capabilities include Federation Infrastructure, AAF as a Service, Multi-protocol infrastructure, international Federation connectivity and Open Research and Contributor ID (ORCID) Infrastructure.
Australian Animal Health Laboratory (AAHL)	AAHL is Australia's national biocontainment laboratory. It provides the highest levels of biocontainment within purpose built biosecurity infrastructure. AAHL also acts as Australia's Reference Laboratory for emergency animal and zoonotic diseases and high consequence pathogens which affect animals and humans. AAHL has two critical functions: supporting international trade in meat and livestock, and holds, investigates and disposes of deadly biological agents of severe risk to humans.
Australian Antarctic Division (AAD)	AAD is responsible for the advancement of Australia's strategic, scientific, environmental and economic interests in the Antarctic by protecting, administering and researching the region. Capabilities include operation of buildings, infrastructure, plant and equipment in support of the Australian Antarctic Program.
Australian Centre for Neutron Scattering (ACNS)	Provides neutrons from the Open-pool Australian Lightwater reactor (OPAL) to solve complex research and industrial problems. ACNS houses (i) 13 neutron-beam instruments, (ii) a suite of sample environment equipment, (iii) unique Helium-3 neutron polarisation capabilities; (iv) three laboratory X-ray instruments; (v) a neutron Laue camera for single-crystal alignment; (vi) physical-properties measurement system; and (vii) atomistic modelling capability.
AIMS – Coastal Research Vessel Fleet (CRV)	AIMS owns and operates of a fleet of research vessels including RV *Cape Ferguson*, RV *Solander* and a number of smaller vessels. Major vessels are equipped with a wide range of facilities essential for long research trips.
Australian Microscopy and Microanalysis Research Facility (AMMRF)	AMMRF integrates and opens up major university-based microscopy facilities around Australia through an unincorporated joint venture. Microscopy techniques include atom probe; ion probe; fluorescence; confocal; scanning electron; transmission electron; micro-Computed Tomography; mass spectrometry; nuclear magnetic resonance; x-ray based spectroscopy; atomic force scanning probe; and optical.
Australian National Data Service (ANDS)	ANDS makes Australia's research data assets more valuable for researchers, research institutions and the nation. ANDS ensures that the data is as findable, accessible, interoperable and reusable as possible. ANDS has partnered with Nectar and RDS.
Australian Phenomics Network (APN)	Provides Australian and international biomedical researchers and pharmaceutical companies with the tools and animals to support large-scale, systematic studies of gene function and therapeutic development. Capabilities include (i) engineering of validated animal models in tandem with platform technologies; and (ii) development and testing of new therapeutics.
Australian Plant Phenomics Facility (APPF)	The facility underpins innovative plant phenomics research aimed at accelerating the development of new and improved crops, healthier food and more sustainable agricultural practice. Capabilities include phenotyping; plant growth environments; controlled environment rooms; gravimetric platforms; data visualisation; drone technology; imaging; precision measurement; lighting systems; sensors; and laboratory instruments.
Australian Synchrotron	The facility operates using an electron accelerator system and storage ring to examine the atomic and molecular detail of a wide range of materials. The Synchrotron has 10 beamlines that can operate in parallel providing key capabilities to researchers in Australia and from overseas.

NRI Facility	Functionality
Bioplatforms Australia	Represents a distributed network of genomics, proteomics, metabolomics and integrative bioinformatics capability whose mission embraces parallel strategic objectives of meeting research market needs via enabling access and services; and strategic deployment to national challenges of scale and complexity. Capabilities include DNA sequencing; protein analysis; metabolite analysis; data analysis; and big data.
Centre for Accelerator Science (CAS)	Australia's largest accelerator science research facility houses four world-class accelerators. It is in the top five megavolt facilities globally. Two principal characterisation capabilities are ion beam analysis and accelerator mass spectrometry. CAS is the only location in Australia capable of operating numerous accelerator-based analysis techniques simultaneously.
CSIRO National Collections / National Biological eCollections	The National Research Collections Australia (NRCA) is a world class "science ready" biological collections research facility that represents the only specimen-based, continent-wide sample of Australian biodiversity in the world. Services include (i) supporting the scientific exchange of specimens nationally and internationally; (ii) delivering continental-scale biodiversity data; and (iii) managing world-class research facilities.
European Molecular Biology Laboratory (EMBL) (Australia's Associate Membership)	EMBL is taking a leading role in the integration of life science research in Europe and across the globe. Capabilities are split over the various facilities and include EMBL core facilities (advanced light micropscopy; chemical biology; electron micoscopy; flow cytometry; metabolomics; protein expression and purification; genomics and proteomics); EMBL Hamburg (synchrotron radiation); EMBL Grenoble (macromolecular crystallography and neutron crystallography); and EMBL Bioinformatics Institute (data and tools).
Heavy Ion Accelerators (HIA)	The Facility comprises three accelerator facilities including (i) HIAF which operates one of the three highest voltage electrostatic accelerators in the world; (ii) AFAiiR which operates three accelerators, two for fabrication and one for characterisation; and (iii) ECMP which comprises two ion microprobes for quantum computation.
Integrated Marine Observing System (IMOS)	IMOS undertakes systematic, sustained and scientifically robust observation of Australia's vast and valuable ocean estate, and turns these observations into data, time series, products and analyses that can be used and reused for broad societal benefit. All of its data is accessible to the marine and climate science community, other stakeholders and users, and international collaborators. Capbilities include maintaining floats and commerical and research vessels for data collection (including underwater); observation of open ocean properties; imaging (including underwater); radar capabilities; animal tracking; coastal water measurements; online data resources; and satellite remote sensing.
Marine National Facility (MNF) – RV *Investigator*	MNF provides blue-water research capability through the ocean class research vessel *Investigator*.
National Computational Infrastructure (NCI)	Is a Tier 1 HPC eResearch Platform and provides HPC, data storage and associated infrastructure to Australian researchers. It is Australia's most highly-integrated, high-performance e-infrastructure and is the Southern Hemisphere's highest performing supercomputer.
National Deuteration Facility (NDF)	NDF is unique globally as it is the only facility to offer both chemical deuteration and biodeuteration. NDF labels molecules in order to enhance contrast in multi-component systems. It is essential for conducting studies into molecular structure. NDF provides deuterium labelled molecules to 25-30 institutions.

NRI Facility	Functionality
National eResearch Collaboration Tools and Resources project (Nectar)	The Nectar Research Cloud enhances collaboration through wide national and international access and interoperability; is relied upon by other NRI facilities, ARC Centres of Excellence, universities, virtual laboratories and researchers; and is a preferred vehicle for institutions, research communities and NCRIS capabilities to invest in scalable computational and storage resources for research. Nectar Virtual Laboratories are a portfolio of online collaborative research platforms which provide access to digital research methods, research data, tools and models.
National Imaging Facility (NIF)	Is a nationwide collaborative facility that provides imaging capabilities in three main themes of (i) Molecular Imaging and Radiochemistry; (ii) Human Imaging; and (iii) Animals, Plant and Materials Imaging. Capabilities include informatics; PET/CT; MRI; radiochemistry; cyclotron; microPET-CT; optical imaging; ultrasound; NMR/MRI; animal MRI; angiography; fluorescence imaging; tomography; and various other microscopy techniques.
OPAL Reactor	The OPAL reactor is a 20 megawatt multi-purpose reactor that uses low enriched uranium to support and enable a range of nuclear medicine, research, scientific, industrial and production goals.
Pawsey Supercomputing facility (Pawsey)	Pawsey is a Tier 1 HPC facility. It is a world-class supercomputing and high volume data management facility operating petascale computers, data analytics and associated storage infrastructure.
Population Health Research Network (PHRN)	PHRN has built networked national infrastructure that enables existing health and human services data from around the nation to be linked and made available for research purposes. The Network includes leading universities, research institutes and government agencies. Capbilities include (i) data linkage services at regional and national level; (ii) secure file transfer and access services; and (iii) coordination of the Network.
Research Cyclotron and Radiochemistry Facility	The facility produces radioisotopes and radiotracers. It is dedicated to supporting a broad research community, with a focus on medical research, both pre-clinical and clinical. The Facility is comprised of an 18 MeV cyclotron that produces carbon-11 and fluorine-18 radioisotopes, as well as other radiochemistry facilities.
Research Data Services (RDS)	RDS provides nationally accessible, high-quality and reliable data storage and data access resources. Capabilities include (i) peta-scale storage resources; (ii) data curation and access initiatives; and (iii) management and leadership of Data Lifecycle Framework activities.
Terrestrial Ecosystem Research Network (TERN)	Is the national observatory for Australian terrestrial ecosystems and delivers data streams that enable environmental research and management. TERN provides ecosystems data and the programs to collect it including (i) plot data from surveillance and targeted monitoring programs; (ii) gas, energy and nutrient exchanges; (iii) remote sensing data; (iv) modelled data products about soil, climate, and landscape attributes; and (v) vegetation and soil samples for physical analysis. TERN maintains and facilitates 12 capability networks including Central Data Discovery Portal, EcoInformatics, eMAST, OzFlux, AusCover, Coasts, Soils, AusPlots, Australian Transects Network, Long Term Ecological Research Network, Supersites and ACEA.
Translating Health Discovery (THD)	Therapeutic Innovation Australia leads the THD project and supports soft infrastructure at critical national translation research facilities. Enabling resources are also available to the wider research community through membership of the Australia Therapeutic Pipeline. Capabilities include genotyping; cell production for clinical trials; clinical evaluations through Phase I/II trials; molecular pathology; small molecule library management; small molecule screening and libraries; clinical trial support services; patient-level databases and training; national-level registries; preclinical testing facilities; and large molecule screening and libraries.

Photo Credits for Public version of RIIP

Credits for images on front cover (from left to right)

- Terrestrial Ecosystem Research Network (TERN) – Credit: Linda James
- Integrated Marine Observing System (IMOS) – Credit: Anita Slotwinski, CSIRO
- Australian Institute of Marine Science (AIMS) – Credit: Scott Bainbridge
- Australian Nuclear Science Technology Organisation (ANSTO) – Credit: ANSTO
- Quantum Nanoscience Laboratory, The University of Sydney (QNL) – Credit: QNL
- Australian Plant Phenomics Facility (APPF) – Credit: APPF
- European Southern Observatory (ESO) – Credit: Babak Tafreshi, ESO Photo Ambassador
- Australian Phenomics Network (APN) – Credit: APN
- Bioplatforms Australia – Credit: Nicole Webster, AIMS
- Australian Microscopy and Microanalysis Research Facility (AMMRF) – Credit: AMMRF
- Terrestrial Ecosystem Research Network (TERN) – Credit: TERN
- Marine National Facility (MNF) – Credit: Owen Foley and MNF
- Australian Microscopy and Microanalysis Research Facility (AMMRF) – Credit: AMMRF
- Integrated Marine Observing System (IMOS) – Credit: Rob Harcourt
- Australian Microscopy and Microanalysis Research Facility (AMMRF) – Credit: AMMRF
- Australian National Fabrication Facility (ANFF) – Credit: ANFF

Credits for images on page 2 (Environment)

- Marine National Facility (MNF) – Credit: MNF
- Bioplatforms Australia – Credit: Nicole Webster, AIMS
- CSIRO – Credit: Carl Davies, CSIRO

Credits for images on page 4 (Health)

- iStock – Credit: iStock
- Australian Microscopy and Microanalysis Research Facility (AMMRF) – Credit: AMMRF
- National Imaging Facility (NIF) – Credit: NIF

Credits for images on page 10 (Humanities)

- CSIRO – CSIRO
- Atlas of Living Australia (ALA) – Credit: Department of Education and Training
- CSIRO – Credit: CSIRO