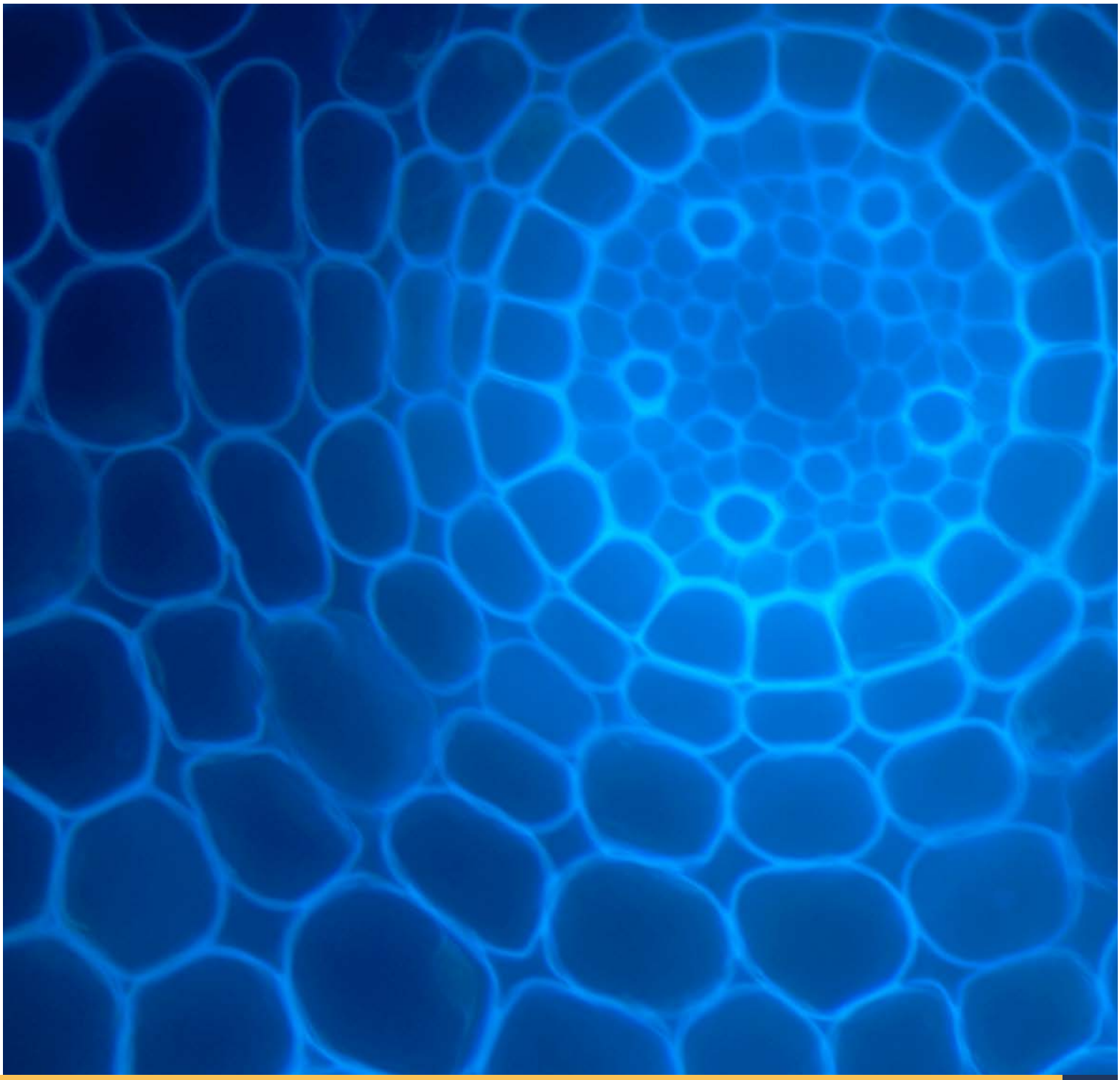
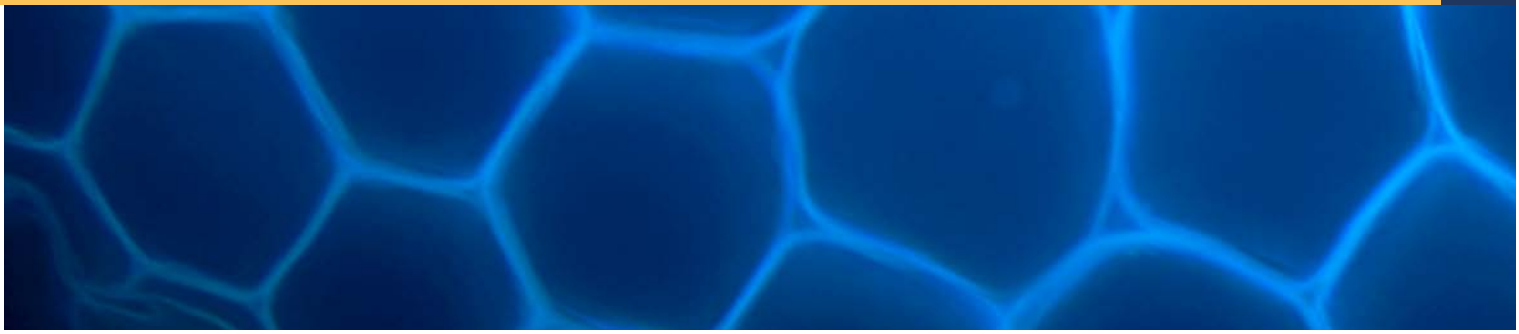


Research Infrastructure Review

Final Report

September 2015



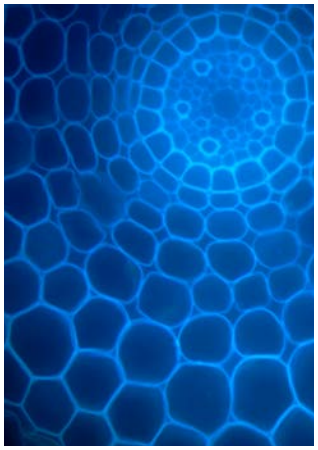


Image on front cover: From Australian Microscopy and Microanalysis Research Facility. Depicts Antarctic 'hair grass' root cross-section, showing the arrangement of cells. These are highly efficient at taking up essential nitrogen nutrients, which means that they are able to out-compete other plants as the temperature in Antarctica rises. Visualised using confocal microscopy by Dr Peta Clode, University of Western Australia.

Size: the larger cells are about 30 micrometres across.

By studying plants like these scientists can start to understand how different species are affected by climate change. In Antarctica plants and microorganisms compete for scarce nutrients such as nitrogen. Findings show that populations of the Antarctic hair grass, *Deschampsia antarctica*, have increased with global warming as they are able to out-compete mosses by being able to uptake nitrogen through their roots.[1]

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1 Incredible inner space Antarctic 'hair grass' root cross section web page.

Letter of Transmittal

The Hon Christopher Pyne MP
Minister for Education and Training
Parliament House
CANBERRA ACT 2600

Dear Minister

In 2014, the National Commission of Audit found that quality research infrastructure is a critical component of Australia's research and development system and recommended that:

> The Government take a more strategic, whole-of-government approach to the funding of research and development, including by committing to ongoing funding for critical research infrastructure in Australia, informed by a reassessment of existing research infrastructure provision and requirements.

In October 2014, you took the initiative and appointed the Review Panel.

The Review Panel has consulted widely with the research sector, including research infrastructure facilities, universities, research institutions including the Learned Academies, publicly funded research agencies, state and territory governments, industry and numerous Australian Government departments and agencies.

Based on our consultations and research we have found:

- The case for investing in research infrastructure is strong. Excellent research requires excellent research infrastructure.
- Current arrangements for planning and funding of National Research Infrastructure are not working well. Australia's research infrastructure is uncoordinated. Multiple Government departments and agencies play a role but there is no single body providing strategic direction to investment in research infrastructure.
- There is considerable concern about successive governments' practice of funding long term investments on short term funding cycles.

We have recommended a new National Research Infrastructure investment model for Australia based on a set of fundamental principles which came out of our consultations. These Principles were strongly endorsed by the research sector and particularly by Government departments and agencies.

A key recommendation is the establishment of the Australian National Research Infrastructure Fund. We have considered funding options and governance options for that Fund in considerable detail and have made recommendations on the preferred approach.

In considering funding options we have taken heed of your response to our interim report and ensured that the funding burden is not simply left to Commonwealth taxpayers.

Similarly, as you requested, we have considered a range of structuring and governance options.

We have also considered operational matters, immediate priorities and legacy issues.

In our deliberations we gave appropriate consideration to Government policy direction, including putting science at the heart of industry and boosting innovation.

The Review Panel members unanimously support all of the recommendations. We believe they will deliver a quantum leap in the effectiveness of delivery of large scale research infrastructure in Australia and the significant outcomes from getting that right.

I would like to thank the many people and organisations that took time to consult with us and to make submissions.

I would also like to thank the team at the Department of Education and Training who provided support, at times under considerable pressure. Their work was much appreciated.

Finally I would like to thank my colleagues, the Review Panel members. I have been fortunate to chair a great team. They have all been very generous with their time, given their other significant commitments. They are very well-informed. They were all committed and engaged on this task. It has been a pleasure and privilege to work with them.

On behalf of my colleagues, I commend this Report to you.

Yours sincerely

Philip Marcus Clark AM
Chair, Research Infrastructure Review

Professor Ian Chubb AC
Dr Alan Finkel AO
Dr Oliver Mayo
Dr Susan Pond AM
Professor Paul Wellings CBE

10 September 2015

Contents

Executive Summary

Overview

In 2014, the National Commission of Audit (NCOA) found that:

> Quality research infrastructure is a critical component of Australia's research and development system and, since 2001, the Commonwealth Government has provided a series of funding programmes for large-scale research infrastructure.[2]

The NCOA recommended that:

> The Government take a more strategic, whole-of-government approach to the funding of research and development, including by committing to ongoing funding for critical research infrastructure in Australia, informed by a reassessment of existing research infrastructure provision and requirements.[3]

In October 2014, the Hon Christopher Pyne MP appointed the Research Infrastructure Review Panel to undertake this Review. It has been over ten years since research infrastructure was last examined comprehensively.

The Review decided to focus on National Research Infrastructure. It did not address institutional research infrastructure, which is being considered in other reviews. National Research Infrastructure includes National Collaborative Research Infrastructure Strategy (NCRIS) and landmark research facilities, both of which involve significant collaboration on at least a national scale.

The approach taken by the Review is that the National Research Infrastructure framework must encompass operating expenses as well as capital investment. In particular, it is essential that human capital is recognised as a critical element of National Research Infrastructure and that Australia takes a proactive approach to developing this area of knowledge infrastructure.

The Review Panel has consulted widely with the research sector, including research infrastructure facilities, universities, research institutions including the Learned Academies, publicly funded research agencies (PFRAs), state and territory governments, industry and numerous Australian Government departments and agencies.

The Review Panel heard very clear and consistent messages from these consultations.

2 National Commission of Audit 2014, p. 170.
3 Ibid. p. 172.

- The case for investing in research infrastructure is strong. Excellent research requires excellent research infrastructure.
- There is a widely held conviction that National Research Infrastructure, and the research and innovation which it enables, grows the economy, boosts productivity and creates jobs.
- Current arrangements for planning and funding of National Research Infrastructure are not working well. Australia's research infrastructure investment is uncoordinated. Multiple Government departments and agencies play a role but there is no single body providing strategic direction to investment in research infrastructure.
- Finally, there is considerable concern about the Government's practice of funding long term research infrastructure investments on short term funding cycles.

Other issues raised are covered in detail in the Report.

Australia needs a new, disciplined and better coordinated approach to Government investment in National Research Infrastructure.

The Review Panel's objectives are to achieve stability, predictability and dependability through coordinated long term planning and long term funding. Accordingly, the Review Panel recommends that the Government should:

- consolidate its National Research Infrastructure outlays;
- align those outlays with the National Science and Research Priorities;
- distribute those outlays more efficiently and effectively;
- eliminate waste, duplication and marginal investments; and
- establish a long term funding program with appropriately independent governance.

Based on its consultations with stakeholders and other experts, including from international government agencies, the Review Panel recommends the establishment of a set of fundamental principles (the Principles) to guide the Government's investment in National Research Infrastructure. These Principles are set out in Section 5.2 and were strongly endorsed by the research sector and by Government departments and agencies.

The Review Panel has recommended a new National Research Infrastructure investment model for Australia based on the Principles. A key recommendation is the establishment of the Australian National Research Infrastructure Fund (ANRIF) to plan and support long term investment in National Research Infrastructure.

The investment required over the next decade is approximately $6.6 billion. The Review Panel is proposing that that $6.6 billion be sourced as follows:

- $3.7 billion initial funding paid into the ANRIF by the Government;
- $1.5 billion earnings on the ANRIF; and
- $1.4 billion co-investment from various sources.

The Review Panel has considered funding options for the ANRIF in considerable detail. Our starting point is:

- The Government should regard its investment in National Research Infrastructure as the patient capital required to secure Australia's future in research and innovation.
- That an additional amount, between 8 and 10 per cent of total Government research outlays net of the Research and Development (R&D) Tax Incentive, should be set aside in advance to fund long term investment in National Research Infrastructure.

Two priorities underpin the Review Panel's recommendations:

1. Connect investment in National Research Infrastructure with research outlays.
2. Put in place a system which more effectively and more efficiently allocates investment in National Research Infrastructure.

In the last decade, the quantum of the Government's investment in National Research Infrastructure has averaged 8 per cent of total research outlays excluding the R&D Tax Incentive. The quantum of initial funding recommended by the Review Panel is at that 8 per cent level. The Review Panel would hope to see that percentage increase in a less constrained fiscal environment or if additional investment can be justified.

The Review Panel has identified some areas of National Research Infrastructure which have been underfunded, other areas which are likely to require more funding in the next decade and some areas which may require less funding in the next decade. The proposed strategic roadmap will drive more effective and efficient allocation of available funding.

Funding recommendations are in Section 6 of the Report.

One option for funding the ANRIF considered by the Review Panel is to transfer the unallocated balance of the Education Investment Fund (EIF) to the ANRIF as a standalone entity. However, the Review Panel noted that the Government has committed the balance of the EIF funds to the establishment of the Asset Recycling Fund as part of the Infrastructure Growth Package (IGP) through legislation that has been presented to the Parliament in the Asset Recycling Bill (see Section 6.4.3).

In these circumstances, the Review Panel's preferred funding option is that the amount of $3.7 billion is set aside for the ANRIF as a discrete element within the overarching IGP framework (see Section 6.4.4).

The proposal fits well with the Government's strategic intent in establishing the IGP. National Research Infrastructure is an entirely appropriate investment under the IGP as it will grow the economy, boost productivity and create jobs and so will the research activity it enables.

The proposal also fits well into the legislative framework the Government has chosen to implement the IGP which is set out in the Asset Recycling Fund Bill.

In the course of its consultations, the Review Panel explored a number of opportunities to attract co-investment so that National Research Infrastructure funding does not rely solely on Australian taxpayers. There have been some encouraging responses. If the Government takes the lead and supports the proposed new model, the Review Panel believes this will pave the way for significant co-investment, estimated at up to $200 million per annum, from a number of sources, both local and international. In the absence of that lead, co-investment prospects are, in the Review Panel's view, much diminished.

The Review Panel has also considered and made recommendations on appropriate protocols for user charges.

The Review Panel considered several governance structures to manage prioritisation, funding and oversight of National Research Infrastructure.

The essential elements of the governance structure are:

- The Government, through the Cabinet, must have ultimate responsibility for decisions about funding National Research Infrastructure.
- In arriving at those decisions, the Government should follow long established best practice - act on the advice of experts.[4]
- A coordinated whole-of-government approach is essential.
- An independent board with appropriate expert membership and the mandate for oversight across all of the Government's National Research Infrastructure activities.

Section 7 of the Report deals with recommended governance arrangements in some detail.

Highlights are:

- Appointment of a responsible minister by the Prime Minister.
- The establishment of an independent board, Research Infrastructure Australia, appointed by the responsible minister to manage the ANRIF on a whole-of-government basis.
- Development by Research Infrastructure Australia of a strategic roadmap, in conjunction with the research sector, updated every four years, to guide investment.
- Alignment with the National Science and Research Priorities.
- Planning and funding timeframes for Research Infrastructure Australia and for each National Research Infrastructure facility should be seven year planning and funding cycles with a comprehensive review after year four of each cycle, and minimum twenty year horizon plans.

The report also deals with operational matters (Section 8), immediate priorities and legacy issues (Section 9). The latter includes:

- recognition that national eResearch infrastructure is pervasive and fundamental to Australian research in all disciplines and that planning for it will be an immediate priority;
- secure short term operational funding for NCRIS (which has now been provided);
- Government ownership and control of the Australian Synchrotron, operated by the Australian Nuclear Science and Technology Organisation with appropriate funding until the ANRIF begins operating; and
- reviewing the Government's treatment of depreciation for institutions or organisations hosting National Research Infrastructure facilities.[5]

The final section of the Report emphasises the importance of consultation with state and territory governments, so there is a national whole-of-government approach that maximises participation and co-investment.

4 HM Treasury 2014. *Principles of the Haldane Report: ...the choice of how and by whom that research should be conducted should be left to the decision of experts.*

5 This relates to publicly funded science agencies only.

Summary of recommendations

Recommendation 1

The Australian Government regard its investment in National Research Infrastructure as the patient capital required to secure Australia's future in research.

Recommendation 2

1. National Research Infrastructure should be coordinated on a whole-of-government approach.
2. Roadmaps should be the mechanism for determination of Australia's future National Research Infrastructure needs.
3. Roadmaps should have regard for the National Science and Research Priorities.

Recommendation 3

Funding for access by Australian researchers to international facilities is deemed to be part of the funding for National Research Infrastructure.

Recommendation 4

Human capital is recognised as a critical element of National Research Infrastructure.

Recommendation 5

Australian industry intending to publish its results in the open literature should be able to gain merit-based access to National Research Infrastructure through the standard peer-review process.

When industry wishes to keep confidential the results generated through the use of a facility, full fee-for-service applies.

Recommendation 6

The Australian Government adopt seven year funding cycles and whole-of-life project planning.

Recommendation 7

The Australian Government adopt the Principles to guide its investment in National Research Infrastructure.

Recommendation 8

The Australian Government should establish the Australian National Research Infrastructure Fund for the sole purpose of investing in National Research Infrastructure.

Recommendation 9

An additional amount of between 8 and 10 per cent of anticipated total annual Australian Government research outlays, net of the R&D Tax Incentive, should be set aside in advance to fund long term investment in National Research Infrastructure.

The initial capital commitment should be sufficient to cover National Research Infrastructure investment requirements for at least ten years.

Recommendation 10

The Australian Government:

1. expand the focus of the Infrastructure Growth Package and the Asset Recycling Fund to include investment in National Research Infrastructure; and
2. commit $3.7 billion funding for the Australian National Research Infrastructure Fund within the Infrastructure Growth Package and the Asset Recycling Fund.

Recommendation 11

The Australian Government commissions more detailed examination of the potential for co-investment in National Research Infrastructure, following its commitment to support the new National Research Infrastructure investment model for Australia, along the lines set out in this Report.

That examination should focus on the sources referred to and should include both Australian and international sources. It should not be focused on user charges that are inappropriate and discourage full participation by both the public and industry research sectors.

Recommendation 12

The Australian Government establish Research Infrastructure Australia.

Recommendation 13

Research Infrastructure Australia develops a strategic roadmap for Australia's National Research Infrastructure facilities within the first twelve months of its operation and updates the roadmap regularly and at least on a four year cycle.

Recommendation 14

Research Infrastructure Australia, in its roadmap exercise, aligns a significant proportion of its investment in National Research Infrastructure with the National Science and Research Priorities and the related Practical Research Challenges.

Recommendation 15

Funding and planning timeframes for Research Infrastructure Australia and for each National Research Infrastructure facility will be:

1. seven year planning and funding cycles with a comprehensive review at year four; and
2. twenty year horizon plans, or longer, for some key National Research Infrastructure facilities.

Recommendation 16

No offsets be required because the fund earnings will cover the expenditure for the first three years of the forward estimates.

Recommendation 17

Research Infrastructure Australia be made responsible for contracting, planning, construction and operation of National Research Infrastructure projects and administration of contracts on behalf of the Australian Government.

Recommendation 18

The Australian Government recognises that national eResearch infrastructure is pervasive and fundamental to Australian research, in all disciplines, and directs Research Infrastructure Australia to seek advice from experts as an immediate priority on the establishment of a national eResearch infrastructure strategy.

Recommendation 19

The Australian Government takes control of the Australian Synchrotron and confirms the Australian Nuclear Science and Technology Organisation as its operator.

Recommendation 20

For National Research Infrastructure owned by publicly funded research agencies, the Australian Government make changes to resolve the treatment of depreciation and that it considers capital funding requirements separately to depreciation expenses.

Recommendation 21

Research Infrastructure Australia consults with the state and territory governments in shaping the roadmaps.

Recommendation 22

Funding arrangements are designed to optimise state and territory government involvement and co-investment at the project level.

1. Investing in Research

Research generates knowledge, the use of which benefits society and opens up new opportunities for business.

The ability to sustain a competitive edge in the generation of new knowledge, and of new scientific knowledge in particular, is at the core of the strategic plans of many nations as they position themselves for growth in a highly competitive global economy.[6] Some countries started decades ago:

> We cannot know where scientific research will lead. The consequences and spin-offs are unknown and unknowable until they happen. But one thing is certain: if we don't explore, others will, and we will fall behind. This is why I have urged Congress to devote more money to research. It is an indispensable investment in America's future.[7]

Nowhere is it simply more of the same. International strategies are aimed at increasing both the quantity and the quality of basic and applied research to prepare for a future in which one certainty is change, and another is that science, technology, engineering and mathematics and innovation will be at the heart of progress.[8] To illustrate:

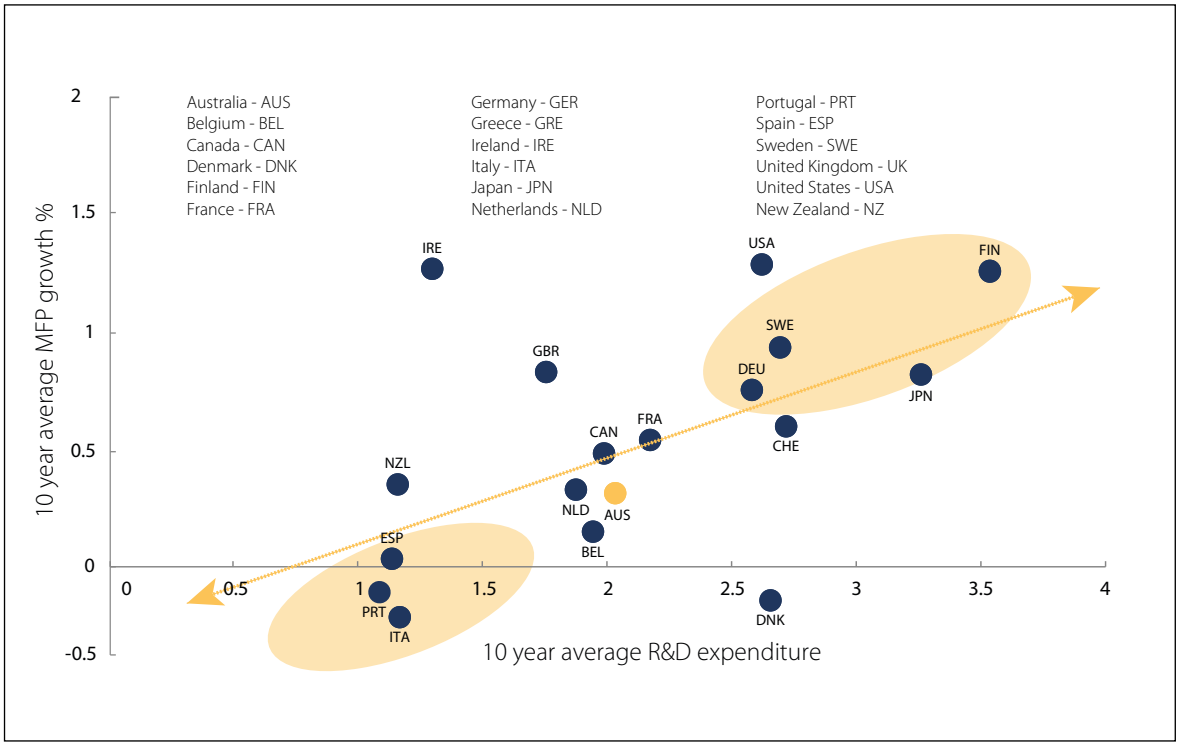
- The European Union's (EU) Horizon 2020 initiative is the biggest EU research and innovation programme ever with nearly €80 billion available over the seven years from 2014 to 2020.[9]
- China's total funding of research and development (R&D) is expected to surpass that of the US by about 2022.[10]
- The UK Government prioritised its science budget after the global financial crisis and more recently announced £5.9 billion in research infrastructure funding over the period 2016 to 2021.[11]

In contrast, the Australian research system is feeling the pressure of the chronic underfunding of key elements. This issue is beyond the scope of the Review but it is an important context for understanding the capacity within the system to support research infrastructure.

The evidence in Figure 1 shows that countries investing in R&D are making the right choice. At the national level, multi-factor productivity growth is positively correlated to expenditure on R&D. The reverse holds true for countries with low levels of R&D expenditure.

6 Australian Council of Learned Academies 2014.
7 Ronald Reagan 1988.
8 Craig et al. 2012.
9 Official Journal of the European Union 2013.
10 Battelle 2013.
11 HM Treasury 2014.

Figure 1: R&D expenditure (share of Gross Domestic Product) and Multi-Factor Productivity (MFP) growth rate (10 year average 2000–2010)



Source: World Development Indicators 2015

Research connections to industry are very important but they are not the sole reason governments invest in research. Governments play the critical role of investing for the public good.[12] While the consequences and spin-offs from research may be unknown and unknowable until they happen, society benefits from the exploration of our world. It enables us to build a future we want.

12 Productivity Commission 2007; Australian Treasury 2009.

2. Research is Central to Australia's Future

Australia will need to keep changing. While it has enjoyed strong economic growth, it is now facing significant global forces that will require a more diversified and resilient economy.[13]

This means Australia must develop new and agile industries that can produce high value products and services for a global and highly competitive market.[14]

To achieve these goals, the Government has announced that science and innovation will be at the heart of industry policy.[15] It is developing a whole-of-government strategy for the medium to long term investment in science, technology, engineering and mathematics, and innovation. It has announced Industry Growth Centres to foster activity where Australia has a need, a comparative advantage, a competitive advantage, or all three.[16] It has announced the National Science and Research Priorities.[17] All of these are positive and interdependent steps; they must link with each other and with critical infrastructure to optimise Australia's capacity and capability.

A country of Australia's population cannot go it alone, however, because 96 per cent of research is undertaken overseas.[18] In a world in which research is increasingly undertaken across large teams of investigators from multiple countries, Australia will need to be a contributor to that effort to draw benefit. If we are to prosper as a strong but relatively small participant in the global wellspring of ideas and innovation, our contribution must be at the high standards required to earn us the connections that we need.

The Government has recognised the importance of better linking our high quality research with industry. The discoveries in our universities and research agencies must translate into outcomes that will contribute to economic growth. This requires making research easily available to industry to commercialise and getting industry to partner with research organisations. The Government's strategy to boost the commercial returns from research sets out a strategy to connect researchers with industry.[19] Research infrastructure can play an important part in this strategy by providing a focus for shared activity.

Australia cannot become like a Germany or Switzerland overnight. Researchers must engage with industry and vice versa. The structure of Australian industry must evolve so there are more firms with the capacity to use research or engage with researchers. If we can make these changes then the payoff will be sustained future prosperity.

13 Commonwealth of Australia 2015.
14 Lydon, Dyer and Bradley 2014.
15 Department of Prime Minister and Cabinet 2014.
16 Industry Growth Centres web page.
17 Science and Research Priorities web page.
18 Department of Education and Department of Industry 2014.
19 ibid.

3. The Importance of Research Infrastructure

To reach and maintain the necessary standards, we need the best researchers and they need quality research infrastructure.

A number of leading economies have recognised that quality research supported by quality infrastructure leads to jobs, growth and a more competitive economy.

The UK House of Lords Select Committee on Science and Technology 2013

The UK's international stature in research is founded in part on the availability of internationally competitive scientific infrastructure. For many areas of science, it is vital that both UK researchers and industry have access to scientific infrastructure, enabling them to be at the forefront of scientific discoveries and pioneering innovation.[20]

The European Commission, European Research Infrastructure Consortium (ERIC)

For the European Union (EU) to become the most competitive and dynamic knowledge-based economy in the world, state-of-the-art facilities are essential for Europe's researchers to stay at the forefront of research development.[21]

HM Treasury, Our plan for growth: science and innovation 2014

Science cannot happen without infrastructure.[22]

The US National Science Foundation's Division of Computer and Network Systems

Experimental infrastructure plays a central role in enabling transformative research and innovation at the frontiers of computing and discovery, and in providing unique learning opportunities for current and future generations of computing researchers and educators.[23]

20 House of Lords Select Committee on Science and Technology 2013, p. 7.
21 ERIC web page.
22 HM Treasury 2014, p. 34.
23 Research Infrastructure program web page.

James Fothergill,
Head of Education and Skills, Confederation of British Industries

Investment in research capital is essential to ensure that the UK has the best available resources to stimulate growth and support the wellbeing of the nation. Industry benefits greatly from capital investment through access to advanced facilities as well as access to world-leading scientific and technical expertise. Ensuring that such capital investment is maintained in order to fund new, cutting edge facilities and attract the best expertise to work with business and industry is vital to the future growth and competitiveness of UK business and Industry as well as to the UK as a whole.[24]

3.1. Benefits from research infrastructure investment

Investing wisely in research infrastructure will benefit the economy by fostering innovation and new ideas, boosting productivity and creating jobs.

Growing the economy and boosting productivity by innovation and new ideas

Research infrastructure facilities are important foundations of modern economies. They stimulate innovation and the creation of new ideas, which are crucial drivers of long term economic growth and improved productivity.

> High quality economic and social infrastructure is vital to ensure Australia can maximise its productivity and maintain a high standard of living.[25]

The Australian Treasury points to the importance of infrastructure to productivity:

> Infrastructure investment is important for productivity… it contributes to productivity by facilitating private sector production and distribution. Infrastructure can facilitate trade and the division of labour, improve market competition, promote a more efficient allocation of activity across regions and countries, encourage the diffusion of technology and the adoption of new organisational practices, and provide access to new resources.[26]

Research infrastructure is an engine of economic growth and productivity. There are numerous examples of innovation and productivity outcomes from research infrastructure internationally and in Australia:

- The National Aeronautics and Space Administration (NASA) created infrastructure and technologies to support its core activities, which led to products like baby formula, Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans, and freeze-dried food.

24 Research Councils UK 2012, p. 3.
25 Infrastructure Australia 2015, p. 12.
26 Australian Treasury 2009, p. 58.

- Work by the OECD on the impact of the European Organisation for Nuclear Research (CERN) research facility points to evidence that innovation by surrounding firms which support CERN has had a positive impact. The evidence suggests that one Swiss franc spent by CERN generated three Swiss francs in economic utility for satellite firms that collaborate directly and indirectly with CERN.[27]
- In Australia, research infrastructure has accelerated the progress and development of new agricultural methods to support future agricultural production. The Terrestrial Ecosystem Research Network has helped farmers, graziers and catchment managers make more informed decisions about issues such as weed control, grazing and environmental water buybacks.
- Mining industries have been aided by existing national research infrastructure in identifying new mineral, gas and petroleum deposits. AuScope is providing scans of 400,000 metres of mineral cores of Australia's continental crust, saving industry tens of millions of dollars by reducing the usual seven year pre-competitive evaluation cycle by two to three years.
- The Integrated Marine Observation System is providing real-time data on wind direction and speed, wave height and water velocity to the Darwin Port Corporation for operational management that allows it to manage shipping more efficiently.

We need more outcomes like these in Australia.

Creating jobs across the nation and growing the nation's human capital

Australia's National Research Infrastructure facilities employ significant numbers of people across the country. National Collaborative Research Infrastructure Strategy (NCRIS) facilities alone employ well over 1,700 staff across 222 institutions and many more are employed at facilities like the Synchrotron, the OPAL reactor and the RV Investigator.

Investment in research infrastructure means new jobs in construction of new research facilities, in maintenance and upgrading of existing facilities and in operating those facilities.

Public and private investment in research infrastructure flows throughout local economies.

There is also an economic multiplier effect. Skilled technicians, researchers and support staff employed in research facilities, some in the regions, purchase goods in local markets which employ even more labour, creating a virtuous circle.

National Research Infrastructure and institutional research facilities are located in every state and territory. These research infrastructure facilities make an important contribution to regional Australia. There are numerous examples of National Research Infrastructure located in regional areas given in an Inventory at Appendix 1, including:

- Murchison Widefield Array (MWA) radio telescope in Western Australia;
- Australian Institute of Marine Science facilities in Townsville and elsewhere;
- Integrated Marine Observing System facilities in Hobart and elsewhere;
- Australian Antarctic Research facilities in Hobart;
- astronomy facilities in regional locations like Parkes, Narrabri and Mopra;

27 OECD 2014.

- the RV Investigator based in Hobart;
- the Australian Animal Health Laboratory based in Geelong; and
- the NCRIS network which has nodes across the nation.

National Research Infrastructure particularly supports the development of the jobs of the future. These facilities play an important role in local innovation ecosystems. The Review's consultations highlighted how the Government's investment in NCRIS, along with targeted state and territory government policies, has resulted in jobs in emerging industries like biotechnology and advanced manufacturing.

The scale of large research infrastructures brings together a wide range of researchers and expert technical staff in a single facility. The mixing of knowledge and skills creates a collaborative environment in which ground breaking discoveries occur. A notable example of this is:

- The high quality research infrastructure at CERN has earned its status as the world's frontline particle physics laboratory. It has brought together talented physicists, engineers and technicians, with some unanticipated beneficial outcomes. CERN researchers discovered that techniques used in particle physics can be used to treat cancer cells in humans. The OECD cites this as an example of how major research infrastructure can generate positive impacts for society and by extension – the economy.[28]

Conclusion

All too often the focus on the role of infrastructure in growing our economy is limited to economic infrastructure such as roads, rail, airports and ports. They are certainly important but National Research Infrastructure should be treated in the same way and deserves recognition as productivity-enhancing infrastructure.

3.2. Definition of Research Infrastructure

Research infrastructure includes the physical facilities, human resources and related services that are used by the research community to conduct research. Examples include: major scientific equipment or sets of instruments; knowledge-based resources such as scientific and cultural collections, archives or structures for scientific information, and eResearch infrastructure, described as cross-cutting and networked information, data and communications tools and technologies that underpin research in many fields.[29]

The Review Panel emphasises the need to include human capital as a major component of research infrastructure. Key management, scientific and technical staffing is critical to the operational effectiveness of research infrastructure facilities.

The Review Panel has divided Australian research infrastructure into two areas with the following definitions:

1. National Research Infrastructure: these are the facilities funded to support research by a diverse range of users from more than one institution or sector. National Research Infrastructure can be large, usually single sited facilities (landmark facilities) or nationally distributed networks and enabling capabilities. They include, but are not limited to, facilities such as the Australian Synchrotron and the RV Investigator, NCRIS

28 OECD 2014.
29 European Commission 2010.

facilities, unique collections, for which a single or a number of institutions may be the custodians; and eResearch infrastructure. They also include Australian investments in international research infrastructure. All facilities involve significant collaboration by researchers on at least a national scale.

The Review Panel included consideration of facilities in a wide range of departments and agencies, including the Defence Science and Technology Organisation, but did not consider facilities in which the infrastructure is primarily used for operational purposes and in which research activity comprises only a small component (such as the Bureau of Meteorology).

National Research Infrastructure does not include facilities, equipment or collections used solely for institutional or operational purposes.

2. Institutional research infrastructure: this is research infrastructure established within an institution (universities, medical research institutes or publicly funded research agencies (PFRAs) or other research organisations). It is funded primarily from the institution's resources, including through the support from the Research Block Grant funding and the Australian Research Council's (ARC) Linkage Infrastructure, Equipment and Facilities Scheme. These facilities may involve collaboration, but not on a national scale.

The Review Panel has focused on the first category, National Research Infrastructure. Its scope does not extend to institutional research infrastructure for the following reasons:

Universities

- The Higher Education Infrastructure Working Group is considering university research infrastructure.[30] The Review Panel also notes and supports the appointment by the Minister for Education and Training of Dr Ian Watt AO, to undertake a Review of Research Policy and Funding Arrangements.[31]

Medical research institutes

- In the case of medical research institutes, the issues paper released by the Review to Strengthen Independent Medical Research Institutes has suggested significant structural change.[32] Medical research institutes are also being considered through the Medical Research Future Fund (MRFF).

Publicly funded research agencies

- In the case of PFRAs, the Review Panel has considered their position as custodians of National Research Infrastructure. Any issues relating to their institutional research infrastructure are dealt with in a submission to the Government made by the PFRAs in May 2015.

30 Higher Education Infrastructure Working Group web page.
31 Review of Research Policy and Funding Arrangements web page.
32 Department of Health 2014.

4. Australia's National Research Infrastructure—The Present State

The Review Panel makes the following observations:

4.1. Australian Government investment in National Research Infrastructure is critical

The Review Panel's Terms of Reference quote the National Commission of Audit (NCOA) 2014:

> Quality research infrastructure is a critical component of Australia's research and development system and, since 2001, the Commonwealth Government has provided a series of programs for large scale research infrastructure.[33]

The NCOA recommended that:

> The Government take a more strategic, whole-of-government approach to the funding of research and development, including by committing to ongoing funding for critical research infrastructure in Australia, informed by a reassessment of existing research infrastructure provisions and requirements.[34]

These are not views unique to Australia. The OECD Science, Technology and Industry Outlook finds that:

> Provision of infrastructure for scientific research is another important aspect of public research policy. Investment in large, expensive, key research equipment and facilities, which are essential for public and private R&D and innovation, are at the heart of the government's role in encouraging innovation.[35]

33 National Commission of Audit 2014, p. 170.
34 Ibid., p. 172.
35 OECD Science, Technology and Industry e-Outlook web page.

4.2. Patient, public capital

Providing essential infrastructure for Australian researchers is primarily the responsibility of the Government. There is no precedent anywhere in the world to suggest that industry, state and territory governments or not-for-profit agencies would accept sole responsibility if the Government stepped away.

Public investment is necessary to provide the 'truly patient' capital needed to create *an environment for the inspired risk taking that is essential to technological discovery.*[36] Only governments have the capacity to invest this patient capital into the long timeframes that must apply to research and to research infrastructure.

The Review's consultations have provided strong indications that significant co-investment in National Research Infrastructure will become available from a number of sources if the Government takes the lead and provides the core investment capital required to establish and maintain National Research Infrastructure. Those sources include universities, state and territory governments, international research collaborations, local and international foundations and philanthropists, and international industry. This matter is discussed in more detail in Section 6.5.

Government investment in research infrastructure has been beneficial. For example, the review of the NCRIS projects by KPMG found that the programme as a whole was high quality. Without it, there would have been a gap in research infrastructure in Australia—and a gap in Australian capability.[37]

It is often suggested that industry should play a bigger part in funding research infrastructure by co-investing capital or paying for use. It is noteworthy that a more common approach internationally is to focus on the impact on industry rather than income from industry. This recognises that while it is important for industry to link with researchers and research facilities, the benefit to industry from an investment in research infrastructure is long term, risky and intangible. Furthermore, there is no evidence that industry will be a major funding source for National Research Infrastructure in Australia.

Recommendation 1

The Australian Government regard its investment in National Research Infrastructure as the patient capital required to secure Australia's future in research.

36 A Moment of Truth for America 1995.

37 KPMG's comments on the programme as a whole are made based on its evaluation of the 27 NCRIS projects funded under the 2013 NCRIS funding allocation.

4.3. Strategic planning is critical

A whole-of-government approach to National Research Infrastructure is essential

The management of Australia's research infrastructure is uncoordinated. Multiple Government departments and agencies play a role but there is no single body providing strategic direction to the investment, nor to the scale and timing of various investments.

The Review Panel's Terms of Reference required compilation of an inventory of existing Government funded National Research Infrastructure. The difficulties in assembling the Inventory have highlighted just how uncoordinated the planning and management of National Research Infrastructure at a whole-of-government level has been over many years. The Inventory is provided in an attachment to this report but more work is needed if it is to be a definitive guide to the research infrastructure estate (see Appendix 1). It is simply an informative baseline for discussion.

There is no single source of data or point of responsibility for National Research Infrastructure within the Government. There is very little coordination. Responsibility for the infrastructure is scattered across multiple departments and agencies. Decisions about expenditure on research infrastructure have been made in isolation by the different agencies, based on different priorities and time pressures. Historically, there has been little strategic planning or prioritisation of future investment in existing or new research infrastructure using a whole-of-government approach.

Coordination across Government through a central body with oversight of all National Research Infrastructure would improve decision making about where funding should be invested and minimise the risk of duplication or gaps. Coordination would also assist in securing co-investment.

National Research Infrastructure planning should align with the National Science and Research Priorities

Prioritisation is a feature of many successful research and innovation systems overseas. A significant proportion of research funding is directed to challenges and associated priorities and the relevant research infrastructure support. The Review Panel proposes that Australia can learn from these successes and adopt this approach.

The Government has already established a new set of National Science and Research Priorities (the Priorities) and associated Practical Research Challenges to guide its annual investment of approximately $9.7 billion in science, research and innovation funding (made up of $6.8 billion in direct expenditure and $2.9 billion in revenue forgone for the R&D Tax Incentive).[38]

The basic purpose of the Priorities is to ensure that research primarily funded with public money addresses in a timely way the most important questions facing Australia and builds on its strengths. The Priorities are neither exhaustive nor exclusive and should influence a significant proportion of the Government's investment.

Clearly, the Priorities will need to be supported by the necessary proportionate investment in research infrastructure.

38 Science, Research and Innovation (SRI) Budget Tables 2015-16 web page.

A roadmap should be used to guide the investment in National Research Infrastructure

Internationally, a strategic roadmap is the accepted approach to plan for investments in national scale research infrastructure.[39] Australia has been at the forefront of using roadmaps in planning for some of its research infrastructure and can continue to benefit from this approach. Indeed, the roadmap process on which NCRIS is based has been acknowledged as world leading. The problem with NCRIS was not the process but that it was a terminating programme. The latter prevented optimal whole-of-life planning and resulted in uncertainty and caution.

The roadmap process is a collaborative exercise that involves experts from the research community and its stakeholders, including industry and the state and territory governments. This consensus driven approach has proven more effective than competitive bidding processes. With NCRIS it resulted in strategic investments that aligned with the national research priorities.

Recommendation 2

1. National Research Infrastructure should be coordinated on a whole-of-government approach.
2. Roadmaps should be the mechanism for determination of Australia's future National Research Infrastructure needs.
3. Roadmaps should have regard for the National Science and Research Priorities.

4.4. International collaboration

To build and sustain a credible research capacity in the long term, Australia must be engaged with international research and research infrastructure. Australia has a strong research base but provides less than 4 per cent of the global research effort.[40] International linkages allow Australian researchers to take part in cutting edge research across national boundaries and to draw on the rich international knowledge base for Australia's benefit.

In 2008, the European Commission's Report *Developing World-Class Research Infrastructures for the European Research Area* (ERA) pointed out:

> Research Infrastructures are essential to modern scientific enquiry. As the frontiers of research evolve and become more advanced and as our technologies progress, the demands for new, upgraded and more elaborate research infrastructures are becoming increasingly complex and more expensive, often placing them beyond the reach of a single research group, region, nation or even continent.[41]

Australia participates in global research infrastructure in a number of ways:

- researcher, institutional and network links;
- Government facilitated but not funded links (via Memoranda of Understanding and other mechanisms);

39 European Strategy Forum on Research Infrastructures 2011; Canadian Foundation for Innovation 2011; Federal Ministry of Education and Research (BMBF) 2013; Research Councils UK 2012; European Commission 2008.
40 Department of Education and Department of Industry 2014.
41 European Commission 2008, p. 14.

- Government facilitated subscriptions to international facilities;
- Government investment in international facilities; and
- Australian hosting of global research infrastructure.

An example of Australian facilities partnering with overseas facilities is the Australian Microscopy and Microanalysis Research Facility and the European Molecular Biology Laboratory. A formal alliance supports research collaboration, resource-sharing, and sharing of expertise via workshops, training and other opportunities that will enhance researchers' understanding of the capabilities of genomics and bioinformatics.

The advice received by the Review Panel during consultations was that access to international facilities or projects can depend on access to similar or complementary research infrastructure in Australia. As an example, the Australian Synchrotron supports access by Australian researchers to overseas synchrotrons and provides reciprocal access by overseas researchers to particular beamlines.

Australia's investment in global facilities results in substantial, affordable access. Without this investment, access would be limited or more expensive. Either would be a bad outcome.

It is not only about academic research. Australia's National Research Infrastructure also facilitates collaboration with international industry partners. These partnerships can be a source of funding, expertise and local industry development if there is excellent Australian research infrastructure on offer.

Access to international research infrastructure

There are a number of joint arrangements between countries for research infrastructure. The EU research community is particularly active. Australia is a member of some joint arrangements, through projects such as the European Molecular Biology Laboratory and the consortium that will build the Square Kilometre Array. Major opportunities will arise in the future. Australia must be positioned to take advantage of these as they become available. The ability to point to a significant dedicated funding source is an important competitive advantage in that positioning.

There was broad support from the consultations for the importance of the role of international research infrastructure as part of the mix of Australia's capabilities. Consequently, the Review Panel recommends that the Government should fund access or subscriptions to overseas facilities when there is a clear national interest in doing so, or when Australian participation can make a difference. This will be a particularly important consideration given the growth in the research enterprise in our region. To be a partner in this growth, we will have to pay and/or reciprocate.

All of these considerations require good planning, decision making and a long term commitment to public funding. Any decision on public funding for access or subscriptions to global research infrastructure needs to be made on the same basis as that for investing in research infrastructure in Australia. Considerations include excellence, national interest, current capacity and growth potential, agility, long term strategy, and funding certainty.

Recommendation 3

Funding for access by Australian researchers to international facilities is deemed to be part of the funding for National Research Infrastructure.

4.5. Human capital, the skilled research infrastructure workforce

The President of the Business Council of Australia, Ms Catherine Livingstone AO, recently spoke about the importance and value to the nation of knowledge infrastructure.[42] Her proposition is that physical infrastructure alone is not enough. Real benefits flow from the skilled workforce that creates knowledge by operating and using that physical infrastructure. The creation of knowledge infrastructure requires investment.

The Review Panel agrees. Capital investment in research infrastructure is sub-optimal without a capital investment in the workforce to operate it. Australia has expert research and technical staff employed in each of the National Research Infrastructure facilities. Their expertise, advice and ability to operate highly technical equipment are essential. They are valuable national assets in a competitive international environment. Maintaining this human capital has proven to be a challenge for some National Research Infrastructure facilities because of the stop start nature of funding in Australia.

Research infrastructure requires a highly specialist skill base in a wide range of disciplines, including: data analysts, statisticians, marine research crews, supercomputer technicians, taxonomists, epidemiologists and mathematicians. These skills are highly sought after by facilities, which need to compete with other employers, both within Australia and internationally, for these specialist staff.

Retaining staff is not just about financial incentives. Certainty of employment is as important, or maybe more so. The current system, with its uncertain funding, severely restricts the ability of National Research Infrastructure operators to offer internationally competitive, long term contracts.

The uncertainty also makes it difficult to manage a workforce. A common issue is the lack of career progression for National Research Infrastructure staff. More broadly, there appears to be a lack of depth in the system and a concerning lack of new staff coming through the pipeline due to funding uncertainty. With tight and uncertain funding, renewing personnel is often problematic. The Review Panel saw examples where only one staff member had the skills to operate equipment within a National Research Infrastructure facility. As a result, the infrastructure may not have been used to its full potential.

The Review Panel believes that funding certainty will go a long way to creating a stable, high quality and sustainable National Research Infrastructure workforce. Mapping the workforce, planning future needs, and supporting training and development opportunities are all essential elements of an effective National Research Infrastructure system. Funding certainty and planning is the key to developing and retaining human capital.

In terms of attracting and retaining infrastructure facility staff, a case can be made to encourage them to continue with their own research. There are three benefits: they maintain up to date knowledge about techniques and applications; their career options are enhanced, including through adjunct appointments with universities and research agencies; and they are in a position to collaborate more effectively and productively with stakeholders.

The Review Panel does not propose that the personal research of facility staff should be funded from the operating budget of the facility, but rather that they be encouraged to apply for research grants to support their own work or that of their team.

42 Livingstone 2015.

Recommendation 4

Human capital is recognised as a critical element of National Research Infrastructure.

4.6. Engagement with industry

National Research Infrastructure investment must be focused on providing effective ways for researchers and industry to work more closely together to maximise the benefits from research.

While the Australian science and research base has real strengths, the linkages between our research base and industry are poor. The structure of the Australian economy (large primary sector, small secondary sector, oligopoly in many fields, overseas control of many major enterprises) is relevant, but only a small part of the explanation.

Over the years, there have been many programmes designed to change this deeply embedded (though not universal) part of the culture. The outcomes have not been good.

Australia ranks 29th out of 30 OECD countries on the proportion of large businesses, and last for small to medium enterprises that collaborate with higher education and public research institutions on innovation.[43] Australia rates poorly on other metrics that judge performance on innovation measures.

The Review Panel's consultations revealed the potential for National Research Infrastructure to be a focal point for research and industry collaboration. Many of those consulted provided examples of companies using National Research Infrastructure facilities productively. But the relatively small number of industry users suggests that the potential impact of the facilities is not being fully realised.

Research infrastructure can provide many spillover benefits to industry and to the national economy. As noted by the UK House of Lords Select Committee on Science and Technology 2013:[44]

> There is a huge host benefit. CERN is a good example. If you drive around Switzerland and part of the Haute-Savoie, which is the part of France that is adjacent to CERN, you see a lot of little high-tech companies that clearly have their original origin in being subcontractors for CERN and will now export precision machines and special purpose electronics through the world. The host countries, which are France and Switzerland, have of course benefited far more than other people who have paid in.[45]

The Catapult Centres in the UK and the Fraunhofer Institutes and Research Establishments in Germany illustrate the benefits of a more targeted model for leveraging research infrastructure into business innovation.[46]

Such leveraging fits well with the Government's commitment to put science at the heart of industry and the adoption of a more targeted approach through its Industry Growth Centres.[47]

43 OECD 2013.
44 The 2nd Report of Session 2013-2014 on Scientific Infrastructure in regard to benefits for the domestic host.
45 House of Lords Select Committee on Science and Technology 2013, p. 32.
46 Catapult web page; Fraunhofer web page.
47 Industry Growth Centres web page.

The NCRIS network has already had success in engaging with industry with examples such as the National Imaging Facility and its collaboration with Siemens Australia on state of the art technology that will improve blood vessel imaging capability, reduce imaging costs and improve patient comfort.

Industry engagement with National Research Infrastructure facilities

Australian governments have at times sought to use industry funding for access to National Research Infrastructure as a device to reduce government expenditure. They have tended to see funding from user charging as an endorsement of their own decision to invest. If this approach has worked, it is at the margins. These are not the lessons learned from international experience. What is not known is what the industry engagement would have been in Australia had there not been the clear signal of cost shifting.

Many overseas governments are taking the opposite approach. Instead of focusing on how to collect income from industry, they are putting effort into identifying and promoting the impact the research infrastructure has on industry, that is, the benefits to industry and the changes in industry thinking and behaviour as a result.

It is likely to be better for Australia to adopt the approach of allowing companies to access National Research Infrastructure facilities under the same arrangements that apply for public researchers, particularly for the small to medium enterprise sector, provided the results are put into the public domain. Higher user charging should only apply if and when the results are not to be made public but rather to remain confidential for commercial or other purposes.

The Review Panel's consultations highlighted awareness that industry involvement is built on a broad sharing of responsibilities through flexible and sustained relationships – not transactional interactions for short term outcomes. A policy approach focused too heavily on user charging or co-investment not only misses the broader opportunities for industry engagement but also undermines these efforts.

This highlights the primary role of the Government in funding National Research Infrastructure. Governments need to provide the patient capital to make the long term investment in research infrastructure to create an environment for the i*nspired risk taking that is essential to technological discovery*[48] and so support a system in which innovative industry can flourish.

Access to National Research Infrastructure should be on the same basis for both public sector researchers and industry users not seeking to retain intellectual property. This will encourage the highest level of engagement by all potential users. Access to facilities should use merit-based selection processes, through the standard peer-review process, to ensure the best access for the best research projects.

Recommendation 5

Australian industry intending to publish its results in the open literature should be able to gain merit-based access to National Research Infrastructure through the standard peer-review process.

When industry wishes to keep confidential the results generated through the use of a facility, full fee-for-service applies.

48 A Moment of Truth for America 1995.

4.7. Current funding mechanisms are inadequate

National Research Infrastructure needs a long term investment cycle with whole-of-life funding.

The current funding arrangements are not adequate. Nor do they support the long timeframes necessary to support and maintain research infrastructure, to develop the knowledge capital, or to manage the maintenance, upgrade, and replacement cycle.

The ad hoc funding cycle for recent investment in National Research Infrastructure has led to an underlying need for capital refreshment of some existing facilities. Crucially, our supercomputing facilities need to be refreshed now to maintain our competitive computing capacity.

Steps to provide a long term solution to operational funding for NCRIS and the Australian Synchrotron are needed but this will not provide the capital upgrade of facilities to keep them at the cutting edge.

Beyond our existing capacity is the next generation of research infrastructure facilities. To maintain our edge in science and research there must be an investment in new technologies and instrumentation. Other countries are looking to the future, we must too.

> Early acquisition of new research technologies is a major requirement of the research base to maintain research and innovation capability. Researchers require access to state of the art instrumentation to underpin cutting-edge research, generate exciting scientific discoveries and to build an effective national capability to sustain high-quality research.[49]

The Review Panel was presented with the amounts available for National Research Infrastructure in the upcoming years of the budget forward estimates. After the first two years the amounts drop off sharply leaving many facilities dependent on another round of uncertain budget considerations in the near future.

The use of ad hoc budget appropriations for National Research Infrastructure is not the way to support the facilities that are the critical underpinning infrastructure necessary for Australia's research capacity and innovation system.

The Australian Synchrotron ($200 million) and the NCRIS network ($2.5 billion) are examples of very significant capital investment that is left with ad hoc funding for operational, upgrading and replacement costs. Suboptimal usage is the inevitable result. Such fragile and unpredictable arrangements that are not strategically planned make long term planning for optimal use of the facility impossible.

Recommendation 6

The Australian Government adopt seven year funding cycles and whole-of-life project planning.

49 Research Councils UK 2012, p.16.

5. A New National Research Infrastructure Investment Model for Australia

5.1. A new approach

Australia needs a new, disciplined and better coordinated approach to Government investment in National Research Infrastructure.

The Review Panel's objectives are to achieve stability, predictability and dependability through long term strategic planning. Accordingly, the Review Panel believes that the Government should:

- introduce sustained reliable funding for investment in National Research Infrastructure;
- consolidate Australian Government National Research Infrastructure outlays;
- align those outlays with the Priorities;
- distribute those outlays more efficiently and effectively; and
- eliminate waste, duplication and marginal investments.

5.2. Fundamental principles

Based on its consultations with stakeholders and other experts, including from international government agencies, the Review Panel recommends establishing the following set of fundamental principles (the Principles) to guide the quantum, allocation and management of Australian Government National Research Infrastructure funding.

The Principles

i. Excellent research requires excellent infrastructure.

ii. Research infrastructure includes physical and human capital.

iii. Continuing and predictable funding for programmes by shifting from the ad hoc to the sustained.

iv. A coordinated whole-of-government approach by shifting from an unsystematic funding process.

v. Whenever funding is provided for research, set aside appropriate additional funding for investment in infrastructure to support that research.

vi. Focus on Australia's research strengths and on agreed National Science and Research Priorities.

vii. Focus on collaboration: NCRIS has clearly demonstrated the benefits of a national networked and collaborative approach.

viii. Focus on eResearch infrastructure as the foundation for research in all disciplines.

ix. Increase effectiveness of engagement with industry users by providing access that is tailored appropriately to the size and level of sophistication of businesses and the likely utilisation of the outcomes from the use of research facilities.

x. Commit to investing in international research facilities and consortia which benefit Australian research and industry.

xi. Robustly and regularly assess the impact of the Australian Government's investment in National Research Infrastructure, including on industry.

Recommendation 7

The Australian Government adopt the Principles to guide its investment in National Research Infrastructure.

6. Funding

6.1. The Australian National Research Infrastructure Fund

Ad hoc funding through the budget cycle is not an efficient or satisfactory way to plan long term National Research Infrastructure investment.

At a conceptual level, the Review Panel prefers a funding option which:

- acknowledges that investment in National Research Infrastructure boosts productivity, creates jobs and is an important part of nation building infrastructure investment;
- provides capital funding which is ring fenced and cannot be taken away or used for purposes other than funding National Research Infrastructure;
- provides secure capital which can be invested until it is needed; and
- provides funding for both capital investment and operating expenses.

The Review Panel strongly favours a capital funding model that will provide a forward funded commitment for at least a decade rather than a model which relies on annual budget allocations. That is the only practical way to provide the certainty and dependability of funding which is essential for efficient systematic long term investment and allows for significant new National Research Infrastructure.

It also demonstrates the Government's ongoing commitment to National Research Infrastructure which will be important in securing co-investment (see Section 6.5) and participation in international research activity (see Section 4.4).

The recommended approach will provide a source of funding that is set aside in a special purpose fund for the specific purpose of investing in National Research Infrastructure. That funding must be committed, secure and ring fenced, preferably by legislation.

Investment outlays must be guided by the Principles set out in Section 5 of this Report.

Recommendation 8

The Australian Government should establish the Australian National Research Infrastructure Fund for the sole purpose of investing in National Research Infrastructure.

The funding, governance and operating arrangements for the Australian National Research Infrastructure Fund (ANRIF) are set out in the following sections of this Report.

6.2. National Research Infrastructure funding requirements

Principle V requires that whenever funding is provided for research, appropriate additional funding is also set aside for investment in infrastructure to support that research. This principle is of fundamental importance. It is the foundation for a strategic, long term approach recognising the fact that it is not possible to undertake quality research without excellent research infrastructure.

The Review Panel proposes that appropriate capital should be committed in advance for investment in National Research Infrastructure. The amount set aside should be equal to a percentage of anticipated total Government research outlays over the planning horizon, that percentage being additional to the research outlays.

The amount which the Review Panel recommends should be set aside is an amount equal to between 8 and 10 per cent of Government research outlays, excluding the R&D Tax Incentive. The Review Panel has determined that amount by reference to international benchmarks:

- In the United States, in 2011, the ratio of research infrastructure expenditure to R&D expenditure for academic institutions, based on new research infrastructure spending, was 9.8 per cent.[50]
- In the UK, based on the UK 2010 funding allocations for 2012 to 2015, the total capital to resource percentage was 10.4 per cent. That may well increase following the commitment to £5.9 billion additional research infrastructure funding over the period 2016–2021. [51]
- Germany's targeted investment is equivalent to 8.2 per cent of total expenditure on science, research and development for 'large appliances in a basic research field' and other 'infrastructures'. [52]

To illustrate, total Government research outlays net of the R&D Tax Incentive, for 2015-16, are budgeted at $6.4 billion. Applying the formula proposed the amount of funding which should have been set aside for National Research Infrastructure in respect of 2015-16 research outlays is between $509 million and $636 million.

These figures are research spend only and exclude any funding for National Research Infrastructure capital items or operating costs.

The Review Panel has taken account of the current constrained fiscal environment and proceeded on the basis that the initial funding provided will be at the lower end of the 8 to 10 per cent range. If the fiscal environment improves, additional funding should be provided. Likewise, if Government research outlays increase, the ANRIF should be topped up. Adjustments can appropriately be made through the annual budget process.

This quantum of funding is consistent with the Government's investment of an average of 8 per cent of the total research outlays excluding the R&D Tax Incentive in National Research Infrastructure over the past decade.[53]

The quantum of funding is one issue. The other pressing concern is the suboptimal manner in which the process of investing in National Research Infrastructure has evolved and been managed.

50 CSIRO 2015.
51 HM Treasury 2014.
52 Federal Ministry of Education and Research (BMBF) 2014.
53 Excluding the R&D Tax Incentive. Funding level is the average over the decade 2004/05 – 2014/15 – data drawn from Review's inventory exercise and the Science, Research and Innovation Budget Tables 2015-16.

Recommendation 9

An additional amount of between 8 and 10 per cent of anticipated total annual Australian Government research outlays, net of the R&D Tax Incentive, should be set aside in advance to fund long term investment in National Research Infrastructure.

The initial capital commitment should be sufficient to cover National Research Infrastructure investment requirements for at least ten years.

6.3. The ANRIF model

6.3.1. A draw-down fund – the preferred model

The Fund should be ring fenced from future budget pressures so that once committed, the ANRIF funds can only be used to fund National Research Infrastructure unless the Parliament legislates otherwise.

The Review Panel recommends that the Future Fund should be appointed as investment manager of ANRIF funds. The investment mandate should reflect the proposed drawdown of the ANRIF funds over a ten year timeframe. That should be done as soon as practicable, to maximise the earnings on the funds.

The modelling provided to the Review Panel by the Department of Education and Training shows that an up-front capital injection of $3.7 billion to the ANRIF, together with the accrued earnings on those funds and co-investment proceeds (which are discussed in Section 6.5), should provide at least ten years of funding for National Research Infrastructure (Table 1).

The key assumptions underlying Table 1 are:

- Government research outlays do not grow in real terms over the next decade. This assumption provides simplicity; it is certainly not advocated by the Review Panel.
- Investment in National Research Infrastructure is maintained at between 8 and 10 per cent of total Government research outlays net of the R&D Tax Incentive.
- Funds are transferred in 2015-16.
- The Future Fund delivers 6 per cent per annum earnings with funds management costs of 25 basis points. The Future Fund recently reported an 8.2 per cent per annum return on investment over that last ten years and 11.6 per cent per annum return over the last five years.
- Forecast outward investment flows for National Research Infrastructure capital expenditure and operating costs are set out in Table 1 as 'investment outlays'.
- Indicative co-investment is secured (see Table 1 and Section 6.5) and applied to investment outlays.
- Table 1 does not include funding which may be required for any immediate priorities (see Section 9) and does not include the Government's committed funding for the NCRIS and the Australian Synchrotron for 2015-16 and 2016 17.
- The ANRIF will make investment outlays on the basis of a strategic roadmap. This roadmap will not be completed until December 2016 at the earliest.

- Investment outlays from the ANRIF are projected to commence in 2017-18 and thereafter significant new investment into National Research Infrastructure will occur as a result of implementation of the new strategic roadmap. The actual profile of investment outlays on existing and new infrastructure will be decided under the ANRIF governance protocols (see Section 7.1).

The Review Panel's proposal is viable, simple and will deliver an effective long term solution to Australia's National Research Infrastructure needs. A ten year horizon provides the certainty and long term commitment of dedicated funding that is essential for effective and systematic investment in these very significant infrastructure assets.

There will be a continuing need for sustained, if not increased, investment in National Research Infrastructure beyond the ten year horizon. The Government will need to make a timely decision on the post-horizon arrangements, preferably through a review based on the 2024 roadmap. It may be necessary to manage investment outlays towards the back end of the ten years so that they dovetail with the new arrangements that commence after the first ten year period.

The proposed ten year life cycle gives the Government adequate time to review and plan further funding to maintain the necessary level of investment beyond the first ten years.

6.3.2. A perpetual endowment fund model

The Review Panel would strongly support a perpetual endowment fund model, along the lines of the Higher Education Endowment Fund (HEEF) and the MRFF. This approach would restrict access to ANRIF capital.

To provide sufficient funding for ANRIF under a permanent endowment fund model for capital and operating costs, a capital commitment by the Government of approximately $10 billion would be required, assuming ANRIF earnings of 6 per cent per annum. The Review Panel felt that a commitment of that magnitude would be beyond the Government's capacity in the current fiscal environment.

The Review Panel also concluded that a permanent endowment fund, with capital of only $3.7 billion, would at best support ongoing operational funding requirements for NCRIS or its successor. The guarantee of funding for NCRIS would be an improvement on the yearly cycle of one-off funding extensions but it would not provide adequate funding for other National Research Infrastructure facilities. The danger then would be that the Government would revert to the current mechanisms to fund landmark facilities, which, as noted in Section 4.7., are far from satisfactory.

Table 1 – Model of ANRIF revenues and outlays

	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m
Opening Balance	3,700	3,802	4,020	4,093	4,010	3,710	3,182	2,570	1,869	1,182	508
Revenue	111	228	232	228	211	181	146	106	67	29	0
Investment outlays from Fund (a)	-	-	150	300	500	700	750	800	750	700	500
Fund management costs	9	10	10	10	10	9	8	6	5	3	1
CLOSING BALANCE	**3,802**	**4,020**	**4,093**	**4,010**	**3,710**	**3,182**	**2,570**	**1,869**	**1,182**	**508**	**7**

	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	Averages
	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m
Indicative co-investment (b)	-	0	50	75	125	150	175	200	200	200	200	
Total Expenditure (a + b)	-	0	200	375	625	850	925	1,000	950	900	700	653

	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	Averages
	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m
8 per cent of research expenditure*	509	522	535	548	562	576	590	605	620	635	651	584
10 per cent of research expenditure*	636	652	669	685	703	720	738	757	775	795	814	730

Note. All amounts are in nominal dollars except percentages of Budgeted research expenditure, * Based on estimates for 2015-16 funding in the Science, Research and Innovation Budget Tables 2015-16.

6.4. Funding options

The Review Panel considered several alternatives for providing the necessary funding. These funding options include:

1. Funding the ANRIF through the budget process, by either:
    1.1. sourcing funds from the overall budget with the Government finding an offset from within total Government expenditure and revenue; or
    1.2. top slicing from portfolio budgets an amount equivalent to 8 to 10 per cent of their expenditure in the Science, Research and Innovation (SRI) Budget tables;
2. Funding the ANRIF by borrowing capital;
3. Funding the ANRIF from the Education Investment Fund (EIF); and
4. Funding the ANRIF under the Government's $50 billion Infrastructure Growth Package (IGP).

6.4.1. Funding the ANRIF through the budget process – top slicing

The Review Panel's primary objective is to source a funding stream for the ANRIF that is sustainable, at sufficient scale to be meaningful, and additional to the total funding for research.

The Review Panel's strong preference is for up-front capital funding rather than relying on annual budget allocations, as noted above. Up-front funding is a critically important conclusion of this Review.

The Review Panel supports the Government seeking opportunities to find offsets from the broader budget to fund National Research Infrastructure but acknowledges that this is unlikely.

The Review Panel considered the option of top slicing funding from the principal users of National Research Infrastructure (the research agencies, departments, universities and industry) based on the relative level of research expenditure. The advantage of this option is that it does not require further offsets and gives the users the responsibility for deciding how to manage their budget to make the contribution to the ANRIF.

Top slicing users of National Research Infrastructure based on a percentage of total research expenditure is sound in theory but ignores the reality that most users already make a contribution to the marginal costs of the facilities by using research funding to pay for user charges and materials. Users are not in a position to pay for the full cost of the facilities. As discussed earlier, Australia's overall R&D funding is not high in the OECD comparisons.

The Review Panel was concerned that this model would not add funding to the research sector and would exacerbate underfunding already created by, for example, inadequate funding for indirect costs of competitive research grants.

The impact of top slicing portfolio budgets is illustrated in Table 2. Competitive research grants through the ARC and National Health and Medical Research Council are included in the amounts for the Departments of Education and Training, and Health respectively.

Table 2 – Top slice of portfolio budgets based on 8 per cent of Science, Research and Innovation Budget table expenditure

Portfolio	2014/15 SRI Budget (excl. the R&D Tax Incentive) ($m)	Total Amount to be Top Sliced (8 percent of SRI) ($m)
Agriculture	306	25
Attorney-General	4	0
Communications	21	2
Defence	437	35
Education	2,802	224
Environment	141	11
Foreign Affairs	100	8
Health	908	73
Industry	1,608	129
Infrastructure	5	0
Prime Minister and Cabinet	1	0
Social Services	30	2
Veterans' Affairs	8	1
TOTAL	6,369	510

Source: The Science, Research and Innovation (SRI) Budget tables 2015–16

An alternative version of the top slice model targets a smaller number of portfolios, or a set of research programmes, with each making a larger contribution. To generate enough funding this would need to include the portfolios of Education and Training, Industry and Science, and Health which manage the majority of research expenditure. Focusing on three portfolios is simpler but magnifies the negative impacts of the top slice.

For these reasons, the Review Panel does not recommend top slicing.

6.4.2. Funding the ANRIF by borrowing capital

The option to use borrowings as a source of ANRIF funds draws on the practice of funding economic infrastructure.

For the ANRIF to borrow to fund projects it would need an income stream to service the debt. Research and research infrastructure produce significant economic returns, productivity enhancements and social benefits for the nation but do not produce an identifiable income stream to service debt. The Review Panel heard from users and capital markets that, without a clearly defined income stream, borrowing is not a viable way to fund research infrastructure, in the absence of a government guarantee.

The Government could support the ANRIF borrowing with a government guarantee. That would add to government debt. Noting the high priority the Government has placed on reducing government debt, the Review Panel rejected this option.

6.4.3. Funding the ANRIF from the EIF balance

The EIF balance currently stands at approximately $3.7 billion which is almost exactly the amount required to fund the ANRIF.

The balance stands in a separate EIF fund managed by the Future Fund. The Future Fund has invested the funds under an existing mandate from the Government.

The EIF was established by the Nation-building Funds Act 2008. It replaced the HEEF, which was established by the Government in 2007 as a $6 billion endowment fund. The EIF's objective was to build a modern, productive, internationally competitive Australian economy by supporting world leading, strategically focused infrastructure investments that will transform Australian tertiary education and research.[54]

A decision to abolish the EIF and transfer the unallocated EIF funds to the Asset Recycling Fund (ARF) was announced in the 2014 budget. However, the necessary enabling legislation has not yet been passed.

This leaves the $3.7 billion EIF balance stranded in the Future Fund and earning low returns because it is invested on a cash mandate.

The salient point to note, in relation to both the HEEF and the EIF, is that the Government of the day directed funding towards infrastructure investment in education and research so there is a strong nexus with the purpose of the ANRIF.

The Review Panel suggests, in all the circumstances, there are good arguments for a proposal to use the EIF balance for investment in National Research Infrastructure. It is the right amount, the funds are not being used productively and the proposal is consistent with the original intended use of the funds.

However the Review Panel has been advised by the Government that the balance of the EIF funds is already fully committed to the ARF.

Should circumstances change, or should the Government stand ready to reconsider any existing commitment of the EIF funds, funding the ANRIF using the unallocated balance of the EIF would be regarded by the Review Panel as an attractive option.

6.4.4. Funding the ANRIF under the $50 billion Infrastructure Growth Package

The Government established the IGP in the 2014-15 budget to fast track investment in critical infrastructure across the country. The commitment made in that budget brought the total infrastructure investment by the Government to more than $50 billion by 2020-21.[55] The Government built on that commitment in the May 2015 budget.

Government statements and announcements in relation to its intentions for the IGP make it clear that funding will be targeted at projects that grow the economy, boost productivity and create jobs.[56]

The IGP is currently made up of several measures, the Asset Recycling Initiative, the Western Sydney Infrastructure Plan and New Investments in roads. The Government's focus to date has been on economic infrastructure investments in roads, rail, ports and airports. The Review Panel considers that the focus could legitimately be expanded to include National Research Infrastructure.

Appropriate investment in National Research Infrastructure will grow the economy, boost productivity and create jobs. Section 3.1 made the case for this proposition and proposed that the Government should recognise that investing in National Research Infrastructure is just as important to Australia's future economic performance and productivity as investing in roads, rail, ports and airports.

54 Education Investment Fund web page.
55 Cormann and Hockey 2014.
56 Truss and Briggs 2014.

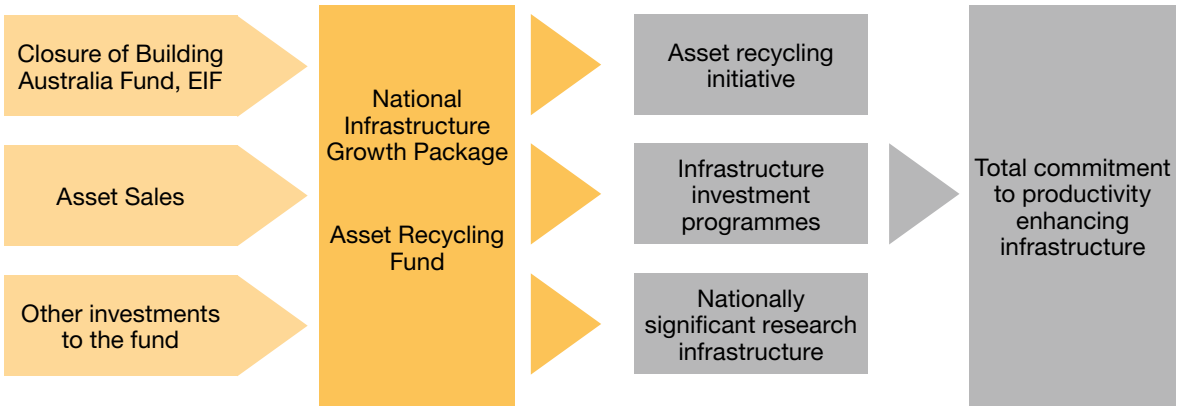
The Review Panel's proposal is that the ANRIF should be included in the IGP. There are good arguments for doing so as the ANRIF is strongly aligned with the Government's infrastructure strategy which underpins the IGP:

- National Research Infrastructure and the research and innovation which it enables grow the economy, boost productivity and create jobs.
- National Research Infrastructure is recognised internationally as an important part of nation building infrastructure.
- National Research Infrastructure has high impact and relevance across the whole country, including in regional areas.

The last point is important and often overlooked. Information in relation to location of National Research Infrastructure facilities in regional areas is given in Section 3.1.

A diagram of the IGP, incorporating the ANRIF, is set out in the following Figure.

Figure 2 – Diagram of the IGP incorporating the ANRIF



The Review Panel proposal is that an amount of $3.7 billion is set aside for National Research Infrastructure within the IGP framework.

The ARF (not to be confused with the Asset Recycling Initiative, which is one of the three existing purposes of the ARF) is being established by the Government by the Asset Recycling Fund Bill (the Bill) which is currently before Parliament.

Division 3 of the Bill provides for credits to the ARF from:

- the balance of the Building Australia Fund ($2.4 billion);
- the balance of the EIF ($3.7 billion); and
- subsequent credits.

The Bill sets out the legislative framework the Government is using to implement IGP initiatives. The Bill proposes using the Future Fund as the investment manager for the IGP initiatives which fits well with the Review Panel recommendation in relation to investment of ANRIF funds. The Review Panel has been advised that the ANRIF could function effectively, as envisaged by the Review Panel, under the Asset Recycling Fund Infrastructure Special Account to be established by the Bill.

The Review Panel notes in passing that it is important that research infrastructure generally is recognised as 'productive infrastructure', which it obviously is, so that state and territory governments which are recipients of Asset Recycling Incentives are able to co-invest those funds in research infrastructure.

There is precedent for establishing a dedicated special purpose fund like the ANRIF, with a long term investment horizon, within the ARF. The Government's Western Sydney Infrastructure Plan is a model which involves using the ARF for a specific infrastructure package. The Plan is funding road and transport infrastructure for Badgery's Creek in Western Sydney over a ten year period through the ARF.

The Review Panel's main concern is that operating the ANRIF through the ARF might reduce the certainty that ANRIF funding will be effectively ring fenced.

The Review Panel supports this option as its preferred alternative, noting that:

- The proposal aligns closely with the Government's strategic intent in establishing the IGP.
- The proposal to include National Research Infrastructure in the IGP complements the Government's existing commitments made as part of the IGP.
- National Research Infrastructure investment is an entirely appropriate investment under the IGP. It will grow the economy, boost productivity and create jobs and so will the research it enables.
- The proposal provides the Future Fund with a larger pool of funding with an additional purpose and that may provide opportunities to optimise investment management.
- After the strategic roadmap is completed in December 2016, there will be a reasonably high degree of predictability and timing about proposed ANRIF outlays over the medium term. On the other hand, there is considerable uncertainty about the timing of the Asset Recycling Initiative incentive payments to state and territory governments. Combining these initiatives under the ARF may provide opportunities for better cash management of infrastructure investment outlays.
- Longer term, additional contributions to the ARF through government asset sales could be used in part to extend funding for the ANRIF beyond the initial ten year horizon.

Recommendation 10

The Australian Government:

1. expand the focus of the Infrastructure Growth Package and the Asset Recycling Fund to include investment in National Research Infrastructure; and
2. commit $3.7 billion funding for the Australian National Research Infrastructure Fund within the Infrastructure Growth Package and the Asset Recycling Fund.

6.5. Co-investment

The case has been made in Section 4.2 for Government investment to provide the patient capital required for National Research Infrastructure.

The Minister directed the Review Panel to explore options that do not rely entirely on Commonwealth taxpayer funding.

The Review Panel explored a number of options to attract co-investment in the course of its consultations. There were some encouraging responses. The Review Panel also examined, in some detail, the significant response to co-investment in the NCRIS programme from various

sources, in both cash and in-kind. The KPMG NCRIS review identified co-investment of $1.06 for every $1 of Australian Government expenditure.[57]

While the Review Panel strongly supports the principle of co-investment, it rejects using payments for access to National Research Infrastructure as an effective or viable way to defray Government expenditure (see Section 4.6). User charging deters industry engagement when it should be encouraged. Charging researchers from public research institutions simply recycles government money from grant programmes to research infrastructure.

An essential prerequisite to attracting significant co-investment is the Government's commitment to take the lead and support the new National Research Infrastructure investment model for Australia, along the lines set out in this Report. If the Government is prepared to make that commitment, the Review Panel believes that this will generate significant interest and pave the way for co-investment from a number of sources, both local and international. Those sources include:

- state and territory governments;
- Australian and international universities;
- Australian PFRAs and their international equivalents;
- international research facilities or collaborators;
- local and international foundations and philanthropists; and
- multinational corporations.

In Table 1, the blended average co-investment over the 10 year period is $0.267 per $1.00. That is made up of:

- $0.50 per $1.00 cash co-investment contribution to NCRIS or its successor; plus
- $0.50 per $1.00 in-kind co-investment contribution to NCRIS or its successor; plus
- $0.12 per $1.00 cash or in-kind contribution to landmark facilities.

Subject to the preconditions mentioned below, the Review Panel believe this level of co-investment is a reasonably conservative estimate of what could be achieved.

Recommendation 11

The Australian Government commissions more detailed examination of the potential for co-investment in National Research Infrastructure, following its commitment to support the new National Research Infrastructure investment model for Australia, along the lines set out in this Report.

That examination should focus on the sources referred to and should include both Australian and international sources. It should not be focused on user charges that are inappropriate and discourage full participation by both the public and industry research sectors.

57 KPMG 2015.

7. Governance

7.1. Research Infrastructure Australia

The Review Panel considered several governance structures to manage funding of National Research Infrastructure.

The essential elements of the governance structure derive in part from the Principles (Section 5.2):

- The Government through the Cabinet should have ultimate responsibility for decisions about funding National Research Infrastructure.
- In arriving at those decisions, the Government should follow long established practice — act on the advice of experts.[58]
- A whole-of-government approach is essential.
- An independent board with appropriate expert membership and the mandate for oversight across all of the Government's National Research Infrastructure requirements.

Governance structure

An independent board, 'Research Infrastructure Australia', should be established. The Board will report to a responsible minister, to be determined by the Prime Minister. That determination should take account of the importance of a whole-of-government approach.

The responsible minister will issue a Statement of Expectations to the Board. The Chair will be appointed according to normal process, which is expected to include Cabinet consideration.

Research Infrastructure Australia will have powers to undertake the roadmap process and recommend a set of funding priorities for National Research Infrastructure. The responsible minister will take the Board's funding recommendations to Cabinet.

Research Infrastructure Australia will be required to make public its recommendations and records of meetings.

Board composition

Research Infrastructure Australia should be a high level and independent board appointed by the responsible minister, to manage the ANRIF and disbursements from the ANRIF on a whole-of-government basis and in accordance with the Statement of Expectations.

58 HM Treasury 2014. *Principles of the Haldane Report: ...the choice of how and by whom that research should be conducted should be left to the decision of experts.*

Research Infrastructure Australia will have up to nine members, including:

- an independent Chair;
- three science and research based members (including members with international expertise);
- three industry based members; and
- the Chief Scientist of Australia and the Secretary, Department of Finance, as ex-officio members.

Some members will need to have expertise relating to international research infrastructure.

The ex-officio membership of the Secretary, Department of Finance, will provide an essential whole-of-government perspective.

Research Infrastructure Australia will be provided with secure funding, adequate staffing and the other resources required to undertake its work. Staffing resources will have experience, capability and capacity to effectively implement a whole-of-government approach.

Responsibilities

Research Infrastructure Australia will:

- Make funding recommendations to the responsible minister for approval by Cabinet.
- Develop roadmaps for National Research Infrastructure, including the first roadmap before 31 December 2016.
- Consult, within Australia and internationally, the research community, industry, state and territory governments and other key stakeholders to inform its decisions.
- Select projects on the basis of criteria that include excellence and alignment with the Priorities and the Principles (see Section 5.2).
- Operate at arm's length from Government by acting independently within the scope of its Statement of Expectations.
- Make decisions across the whole life cycle of research infrastructure under its remit.
- Provide high level oversight for the programme and projects supported through the programme.
- Work on a seven year planning and funding cycle with a review at the end of year four that will include a new roadmap.
- Prepare an over the horizon long term plan for National Research Infrastructure.

Research Infrastructure Australia will also have responsibility for seeking co-investment from the various sources identified in Section 6.5.

Research Infrastructure Australia will work in close collaboration with the Commonwealth Science Council. The proposed common membership of the Chief Scientist will provide an important bridge.

The Review Panel understands that in the current legislative environment, proposals that require new boards to be established are problematic. It has been asked to explore options that avoid the need to establish a new board.

A simple and pragmatic solution that could be explored would be to re-activate the EIF Advisory Board with a new name, with new membership and with appropriately revised functions and powers, along the lines outlined above.

A second alternative solution is to repurpose an existing board in the research policy area. Using an ARC designated committee could be an option.

Recommendation 12

The Australian Government establish Research Infrastructure Australia.

7.2. Strategic Roadmap

The roadmap process for NCRIS is an example of good policy that has worked well in practice.[59] It was strongly supported in the consultations by NCRIS facilities, PFRAs, universities, industry, state and territory governments and government agencies.

Similar processes are used internationally. Roadmaps have been used with a much wider scope, best typified by the European Strategy Forum on Research Infrastructures.[60] This process covers very large global infrastructure facilities like European Molecular Biology Laboratory, and CERN and the Large Hadron Collider.[61]

The use of a collaborative roadmap process to decide National Research Infrastructure priorities should continue to be a feature of the planning for future investment. It should now be extended to include all National Research Infrastructure facilities, including landmark facilities.

Research Infrastructure Australia will develop roadmaps and evaluate and update them on at least a four year cycle. Its first roadmap should be completed by 31 December 2016.

National Research Infrastructure facilities will be funded through this roadmap process, rather than through a competitive proposal process.

The strategic roadmap will be guided by the Principles outlined in this Report and must include consideration of each of the following five project phases for each investment, to ensure consideration of each project over its whole anticipated life:

1. planning, development, pilot;
2. construction and commissioning;
3. operation (including personnel planning for key management and technicians);
4. expansion and upgrade, if any; and
5. renewal or decommissioning.

Recommendation 13

Research Infrastructure Australia develops a strategic roadmap for Australia's National Research Infrastructure facilities within the first twelve months of its operation and updates the roadmap regularly and at least on a four year cycle.

59 Department of Innovation, Industry, Science and Research 2010.
60 Towards the ESFRI Roadmap 2016 web page.
61 European Strategy Forum on Research Infrastructures 2011.

7.3. Alignment with the National Science and Research Priorities

The Government has agreed the nine Priorities that will *align areas of research excellence with Australia's industrial strengths, comparative advantages, community interests and global trends*.[62]

Identified gaps in research activities within a priority area will be addressed through the development of tailored strategies and targeted interventions. The nature of the tailored strategies will be determined by the circumstances of a particular priority area. When common challenges are identified across the Priorities, system-wide strategies will be developed.

The Review Panel supports the use of the Priorities as a framework for identifying the best projects to support Australia's economic growth and wellbeing. The roadmap will identify the infrastructure needs in consultation with the research community and other stakeholders.

A process to map the capability and capacity of the current research system to the Priorities is currently underway. Following the mapping process, departments and agencies will be asked to develop implementation plans consistent with their mission and core activities. Research Infrastructure Australia will review and coordinate the development of future infrastructure capability using those plans.

The mapping to the Priorities will be a valuable tool for Research Infrastructure Australia in its strategic planning and roadmapping processes. The mapping will also provide the information to apply a threshold test for continued investment in existing National Research Infrastructure projects.

Recommendation 14

Research Infrastructure Australia, in its roadmap exercise, aligns a significant proportion of its investment in National Research Infrastructure with the National Science and Research Priorities and the related Practical Research Challenges.

62 Chief Scientist 2014.

7.4. Planning timeframes

The Review Panel consultations disclosed strong and unanimous support for a shift from ad hoc short term funding and planning to sustained predictable and continuing funding programmes and for a more rigorous planning process for investment in National Research Infrastructure. Those changes are reflected in the Principles.

There is a need to balance certainty with regular review. A seven year planning and funding cycle with a four year review provides that certainty while ensuring that projects are thoroughly reviewed before the next seven year funding cycle and decommissioned when no longer supported by the strategic roadmaps.

The seven year timeframe is shorter than the life cycle for some National Research Infrastructure facilities but, as the EU has found, a shorter timeframe brings discipline to managing long lived assets.

Recommendation 15

Funding and planning timeframes for Research Infrastructure Australia and for each National Research Infrastructure facility will be:

1. seven year planning and funding cycles with a comprehensive review at year four; and
2. twenty year horizon plans, or longer, for some key National Research Infrastructure facilities.

8. Operational Matters

8.1. Design of the ANRIF

Research Infrastructure Australia should work with the Government to undertake the detailed design of the ANRIF.

That process must be guided by the Principles outlined in Section 5.2. In particular, the ANRIF must cover equipment, human capital and other operational costs, the whole-of-life cycle of a project, and engagement with international research infrastructure facilities as deemed appropriate.

It must allow for the occasional large investment in landmark infrastructure by establishing a forward looking, orderly pipeline that avoids the requirement for funding of a number of large facilities at the same time.

The ANRIF must be ring fenced by legislation from future budget pressures. Once committed, funds can only be used to fund National Research Infrastructure and should not be able to be withdrawn by Government or used for any other purpose, without amending legislation.

Research Infrastructure Australia will determine the final profile of the expenditure from the ANRIF once it is established and has completed the roadmapping process. This is likely to take at least a year based on previous experiences. The Review Panel recommends that the roadmapping process commences now and has a deadline for completion of 31 December 2016.

After the roadmap and implementation strategies are completed, the recommendation is that the ANRIF will be drawn down over ten years.

8.2. Expenditure from the ANRIF

The Fund should be set up so that offsets will not be required as it is drawn down.

There is precedent for this approach in other funds. The Review Panel has been advised that offsets will not be required for the Future Fund as it dispenses superannuation costs; nor will offsets be required for grants from the MRFF.

If the ANRIF is established in the 2016 budget, expenditure will be covered by fund earnings for the first three years of the forward estimates so no offsets will be required. Thereafter, capital drawdowns should also be allowed without offsets. The Review Panel believes that offsets would defeat the whole purpose of using an existing pool of funding instead of seeking new money from the budget.

Recommendation 16

No offsets be required because the fund earnings will cover the expenditure for the first three years of the forward estimates.

8.3. Management of projects

Research Infrastructure Australia will have oversight of, but not be responsible for, delivering individual National Research Infrastructure projects. The Board will contract third parties as hosts for the construction and operation of the infrastructure.

Research Infrastructure Australia will have responsibility for monitoring delivery of outcomes during both the construction and operational phases of the contract. The Board will have powers to vary or terminate contracts in cases where outcomes are not met or by mutual agreement where circumstances change.

Binding contracts for the delivery of services will guarantee funding for seven years and provide for a review at the end of year four, to plan well in advance for another seven year funding cycle or orderly decommissioning.

The contracts will ensure that the funding is ring fenced from budgetary pressures for the host organisation and not vulnerable to efficiency dividends. Contracts will prohibit diversion of funding to other purposes by the host organisation.

Recommendation 17

Research Infrastructure Australia is made responsible for contracting, planning, construction and operation of National Research Infrastructure projects and administration of contracts on behalf of the Australian Government.

9. Immediate Priorities and Legacy Issues

The Review Panel sought advice from across the research sector on the immediate needs for investment in new infrastructure and any legacy issues.

There are a number of priorities and immediate needs discussed below. These may require funding before the roadmap can be completed at 31 December 2016. The Government, preferably with advice from Research Infrastructure Australia, will need to address these issues and provide funding from the budget.

The Review Panel was advised of and considered the following immediate legacy issues:

- eResearch infrastructure, including Australia's supercomputer capability (National Computational Infrastructure and the Pawsey Supercomputing Centre), requires funding to support upgrading on a rolling basis of approximately every three years.
- The need to secure operational funding for existing National Research Infrastructure facilities after 30 June 2017 to allow Research Infrastructure Australia to implement its first roadmap.
- The need to review the treatment of depreciation for institutions or organisations hosting National Research Infrastructure facilities.

9.1. eResearch infrastructure

The Review Panel was given a strong and consistent message from across the sector about the fundamental and transformational significance of eResearch infrastructure.

> A coordinated, appropriately scaled approach to data infrastructure will greatly increase the probability that Australian research and technology will deliver sustained benefit to current and future generations.[63]

Researchers today access petascale computing infrastructure, high speed networks, high capacity storage and big and complex data management and analytical capabilities. It is empowering them with supercomputing, connectivity, storage, instrumentation and (big) data analytical capabilities.

Data collection and analysis are central to research. Effective data infrastructure provides Australian researchers with the critical enabling capability to compete and collaborate locally and internationally; and to address national and global research challenges. It serves an increasingly technology dependent research sector as well as government and industry.

63 Research Data Infrastructure Committee 2014, p. 18.

eResearch infrastructure investments under NCRIS as well as initiatives taken by agencies and institutions have laid a reasonable foundation. This investment has created one of the fastest supercomputers in the Southern Hemisphere, the National Computational Infrastructure, supported by a large scale high performance research cloud and storage through the National eResearch Collaboration Tools and Resources and Research Data Services.

However, that foundation is not comprehensive, sufficient or cohesive. The eResearch infrastructure challenge for the future is to maintain and probably increase the level of investment and planning supporting this national and omnipresent enabling capacity. It will be more efficient and effective to do this on a national basis as a key component of National Research Infrastructure.

The goal is to have a dispersed and coordinated national eResearch infrastructure system to support researchers using large amounts of complex data from multiple sources at local, regional, national and global scales. It is also important to have the technically expert workforce to support the operation of the myriad of systems and drive their overall pace of innovation.

The Review Panel received feedback from several significant industry stakeholders (energy, retail, banks and ICT) that eResearch infrastructure is an area where there is potential for co-investment.

Recommendation 18

The Australian Government recognises that national eResearch infrastructure is pervasive and fundamental to Australian research, in all disciplines, and directs Research Infrastructure Australia to seek advice from experts as an immediate priority on the establishment of a national eResearch infrastructure strategy.

9.2. Existing National Research Infrastructure facilities

The Review Panel's early consultations highlighted a pressing need for continuing funding for existing National Research Infrastructure. The Review Panel provided advice to the Minister for Education and Training on this issue at the time of its interim report.

The Review Panel welcomes the Government's commitment to funding NCRIS for 2015-16 and 2016-17. The roadmap, governance and Fund arrangements suggested by the Review Panel will help avoid similar issues in future. We should learn from experience and not leave long term funding for NCRIS in the state of uncertainty while the Government considers and acts on this Report.

A review of NCRIS would be an important part of the December 2016 roadmap.

The Australian Synchrotron is a vital element of Australia's national scientific infrastructure, contributing directly to increasing the productivity of Australian industry and delivering world-leading scientific discoveries in response to national challenges. It is unique in South-East Asia and Oceania. Its relevance extends across all nine Priorities.

It will take time for the Government to consider this Report and establish the new mechanisms proposed. Future ownership and sustainable funding for the Australian Synchrotron need to be secured now. To not do so would put at risk the Australian

Synchrotron's competitive position and the significant investment made to date by successive governments and other stakeholders.

The Review Panel strongly supports Australian Government control of the Australian Synchrotron as a key component of National Research Infrastructure. The Review Panel believes the Australian Nuclear Science and Technology Organisation operates the facility well and is the most suitable entity to own and operate the facility.

Like NCRIS the Government should not leave funding for the Australian Synchrotron in a state of any uncertainty.

There is also the need to upgrade several National Research Infrastructure facilities which have been underfunded to date, including the National Collections and the Australian Animal Health Laboratory.

The Review Panel supports funding for existing National Research Infrastructure facilities in the short term but emphasises that the roadmapping process may identify that some existing facilities should be defunded.

Recommendation 19

The Australian Government takes control of the Australian Synchrotron and confirms the Australian Nuclear Science and Technology Organisation as its operator.

9.3. Depreciation of National Infrastructure Research facilities

There are numerous host organisations and custodians of National Research Infrastructure facilities including universities, government agencies and PFRAs. The PFRAs play a particularly important role as hosts of landmark facilities.

The Review Panel has consulted widely with these groups and has received a working paper authored by eight CEOs of PFRAs titled *Securing the future of Australia's National Research Infrastructure Portfolio*. The Review Panel understands that the paper has been provided to the Government.

The working paper supports many of the conclusions and recommendations included in this Report.

One particular issue raised in the working paper, which has not been covered elsewhere in this Report, is the issue of depreciation.

The PFRAs and other National Research Infrastructure hosts currently operate under a range of rules regarding depreciation expensing on balance sheets in relation to the infrastructure facilities they host. Current arrangements lead to three highly related issues, highlighted in the PFRA working paper:

Depreciation expensing: unless the PFRAs are specifically funded for the depreciation expense, they need to either divert research operational funding or apply for a non-cash depreciation loss approval that subsequently impacts on the national profit and loss outcome.

1. **Depreciation cash balances:** funding the depreciation expense results in the accumulation of cash (creating a sinking fund for the next replacement). However, cash holding limitations on some PFRAs conflict with this requirement. PFRAs are not able to put aside funding against the expense and consequently cannot self-fund replacement and require operating loss approvals.
2. **Sustaining/Refurbishment/Replacement Funding:** when the annual depreciation expense is used by the Government as a proxy for new research infrastructure spending, it results in a substantial shortfall compared to actual capital needs to sustain and replace research infrastructure.

The Review Panel consultations revealed that these issues are becoming a significant deterrent to agencies considering hosting National Research Infrastructure facilities.

The Review Panel supports the recommendations set out in the PFRA Working Paper:

i. Depreciation and capital funding should be treated as separate matters.

ii. Capital funding for landmark and National Facilities should be part of the funding agreement for each facility (for example current NCRIS facilities operate under this model). Major institutional infrastructure should be funded as part of an agreed component of the institutional appropriation funding.

iii. Host organisations should be given automatic approval to run depreciation based operating losses should these be required, or alternatively to remove the depreciation from the host's profit and loss statements. Without this change organisations would still be required to "fund" depreciation expenses, even if, for example, the agreed strategy is not to replace the infrastructure at end of life.

Recommendation 20

For National Research Infrastructure owned by publicly funded research agencies, the Australian Government make changes to resolve the treatment of depreciation and that it considers capital funding requirements separately to depreciation expenses.

10. State and Territory Governments

State and territory governments have pursued strategic policies to invest in research and innovation as a contributor to their economic growth and productivity improvements.[64] The Review Panel has consulted extensively with them.

The state and territory governments also play a significant role in the research infrastructure landscape. They have a demonstrated history of co-investing in research infrastructure with the Australian Government. During the Review a number of them expressed an in-principle commitment to further co-investment in National Research Infrastructure but they are looking for the Australian Government to take the lead.

The current role of state and territory government investment in research infrastructure

The NCRIS programme has played an important role in recent engagement around research infrastructure. The state and territory governments were actively engaged in the roadmap process that identified the final capabilities. The 2010 NCRIS evaluation found that:

> NCRIS appears to have been successful in engaging Australian Government, state and territory governments and government agencies on priority areas without compromising a national approach to funding research infrastructure.[65]

The future role of the state and territory governments

The Review Panel's proposals for the dedicated Fund and independent Board to bring a more strategic and coordinated approach will need to build on the best examples of coordination between Australian governments.

The Review Panel considered how state and territory governments should be involved as investors in research infrastructure and how they should be involved in the governance and planning of research infrastructure funding. For example, the Review Panel seeks to prevent in the future the poor coordination between the Australian and state governments that has led to the continued funding uncertainty for the Australian Synchrotron.

The Research Infrastructure Australia strategic planning exercises will involve the widest range of stakeholders, including state and territory governments, to seek the broadest possible range of views on priorities and co-investment strategies.

64 Salisbury 2015.
65 Department of Innovation, Industry, Science and Research 2010, p. 9.

The challenge is to strike a balance between the Australian Government's primary role of funding research and research infrastructure and the state and territory governments' role of facilitating the location of facilities, providing additional investment, and leveraging local industry involvement.

Recommendation 21

Research Infrastructure Australia consults with the state and territory governments in shaping the roadmaps.

It is important that Research Infrastructure Australia is given the mandate to pursue state and territory government co-investment as part of its planning processes.

The interest the state and territory governments expressed in co-investing with the Australian Government will not turn into tangible proposals until the Australian Government's own commitment is clear. For this reason the establishment of the Fund with its long timeframe and consultative planning process will be the key to attracting state and territory government co-investment.

Once the Fund is established, the planning and implementation of the roadmap should be used to optimise co-investment. The willingness of state and territory governments to co-invest may be one factor in guiding the location of projects developed through the roadmap, but effective and efficient National Research Infrastructure, located in the best place, is paramount.

Recommendation 22

Funding arrangements are designed to optimise state and territory government involvement and co-investment at the project level.

Appendix 1—Australian National Research Infrastructure Inventory

Overview and purpose

The Australian National Research Infrastructure Inventory (the Inventory) was developed as a key input to the Research Infrastructure Review. The intent of the Inventory is to provide a snapshot of the nationally significant research infrastructure in Australia with a primary focus on Australian Government funded research infrastructure. It has been developed in order to provide the context in which future plans for major items of research infrastructure must be developed. It makes clear the scale of past investment, the current costs and the base for future investment. It shows broadly the current custodians, managers and beneficiaries of each item. The inventory is meant to make clear where each item is in its life-cycle in order to provide the basis for orderly planning of termination, replacement, refurbishing or other major change. Understanding of these matters allows clarification of needs for and effects of, gaps in particular areas.

The Inventory is not yet a definitive stocktake of all nationally significant research infrastructure in Australia. Non-appearance on this Inventory does not indicate a lack of importance or provide an indicator for future Australian Government funding.

Development

The Inventory was developed by the Research Infrastructure Review Secretariat from November 2014 – March 2015. Public sources of information provided the core of the data provided. Members of the Research Infrastructure Review Interdepartmental Committee refined the Inventory as required.

Findings

Quick facts

- 42 National Research Infrastructure projects identified.
- Total investment in the 42 National Research Infrastructure projects of:
  - $2,157 million in Australian Government capital investment;
  - $2,383 million in Australian Government operational investment;
  - $1,312 million in other co-investment; and
  - At least 41,231 users in 2013–14.
- 32 ‘other research infrastructure of national significance’ also identified.
- The majority of National Research Infrastructure is at the mid or end-point of its life cycle.
- Environmental research related research infrastructure projects/facilities were the most common, followed by health and multi-disciplinary facilities.

Caveats and issues

Aggregation of infrastructure

Aggregations of separate pieces of research infrastructure into 'projects' is common practice under National Collaborative Research Infrastructure Strategy (NCRIS). Such aggregations may include significant research infrastructure facilities that may be nationally significant in their own right but are included under the overarching NCRIS project banner. Examples of this aggregation include:

- the Australian SKA Pathfinder (ASKAP) facility forming part of the Australia Telescope National Facility (ATNF);
- access to the Magellan and Keck telescopes under the Australian Astronomy Limited project; and
- operation of the Australian Genome Research Facility and the Australian Proteome Analysis Facility under the Bioplatforms Australia project.

For the purposes of this Inventory, aggregated infrastructure is only listed at the aggregated project level.

Annual operating cost

The annual operating cost element was based on public or provided information, and may not be directly comparable across projects because:

- Many projects are constrained by operational or financial requirements to a certain operational level that could be increased should additional funding be forthcoming.
    - This is particularly the case for NCRIS projects, which have been operating at minimal funding levels since 2013.
- Provided annual operational costs may or may not have included depreciation or rolling capital replacement depending on the project, its governance structure and the manner in which it accounts for funding.
- The difficulty in ascertaining the required Australian Government component for operational costs in many projects.

Collections

The Review Panel have highlighted the irreplaceable nature and permanent supranational value of the scientific collections curated by CSIRO and other institutions.

The Review Panel have not discussed equivalent cultural, humanities and social sciences collections. To give just three examples from one field, there are the premier Australian Indigenous languages and cultural collection at the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS), the Australian English collection and the Pacific and Regional Archive for Digital Sources in Endangered Cultures.[66] In some cases these collections are more widely dispersed than the scientific collections.

However, the digitisation, curation and management of such collections are becoming increasingly national through tools such as the National eResearch Collaboration Tools and Resources (NeCTAR). Even when they make use of research infrastructure like supercomputers and the cloud, they may not be recognised as major national collections. Work is needed to identify such collections, ensure that their curation is national and otherwise ensure their

66 AIATSIS web page; Welcome to the Australian National Corpus web page; Pacific and Regional Archive for Digital Sources in Endangered Cultures (PARADISEC) web page.

continuing viability, which are questions that could be addressed through the roadmapping process if identified as national priorities but this has been beyond the scope of the Review.

Facilities like the National Archives of Australia and the National Film and Sound Archive have been excluded because they are not primarily research infrastructure.[67]

Future of the Inventory

This Inventory was developed to inform the Research Infrastructure Review, and should be viewed as the start of an ongoing Australian Government activity to identify and characterise its current research infrastructure holdings.

67 National Archives of Australia web page; National Film and Sound Archive web page.

New integrated capacities

Two existing sets of dispersed research infrastructure can be considered integrated capabilities, but these investments are not currently managed as a whole:

- National Collections, consisting of the Atlas of Living Australia and CSIRO's 8 national collections; and
- eResearch infrastructure, consisting of existing high performance computing, data and tools investments.

The parts of the National Collections are identified separately below as other infrastructure of national significance. Likewise the parts of the eResearch infrastructure capacity are included separately as National Research Infrastructure investments.

National research infrastructure

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
AuScope (NCRIS) auscope.org.au Geoscience and Geospatial Infrastructure System that combines traditional research infrastructure with applied science infrastructure. Host: AuScope Ltd	Multi-site	01. Exploration and exploitation of the Earth	2011 RI Roadmap	5.60	44.65/34.60	80.36	7/10	Mixed	100% of available capacity	Online portal Membership	4125
AIMS Sea Simulator aims.gov.au/ seasim Marine research aquarium facility for tropical marine organisms with the ability to finely manipulate key environmental factors. Host: Australian Institute of Marine Science	Single site	02. Environment	National interest	3.30	36.20/1.50	0.00	2/20	Mixed	50% of research capacity	Merit allocation	Not provided

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
Atlas of Living Australia (NCRIS) ala.org.au Online access to a repository of information about Australian plants, animals, and fungi. Part of the CSIRO National Research Collections. Host: CSIRO	Virtual	02. Environment	2011 RI Roadmap	5.10	34.10/9.10	1.01	7/10	Free	100% of service	Online portal	528,000[68]
Aurora Australis antarctica.gov.au National icebreaker and Antarctic supply vessel. Host: Department of the Environment	Vessel	02. Environment	National interest	~24	~2.00/~200.00	0	24/25	Free (majority of users) or agreed contribution	100% of available capacity	Merit allocation	219
Australian Antarctic Krill Aquarium Antarctic and subantarctic research aquarium facility for marine organisms with the ability to manipulate key environmental factors. Host: Department of the Environment	Single site	02. Environment	National Interest	~0.6		0	15/20	Free	100% of available capacity	Merit allocation	50
Australian Antarctic Territory antarctica.gov.au Australian bases in Antarctic and sub-Antarctic. Host: Department of the Environment	Multi-site	02. Environment	National interest	~45	~120.0/~375.0	0	25/50	Free (majority of users) or agreed contribution	100% of available capacity	Merit Allocation	420
Groundwater Infrastructure (NCRIS) groundwater.com.au National network of world-class groundwater infrastructure sites. Host: University of New South Wales	Multi-site	02. Environment	2011 RI Roadmap	3.70	15.00/7.84	1.40	10/20	Free	100% of service	Online portal	74

68 Unique users of web portal.

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
Integrated Marine Observing System (NCRIS) imos.org.au Distributed national ocean monitoring system. Host: University of Tasmania	Distributed	02. Environment	2011 RI Roadmap	35.80	77.00/67.60	32.10	7/10	Free	100% of service	Online portal	845
Marine National Facility (RV Investigator) mnf.csiro.au National research vessel. Host: CSIRO	Vessel	02. Environment	National interest	30.10	120.00/127.90	0.00	1/25	Free	100% of available capacity	Merit allocation	N/A
National Coral Core Archive aims.gov.au/docs/about/facilities Extensive collection of coral cores and natural historical archives that extend over several centuries, pre-dating both observational records of reef environments and human interference in regional and global environments. Host: Australian Institute of Marine Science	Single Site	02. Environment	National interest	0.18	1.9/0	0.00	2	Mixed[69]	100% of available capacity	Collaboration / Merit allocation	Five orgs, including AIMS
Terrestrial Ecosystem Research Network (NCRIS) tern.org.au TERN enables ecosystem scientists to collect, contribute, store, share and integrate data across disciplines. Host: University of Queensland	Distributed	02. Environment	2011 RI Roadmap	6.71	35.80/22.30	6.70	7/10	Free	100% of service	Online portal	2378

69 Access is dependent on project type and counter-party, including free for collaboration on AIMS project, co-invested where AIMS and counter party are co-investing in a project targeting joint outcomes, commercial where AIMS sells science products that utilise the infrastructure.

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
Astronomy Australia (NCRIS) astronomyaustralia.org.au AAL works with Australia's astronomy community to advance the goals in the Australian astronomy Decadal Plan and Mid-Term Review of the Decadal Plan. Host Astronomy Australia Ltd	Multi-site	03. Exploration and exploitation of Space	National interest	12.00	10.70/46.40	0.00	40/50	Free	100% of service	Merit allocation	190
Australian Astronomical Observatory aao.gov.au The AAO is an optical/near-infrared astronomy previously administered as a joint facility of Australia and the United Kingdom. Host: Department of Industry and Science	Multi-site	03. Exploration and exploitation of Space	National interest	12.00	10.70/46.40	0.00	40/50	Free	100% of service	Merit allocation	190
Australian Telescope National Facility atnf.csiro.au Networked collection of national radio telescopes of global significance, incorporating the Australian Square Kilometre Array Pathfinder, Parkes, Narrabri and Mopra. Host: CSIRO	Multi-site	03. Exploration and exploitation of Space	National interest	23.6[70]	131 .00/177.60	0.00	Various[71]	Free[72]	100% of available capacity	Merit allocation	Various[73]
Giant Magellan Telescope gmto.org 22m international telescope currently being constructed in Chile. Host: Australian National University	Single site	03. Exploration and exploitation of Space	International agreement (non-treaty)	TBA when complete	88.40/0.00	571.60	0/50	Free	10.5% of total capacity/	Membership	N/A

70 14/15 annual cost ASKAP, Parkes, Narrabri and Mopra, noting that ASKAP is in development stage, and SKA is aspirational.
71 As above.
72 Free to all except mixed cost for Mopra.
73 Projects/users: ASKAP 10/363; Parkes 31/70; Narrabri 126/300; Mopra 18/30.

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
Australian Urban Research Infrastructure Network (NCRIS) aurin.org.au National collaboration delivering eResearch infrastructure to empower better decisions for Australia's urban settlements and their future development. Host: University of Melbourne	50% of Australia's access right	Membership	N/A	1.78	20.00/4.00	0.70	5/10	Free	100% of service	Online portal	397
Australian Plasma Fusion Research Facility (NCRIS) h1nf.anu.edu.au Facility enables basic experimental research on magnetically confined plasma. Host: Australian National University	Single site	05. Energy	2011 RI Roadmap	1.80	7.00/0.90	0.00	20/30	Free	100% of available capacity	Merit allocation	49
Biofuels (NCRIS) Infrastructure to support research into the conversion of agricultural wastes to fuels, including a renewable biocommodities pilot plant and a photobioreactor facility. Host: AusBiotech Ltd	Multi-site	05. Energy	2011 RI Roadmap	0.48	7.00/4.30	6.60	7/10	Fee for service	100% of available capacity	Merit allocation	33
Australian Microscopy and Microanalysis Research Facility (NCRIS) ammrf.org.au National grid of equipment, instrumentation and expertise in microscopy and microanalysis for widely used and cutting edge techniques, including optical, electron and X-ray techniques. Host: University of Sydney	Distributed	06. Industrial production and technology	2011 RI Roadmap	5.60	10.60/17.30	24.50	9/10	Fee for service	100% of available capacity	Merit allocation	3161

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
Australian National Fabrication Facility (NCRIS) anff.org.au National network of state-of-the-art fabrication facilities and expertise. Host: Australian National Fabrication Facility Ltd	Distributed	06. Industrial production and technology	2011 RI Roadmap	16.20	70.70/63.90	87.90	7/10	Fee for service	100% of available capacity	Merit allocation	2190
Australian Animal Health Laboratory csiro.au Nation's premiere biosecure research facility. Regional and international biosecurity role. Host: CSIRO	Single site	07. Health	National interest	33.00	63.39/428.10	1.7	29/50	Fee for service	100% of available capacity	Merit allocation	82
Australian Phenomics Network (NCRIS) australianphenomics.org.au Mouse models and related services for the study of human and animal disease. Host: Australian National University	Multi-site	07. Health	2011 RI Roadmap	12.20	23.30/16.20	5.50	10/12	Fee for service	100% of available capacity	Merit allocation	753
Bioplatforms Australia (NCRIS) bioplatforms.org.au Network of facilities providing services, scientific and data infrastructure in the specialist fields of genomics, proteomics, metabolomics and bioinformatics. Host: Bioplatforms Australia Ltd	Distributed	07. Health	2011 RI Roadmap	17.16	75.60/51.00	45.70	7/10	Fee for service	100% of available capacity	Merit allocation	8319

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
Population Health Research Network (NCRIS) phrn.org.au Provides researchers with the ability to link de-identified population health data from a diverse and rich range of health data sets, across sectors and jurisdictions. Host: University of Western Australia	Virtual	07. Health	2011 RI Roadmap	8.94	20.00/18.00	11.20	5/10	Free	100% of service	Merit allocation	>400
Translating Health Discovery into Clinical Applications (NCRIS) therapeuticinnovation.com.au National infrastructure and partnering network enabling the development of small molecules, biopharmaceuticals, cell therapies and biomarkers. Host: Therapeutic Innovation Australia Ltd	Distributed	07. Health	2011 RI Roadmap	38.89	35.00/7.00	18.50	4/10	Free	100% of service	Merit allocation	147
Australian Plant Phenomics Network (NCRIS) plantphenomics.org.au State-of-the-art plant phenotyping tools and expertise. Host: University of Adelaide	Multi-site	08. Agriculture	2011 RI Roadmap	5.00	17.60/16.90	2.90	7/10	Fee for service	100% of available capacity	Merit allocation	95
ANSTO Nuclear Science Facilities (Bragg Institute EIF Neutron Beam Facilities & Centre for Accelerator Science – CAS) (NCRIS) ansto.gov.au Upgraded nuclear science facilities at ANSTO's Bragg Institute. Host: ANSTO	Single site	13. General advancement of knowledge: R&D from other sources	National interest	5.8	62.00/19.30	10.00	8/15-20	NBI Free. Centre of Accelerator Science: fee and free	90% of total capacity	Merit allocation	168

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
ANSTO Nuclear Science Facilities (Bragg Institute) (Non-EIF) ansto.gov.au Upgraded nuclear science facilities at ANSTO's Bragg Institute. Host: ANSTO	Single site	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	9.50	77.00/60.00	11.00	1-8/15	Free	90% of reactor operation days (300 days/year)	Merit allocation	386
Australian Access Federation aaf.edu.au Framework and support infrastructure to allow trusted electronic communications and collaboration within and between universities and research institutions in Australia and overseas Host: CAUDIT	Virtual	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	1.19	4.80/2.39	0.00	8/10	Fee for service	100% of service	Membership	800
Australian National Data Service (NCRIS) ands.org.au Data management, connectivity and discovery services. Host: Monash University	Virtual	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	8.30	60.30/28.30	0.00	7/10	Free	N/A	Merit allocation	2750
Australian Research and Education Network aarnet.edu.au nrn.edu.au National dedicated high performance education and research broadband telecommunications network. Host: AARNet Pty Ltd	Network	13. General advancement of knowledge: R&D from other sources	National interest; 2011 RI Roadmap	~50.00	38.50/1.50	11.20	25/30	Fee for service	100% of service	Membership	42 unis, CSIRO, other partners

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
Australian Synchrotron synchrotron.org.au Australia's national synchrotron light source. Host: Australian Synchrotron Holding Company Pty Ltd (owner) & ANSTO (operator)	Single site	13. General advancement of knowledge: R&D from other sources	National interest; 2011 RI Roadmap	25.00	75.47/75.30	287.50	7/25	Free	100% of total capacity	Merit allocation	4347
Camperdown Cyclotron ansto.gov.au Australia's first cyclotron dedicated to biomedical research Host: ANSTO	Single site	13. General advancement of knowledge: R&D from other sources	National interest	1.3	8.60/2.00	0.00	2/15	Free	100%	Merit allocation	27
European Molecular Biology Laboratory (NCRIS) emblaustralia.org Associate Membership of the European Molecular Biology Laboratory (EMBL), Europe's flagship laboratory for basic research in molecular biology Host: Monash University	Membership	13. General advancement of knowledge: R&D from other sources	National interest	~4.00	8.3/8.00	~15.00		Mixed fee for service and free	100%	Membership	N/A
Heavy Ion Accelerators (NCRIS) physics.anu.edu.au 14UD pelletron accelerator and superconducting 'booster' linear accelerator located at the ANU. Host: Australian National University	Single site	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	17.75	10.00/3.00	3.55	40/50	Fee for service	100% of available capacity	Merit allocation	74

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
National Computational Infrastructure (NCRIS) nci.org.au National high performance computer facility, focusing on climate and geoscience. Managed by CSIRO. Does not include the ANU managed supercomputing facility in Canberra. Host: Australian National University	Single site	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	18.57	63.00/17.30	11.00	4/5	Mixed	20% of total capacity	Merit allocation	2433
National Deuteration Facility (NCRIS) ansto.gov.au Biological and chemical deuteration facility. Host: ANSTO	Single site	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	1.24	3.60/10.40	0.00	6/25	Free for Australian users. Fee for service for international users	100% of available capacity	Merit allocation	87
National eResearch Collaboration Tools and Resources (NCRIS) nectar.org.au ICT infrastructure that: • Creates new information centric research capabilities; • Significantly simplifies the combining of instruments, data, computing, and analysis applications; and • Enables the development of research workflows based on access to multiple resources. Host: University of Melbourne	Virtual	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	4.14	47.00/9.40	5.70	4/10	Free	100% of service	Merit allocation	4369

	Nature			Cost ($m)				Usage and Access			
Infrastructure and description/ host/owner	Type	Socio-Economic outcome	Alignment with national priorities	Annual Operating	Commonwealth Investment (capital/ operational) (2004–14)	Co-investment (2004–14)	Age (years)	Cost	Extent available to external users	Arrangements	# users 2013/14
National Imaging Facility (NCRIS) anif.org.au National network providing state of the art imaging of animals, plants and materials. Host: University of Queensland	Multi-site	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	5.67	33.60/9.30	68.40	7/10	Fee for service	100% of available capacity	Merit allocation	856
OPAL Reactor ansto.org.au National nuclear research reactor. Host: ANSTO	Single site	13. General advancement of knowledge: R&D from other sources	National interest	45.00	442.90/390.00	0.00	8/40	Fee for service	Fee for service	Merit allocation	Not provided
Pawsey Supercomputing Centre (NCRIS) ivec.org.au National high performance facility, focusing on astronomy. Host: CSIRO	Single site	13. General advancement of knowledge: R&D from other sources	National interest	8.92	80.00/4.50	0.00	1/4	Free	100% of service	Merit allocation	596
Research Data Services Initiative (NCRIS) rds.edu.au National network of data storage that improves the availability, management and sharing of data, to support data intensive research. Host: University of Queensland	Enabling	13. General advancement of knowledge: R&D from other sources	2011 RI Roadmap	Not provided	50.00/10.00	0.00	5/5	Free	100% of service	Merit allocation	Not provided

Other infrastructure that has national significance

International Ocean Discovery Program

iodp.org.au

International partnership of scientists and research institutions organised to explore Earth's structure and history through scientific ocean drilling.

Owner/Host: Australia-NZ IODP Consortium

Type: Membership to international project

Social-economic outcome :01. Exploration and exploitation of the Earth

Australia's Virtual Herbarium (AVH)

avh.chah.org.au

AVH provides access to information obtained from the collections held in Australian herbaria.

Australia's herbaria house over seven million plant, algae and fungi specimens. The collected data stored with these specimens provides the most complete picture of the distribution of Australia's flora to date.

Owner/Host: AVH is a collaborative project of the Commonwealth, state and territory herbaria, under the auspices of the Council of Heads of Australasian Herbaria (CHAH).

Type: Distributed

Social-economic outcome :02. Environment

Australian National Algae Culture Collection

csiro.au/research/collections

Part of the CSIRO Australian National Collections.

Owner/Host: CSIRO

Type: Collection

Social-economic outcome :02. Environment

Australian National Fish Collection

cmar.csiro.au/anfc
csiro.au/research/collections

Part of the CSIRO Australian National Research Collections.

Owner/Host: CSIRO

Type: Collection

Social-economic outcome: 02. Environment

Australian National Herbarium

csiro.au/research/collections

Part of the CSIRO Australian National Research Collections.

Owner/Host: CSIRO and Department of the Environment

Type: Collection

Social-economic outcome: 02. Environment

Australian National Insect Collection

csiro.au/research/collections

Part of the CSIRO Australian National Research Collections.

Owner/Host: CSIRO

Type: Collection

Social-economic outcome: 02. Environment

Australian National Wildlife Collection

csiro.au/research/collections

Part of the CSIRO Australian National Research Collections.

Owner/Host: CSIRO

Type: Collection

Social-economic outcome: 02. Environment

Australian Seed Bank Online

seedpartnership.org.au

Distributed database of Australia's ex situ conservation seed collections of native flora that are for research, species recovery, education and safeguarding for future use. Working to increase data coverage to include germination data and have that publicly accessible for use by the conservation and restoration groups and organisations.

Host: Atlas of Living Australia

Owner: Owner of data: individual State and Australian Government botanical agencies, which are members of the Australian Seed Bank Partnership.

Type: Distributed

Social-economic outcome: 02. Environment

Australian Soils Archive

csiro.au

CSIRO collection of soil samples.

Host/Owner: CSIRO

Type: Collection

Social-economic outcome: 02. Environment

Australian Tree Seed Centre

csiro.au/research/collections

Part of the CSIRO Australian National Research Collections.

Host/Owner: CSIRO

Type: Collection

Social-economic outcome: 02. Environment

Australian Tropical Herbarium

ath.org.au

Reference set of tropical plants, both native and introduced.

Host/Owner: James Cook University

Type: Collection

Social-economic outcome: 02. Environment

Bureau of Meteorology monitoring facilities (various)

bom.gov.au
cawcr.gov.au

Includes advanced polarimetric weather radar, cloud radar and LIDAR; Baseline Air Pollution Station, Cape Grim; satellite ground stations for earth observations from space.

Host/Owner: Bureau of Meteorology

Type: Multi-site

Social-economic outcome: 02. Environment

Bureau of Meteorology Supercomputer

bom.gov.au

Supercomputer facility focused on operational weather forecasting.

Host/Owner: Bureau of Meteorology

Type: Single site

Social-economic outcome: 02. Environment

Commonwealth Paleontological Collection

ga.gov.au

National collection of Australian fossils.

Host/Owner: Geoscience Australia

Type: Collection

Social-economic outcome: 02. Environment

Environmental Research Institute of the Supervising Scientist – Laboratory facilities

Laboratory facilities in Darwin and Jabiru supporting remote sensing, radiological, water quality, biological, ecotoxicological and geomorphic research and monitoring activities to support the statutory role of the Supervising Scientist.

Host/Owner: Supervising Scientist – Department of the Environment

Type: Multi-site

Social-economic outcome: 02. Environment

Environmental Research Institute of the Supervising Scientist – Monitoring network

Network of water quality, radiological and biological monitoring equipment and sites across the Alligator Rivers Region of the NT.

Host/Owner: Supervising Scientist – Department of the Environment

Type: Multi-site

Social-economic outcome: 02. Environment

Geoscience Australia Research Facilities (various)

Includes Geodetic Observatory Network, Geomagnetic Observation Network, National Earth Observation Data Acquisition, Processing, Archive & Data Cube Research Capability, Seismo-acoustic Observatory Network, Satellite Laser Ranging Station.

Host/Owner: Geoscience Australia

Type: Multi-site

Social-economic outcome: 02. Environment

RV Cape Ferguson (AIMS Research Vessel)

aims.gov.au

24m AIMS research vessel used for coastal research. Predominantly utilised to support GBR research and monitoring.

Host/Owner: Australian Institute of Marine Science

Type: Vessel

Social-economic outcome: 02. Environment

RV Solander (AIMS Research Vessel)

aims.gov.au

35m AIMS research vessel used for coastal research. Predominantly utilised to underpin research in support of the oil and gas sector.

Host/Owner: Australian Institute of Marine Science

Type: Vessel

Social-economic outcome: 02. Environment

Specialist Marine Laboratories

aims.gov.au/laboratories

Extensive range of laboratories including microscope, organic geochemistry, radiation and PC2 facilities.

Host/Owner: Australian Institute of Marine Science

Type: Laboratories

Social-economic outcome: 02. Environment

Australian Centre for Hypersonics

hypersonics.mechmining.uq.edu.au

Impulse facilities for testing aerodynamic flow and other effects at hypersonic speeds.

Host/Owner: University of Queensland

Type: Single site

Social-economic outcome: 03. Exploration and exploitation of Space

Australian International Gravitational Observatory

aigo.org.au

Gravity wave observatory based in Western Australia.

Host/Owner: University of Western Australia

Type: Single site

Social-economic outcome: 03. Exploration and exploitation of Space

CESARE Large Scale Experimental Building Fire Facility

vu.edu.au

Large scale fire testing facilities.

Host/Owner: Victoria University

Type: Single site

Social-economic outcome: 04. Transport, telecommunication and other infrastructure

AGL Energy Ltd Solar Flagship

agl.com.au
uq.edu.au

Research infrastructure component of $450m western NSW solar plant.

Host/Owner: University of Queensland

Type: Multi-site

Social-economic outcome: 05. Energy

CO2CRC - CCSNet research infrastructure project

Network of carbon capture and storage research infrastructure facilities, established to support the CarbonNet project.

Host/Owner: CO2CRC Ltd

Type: Distributed

Social-economic outcome: 05. Energy

National Geosequestration Laboratory

ngl.org.au

Carbon capture and storage research infrastructure facility established to support the South West Hub project.

Host/Owner: CSIRO

Type: Distributed

Social-economic outcome: 05. Energy

Victorian Life Sciences Computation Initiative

vlsci.org.au

Supercomputing facility focused on Victorian life science research.

Host/Owner: University of Melbourne

Type: Single site

Social-economic outcome: 07. Health

National Hydrodynamics Research Centre

amc.edu.au

Suite of hydrodynamics research facilities including the Cavitation Research Laboratory and the Centre for Marine Simulations.

Host/Owner: Australian Marine College

Type: Single site

Social-economic outcome: 12. General advancement of knowledge: R&D from General University Funds

Multi-modal Australian Sciences Imaging and Visualisation Environment (MASSIVE)

massive.org.au

Specialised High Performance Computing facility for Imaging and Visualisation.

Host/Owner: Monash University

Type: Single site

Social-economic outcome: 13. General advancement of knowledge: R&D from other sources

Appendix 2—Terms of Reference

In 2014, the National Commission of Audit (NCOA) found that:

> Quality research infrastructure is a critical component of Australia's research and development system and, since 2001, the Commonwealth Government has provided a series of funding programmes for large-scale research infrastructure.

The NCOA recommended that:

> The Government take a more strategic, whole of government approach to the funding of research and development, including by committing to ongoing funding for critical research infrastructure in Australia, informed by a reassessment of existing research infrastructure provision and requirements.

In its 2014–15 budget, the Australian Government has provided an additional $150 million in 2015–16 to continue the National Collaborative Research Infrastructure Strategy. In August 2014, the Minister for Education announced that, in line with the NCOA's constructive approach, a positive review of research infrastructure would begin in the coming months.

The Minister has established the Research Infrastructure Review to undertake this review.

1. To undertake an assessment of existing research infrastructure provision and requirements, that will inform future commitment to ongoing funding for critical research infrastructure in Australia.
2. To examine the role of public funding, including from the Commonwealth, in supporting the provision of research infrastructure in maximising the use of existing funding.
3. To examine the operating costs and priorities of the National Collaborative Research Infrastructure Strategy and its need for ongoing investment required from the Commonwealth.
4. To examine alternative arrangements for leveraging funding for the development and ongoing operations of research infrastructure, such as through partnerships with the private sector and the appropriate application of cost recovery.

The Review will be conducted in close consultation with the research sector, including research infrastructure facilities, universities, research institutions, publicly funded research agencies, state and territory governments, industry and other relevant government and non-government parties.

The Research Infrastructure Review will provide a final report by mid-2015 to the Minister for Education and Training.

The Research Infrastructure Review will be supported by the Department of Education and Training.

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