



Australian Government



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Industry Innovation
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Driving effective Government investment in innovation, science and research



Acknowledgments

Industry Innovation and Science Australia's (IISA) report *Driving effective Government investment in innovation, science and research*, responds to a request from the Honourable Karen Andrews, MP, the Minister for Industry, Science and Technology. Minister Andrews requested a report on the effectiveness of the Commonwealth Government's investment in, and system performance of, innovation, science and research (ISR).

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Executive summary

Innovative countries are more productive, resilient, adaptable to change and better able to support higher living standards.¹ Investment in innovation, science and research (ISR) provides the foundation for ground breaking technologies as well as new and significantly improved processes, products, marketing and organisational practices.²

The Commonwealth Government's³ ISR investment is used to underpin a strong research and intellectual capital base, support translation and innovation, maintain Australia's comparative and competitive advantages,⁴ ensure the Government's own national and sovereign needs are met and ensure Australia has the human capital and physical infrastructure to deliver on its objectives. This investment should include support for both research and development (R&D) and non-R&D innovation.⁵ The Government's ISR investment is complemented by ISR investments from other areas such as state and territory governments, businesses, universities, private not-for-profit organisations and overseas investors. Recent events have served to reinforce the critical importance of ISR to Australia's response to, and recovery from, crises.

The ISR system does not operate in a vacuum. It is strongly influenced by the broader economic, social and political environment. It is also related to other realms of policy such as economic policy, higher education policy, energy policy, agricultural policy and broader industrial policy. ISR policies should take this complex landscape into account and should be situated within the broader policy aims of related areas.

Despite some high-impact outcomes from Government-funded ISR, findings from internationally comparable metrics⁶ indicate that Australia's ISR system has achieved mixed results. While Australia has maintained its position in traditional areas of strength, such as educational institutions, Australia appears to be behind or trending against our global competitors in other key areas, such as business collaboration on innovation. This indicates that there are areas of the Government's ISR investment that could be improved.

Internationally, governments are harnessing ISR investments to drive their economies, as they recognise the key 'entrepreneurial' role of these investments. Economies with well-designed ISR investments, appropriately scaled to deliver against the government's priorities, are delivering short, medium and long-term returns. Returns can range from short-term economic stimulus to long-term transformations that underpin future prosperity. Ensuring the effectiveness of the Commonwealth Government's annual ISR investment is key for ongoing accountability and sustainability, particularly in times of increased fiscal pressure.

Industry Innovation and Science Australia's (IISA) report responds to a request from the Honourable Karen Andrews, MP, the Minister for Industry, Science and Technology, for a report on the effectiveness of the Commonwealth Government's investment in, and system performance of, ISR.⁷

1 OECD. (2015). The innovation imperative – contributing to productivity, growth and well-being. www.oecd.org/publications/the-innovation-imperative-9789264239814-en.htm

2 An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. OECD. Glossary of statistical terms. <https://stats.oecd.org/glossary/detail.asp?ID=6865>

3 For this report, Commonwealth Government refers to the Australian Government. References to state and territory government investment are referenced separately throughout the report.

4 See implementation section of this report for further discussion.

5 Non-R&D innovation includes investment in new or significantly improved product, process, marketing and organisational practices that are broader than R&D alone. More information about the economic benefits of non-R&D innovation can be found in Innovation and Science Australia. (2020). Stimulating business investment in innovation. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf

6 For example, total expenditure on innovation by business as a percentage of GDP, gross expenditure on research and development as a percentage of GDP (GERD), and total expenditure of educational institutions as a percentage of GDP etc. See Appendix H for more detail.

7 The Statement of Expectations, dated 19 February 2019, can be found at www.industry.gov.au/sites/default/files/2019-10/isa-statement-of-expectations-2019.pdf

IISA examined the effectiveness of the Commonwealth Government's ISR investment based on an evaluation of Australian and international literature and analyses of the available data.⁸ IISA also conducted a more detailed analysis of the Government's ISR investment in space. The space sector was chosen as an exemplar of an emerging Government priority with the potential to lift the broader economy, delivering benefits from healthcare through to financial services.⁹

IISA found that evidence of unintended duplications¹⁰ and gaps in the Government's ISR investment is a symptom, rather than the cause, of a system that could be more effective. Effective Government investment in ISR is characterised by five best-practice principles (Table 2). That is, Government investment is most effective when it is aligned to the Government's priorities, delivers impact, is sustainable, is coordinated and is strategically balanced. Similar to a share portfolio, the Government's ISR investment is most effective when it is strategically balanced for each of the following attributes:

- ISR phases¹¹ and along the ISR pipeline,¹²
- scale,
- level of technical and commercial risk,
- broad-based and targeted investment mechanisms, and
- resource allocation.¹³

IISA used these principles to frame its analyses and recommended actions to ensure that the Government's investment is effective by design, policies are aligned and unintended duplication and gaps are avoided. The key findings from IISA's analyses are provided in Table 1. In response to these findings, IISA has identified three recommended actions to increase the overall effectiveness of the Government's ISR investment. An overview of some ways in which the recommended actions could be implemented is provided at the end of this report.

8 For this assessment, effectiveness is defined as the ability of public resources to achieve a given set of objectives.

9 Australian Space Agency. (2019). Advancing Space: Australian Civil Space Strategy 2019-2028. <https://publications.industry.gov.au/publications/advancing-space-australian-civil-space-strategy-2019-2028.pdf>

10 It should be noted that duplication, in and of itself, is not a sign of an ineffective ISR system. Duplication of ISR investment may be intentional by design. For example, multiple teams have been funded to develop a COVID-19 vaccine to ensure an effective outcome for a time critical problem. However, unintended duplication may indicate that the Government's ISR investment is not as effective as it could be.

11 That is, across basic, applied and translational ISR.

12 Where ISR can move seamlessly along the innovation pipeline.

13 A description of each of these principles is provided in Table 2.

Table 1 Key findings for each principle

Aligned to priorities

- Current system-level ISR priorities are not driving ISR investments, incentivising ISR investments, or were never designed to do so. As a result, ISR investments such as defence and political and social systems (which account for over 10 per cent of government ISR investments) are not captured as a part of extant system-level ISR priorities.
- ISR investments are predominantly developed on an organisation-by-organisation basis and are intended to meet the needs of the individual organisation, rather than the system.
- There are overlaps between the objectives of the Commonwealth and state and territory governments, with limited coordination of these investments.
- There are no effective reviews of extant priorities to ensure they reflect emerging areas.

Delivers impact

- There is poor transparency, consistency and independence of evaluations at the system level and a lack of feedback loops driving subsequent investment decisions.
- There is no whole-of-government approach to evaluating ISR investments despite the existence of effective domestic and international models.
- There are some good examples of sector level evaluations, including the higher education sector level assessments of excellence, engagement and impact.

Sustainable

- There have been few long-term and truly transformative¹⁴ ISR programs.
- There has been a high turnover of investment measures, resulting in uncertainty in the business and research sectors.
- Short-term investments can minimise transformative approaches.

Coordinated

- ISR investment processes are complex, with investments split across 202 programs and 13 portfolios.
- Multiple ministers and departments have investment responsibilities.
- There is limited investment coordination with state and territory governments.
- There is a lack of consistent, granular and contemporary investment and performance data to assess the performance of the ISR system.
- Fragmentation, unintended duplication and gaps are a symptom of a lack of coordination at the system level.

Strategically balanced

- There are no mechanisms for Government to strategically balance its \$10.1 billion investment.
- Australia punches above its weight in producing quality research outcomes.
- Improved industry-research collaboration and commercialisation is needed.
- There is insufficient government investment in non-R&D innovation.
- The fragmented approach to investment means that many ISR investments lack scale.
- There is no Government-wide framework to assess the level of commercial and technical risk of the Government's investments.
- There is little targeted ISR investment for business and higher education.
- Funding for research overheads varies greatly across sectors creating inequitable and inadequate support for researcher salaries, administration costs, infrastructure and operating costs.

¹⁴ Note, 'transformative' research as used here has been defined as "involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice or leads to the creation of a new paradigm or field of science, engineering, or education. Such research challenges current understanding or provides pathways to new frontiers." National Science Foundation. (2007). Enhancing Support of Transformative Research at the National Science Foundation. https://www.nsf.gov/nsb/documents/2007/tr_report.pdf

Recommended Actions

Recommended Action 1

The development of whole-of-government ISR priorities could be used to drive investment decisions by ensuring:

1. All new ISR investments, and planned reviews of existing investments, are tied to whole-of-government priorities.
2. Such ISR priorities should:
 - a) Provide system-level stability; be reviewed every 10 years, or when significant changes occur; and be responsive to societal, economic, and environmental challenges.
 - b) Be aligned with other Commonwealth Government priorities (such as short-term stimulus and long-term economic growth priorities).
 - c) Support both R&D and non-R&D innovation.
 - d) Support ISR excellence.

Recommended Action 2

A 10-year ISR investment plan, that is aligned with the Government's ISR priorities, coordinated at the whole-of-government level, and has effective evaluation processes could increase investment effectiveness by ensuring investments are:

1. Coordinated through centrally-facilitated engagement between Commonwealth Government funders and performers.
2. Designed with clarity of purpose and well-defined milestones, expected outcomes, key performance indicators, return on investments (societal, economic or environmental) and user/targets. This information should be used to underpin evaluations which assess investment effectiveness at a whole-of-government level, through a coordinated evaluation process. Evaluation outcomes should be used to enhance investment effectiveness and inform investment plan updates.
3. Reviewed on a rolling three-yearly basis to provide investment certainty, unless rigorous evaluation proves they are ineffective, or they are pilot investments.

Recommended Action 3

A strategically balanced, whole-of-government ISR investment plan could ensure there are returns in the short, medium and long-term by:

1. Supporting both R&D and non-R&D innovation.
2. Ensuring investment in basic research does not fall below current levels (22 per cent of overall R&D investment) so that it can underpin future commercial opportunities.
3. Scaling and coordinating research commercialisation programs, particularly those which embed researchers in businesses.
4. Ensuring the technical and commercial risk profile of the Government's ISR investment is higher than would be acceptable in the private sector to enable breakthrough ISR in priority areas.
5. Ensuring the scale of the Government's overall ISR investment is sufficient to achieve its priorities, and individual ISR investments are appropriately scaled to achieve maximum impact.
6. Ensuring the costs of conducting research (including researchers, administration and infrastructure) are met by Government or other investors.
7. Ensuring ISR priorities are achieved using more targeted support measures for business and higher education-performed ISR, while flexible measures are in place across the system to address emerging priorities.

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Introduction

The year 2020 has been an extremely challenging time for Australians. Many parts of the country have experienced unprecedented bushfires,¹⁵ closely followed by the global COVID-19 pandemic. These events have tested Australia's preparedness, resilience and ability to recover from significant crises.¹⁶ However, they have also highlighted the importance of innovation, science and research (ISR) capabilities to Australia's resilience and prosperity.

ISR has underpinned critical expert medical and economic advice to inform government policy responses during the COVID-19 pandemic, which has minimised the human and economic cost of the crisis.¹⁷ This has included both research and development (R&D) and non-R&D innovation.¹⁸ Australia demonstrated its internationally competitive ISR during the pandemic with the University of Queensland drawing on its existing research to develop a COVID-19 vaccine candidate in three weeks¹⁹ and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) being selected to conduct pre-clinical trials for international vaccine candidates.²⁰

Innovation has also played a key role for many businesses in the weeks following nation-wide restrictions. An extraordinary deployment of remote work and digital access to services has occurred across almost every domain. Global data suggests that five years of progress has been made in consumer and business digital adoption in just eight weeks,²¹ though this rate of adoption has not been observed in all sectors. In Australia, 38 per cent of Australian businesses changed their delivery method and moved their businesses online in a matter of weeks.²²

The benefits of government investment in ISR are well documented internationally. The European Commission's review of innovation studies concludes that the overall value generated by public research is high, estimating a return of "between three and eight times the initial investment over the entire life cycle of the effects".²³ Australia's Productivity Commission similarly states that there are widespread and important economic, social and environmental benefits generated by Australia's public funding support for science and innovation.²⁴ For example, the net economic benefit to the Australian economy of the Government's Cooperative Research Centres (CRC) Program has been estimated to exceed costs by a factor of three to one.²⁵

15 The Australian Academy of Science. (2020). The Australian bushfires – why they are unprecedented.

www.science.org.au/news-and-events/news-and-media-releases/australian-bushfires-why-they-are-unprecedented

16 Prime Minister of Australia. (2020). National Royal Commission into Black Summer Bushfires Established. www.pm.gov.au/media/national-royal-commission-black-summer-bushfires-established; Air Chief Marshal Mark Binskin AC (Retd) (October 2020). Royal Commission into Natural Disaster Arrangements. <https://naturaldisaster.royalcommission.gov.au/publications/royal-commission-national-natural-disaster-arrangements-report>

17 Department of Health. (2020). Government response to the COVID-19 outbreak. www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/government-response-to-the-covid-19-outbreak#who-manages-the-response; Alliance for Health Policy and Systems Research (2020). Bringing together evidence to tackle COVID-19. www.who.int/alliance-hpsr/news/2020/bringing-evidence-together-for-covid-19/en; Australia's Chief Scientist. (2020). Research sector answers the Government's call for the best available evidence on COVID-19. www.chiefscientist.gov.au/news-and-media/research-sector-answers-governments-call-best-available-evidence-covid-19

18 That is investment in new or significantly improved product, process, marketing and organisational practices that are broader than R&D alone. More information about the economic benefits of non-R&D innovation can be found in Innovation and Science Australia. (2020). Stimulating business investment in innovation. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf

19 University of Queensland. (2020). 'Significant step' in COVID-19 vaccine quest. www.uq.edu.au/news/article/2020/02/significant-step%E2%80%99-covid-19-vaccine-quest

20 CSIRO. (2020). Pre-clinical COVID-19 vaccine trials begin at CSIRO. https://blog.csiro.au/covid19-vaccine-trials/?utm_source=Snapshot-April-2020&utm_medium=newsletter&utm_campaign=Snapshot

21 McKinsey (2020). The COVID-19 recovery will be digital: A plan for the first 90 days. www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-covid-19-recovery-will-be-digital-a-plan-for-the-first-90-days?cid=other-eml-alt-mbl-mck&hlkid=ffa7f7dace64429f82c354ddf40accb6&hctky=11986719&hdpid=dfb4c609-2604-4df3-aa42-ae7ed2aff045

22 Australian Bureau of Statistics (ABS). (2020). 5676.0.55.003 Business Indicators, Business Impacts of COVID-19, Week Commencing 30 March 2020. <https://www.abs.gov.au/statistics/economy/business-indicators/business-indicators-business-impacts-covid-19/mar-2020>

23 European Commission, Research, Innovation, and Science Policy Experts. (2015). Value of Research. https://ec.europa.eu/futurium/en/system/files/ged/60_-_rise-value_of_research-june15_1.pdf

24 Productivity Commission. (2017). 5 Year Productivity Review, Supporting Paper No.12: An overview of innovation policy. www.pc.gov.au/inquiries/completed/productivity-review/report/productivity-review-supporting12.pdf

25 The Allen Consulting Group. (2012). The economic, social and environmental impacts of the Cooperative Research Centres Program, report to the Department of Industry, Innovation, Science, Research and Tertiary Education. www.acilallen.com.au/projects/public-policy/the-economic-social-and-environmental-impacts-of-the-cooperative-research-centres-program

The Commonwealth Government's investment in ISR has led to world-changing research and innovation. For example:

- CSIRO developed the first plastic bank notes with optically variable devices to secure currency against forgery. The agency also developed the first contact lenses that could be worn for a month at a time.²⁶
- Defence Science and Technology Group (DST Group) developed the world's first low-cost device to counter improvised explosive devices, with over 100,000 units manufactured, tested and delivered to the Afghan military.²⁷
- Engineers at the University of New South Wales made world-leading discoveries in quantum computing with the support of the Australian Research Council (ARC) by creating the first working quantum bit (qubit)²⁸ and developing the first two-qubit gate.²⁹
- The Department of Foreign Affairs and Trade developed a mobile diplomatic post that can be rapidly established during international natural disasters and conflicts.³⁰
- Australian-sourced low-emission hydrogen will be able to fuel vehicles globally in the future through CSIRO's technological innovations. These enable the storage of hydrogen as ammonia for safe shipping, and conversion back into hydrogen once overseas.³¹

Despite producing some high-impact outcomes, internationally comparable metrics suggest that Australia's ISR system as a whole has achieved mixed results. Based on a scorecard of the performance of Australia's ISR system (Appendix H), Australia has maintained its position in established areas of strength such as investment in educational institutions and the diffusion of cloud computing technology. However these investments have not been translated into improved outcomes in areas such as total innovation investment, investment in knowledge-based capital and business collaboration on innovation. Australia appears to be behind or trending against our global competitors in these key metrics. In addition, despite the increased revenue and jobs growth associated with non-R&D innovation,³² it has not been a focus of Government policy to date.

In February 2019, the Honourable Karen Andrews MP, Minister for Industry, Science and Technology, requested the Board deliver a report on the effectiveness of the Australian Government's investment in, and system performance of, ISR including a scorecard of the performance of Australia's ISR system.³³ Ensuring effective use of Government³⁴ investment in ISR is particularly important in times of increased fiscal pressure.³⁵ IISA has used both quantitative and qualitative analyses to assess the effectiveness of the Government's ISR investment. Based on the findings from these analyses, IISA has developed recommended actions to increase the effectiveness of this investment.³⁶

26 CSIRO. (2020). Our top 10 inventions. www.csiro.au/en/About/History-achievements/Top-10-inventions

27 Department of Defence, Science and Technology. (2016). Countering the threat of Improvised Explosive Devices. www.dst.defence.gov.au/podcast/countering-threat-improvised-explosive-devices

28 University of New South Wales (2012). Breakthrough in bid to create first quantum computer. <https://newsroom.unsw.edu.au/news/technology/breakthrough-bid-create-first-quantum-computer>

29 University of New South Wales. (2019). 200 times faster than ever before: the speediest quantum operation yet. <https://newsroom.unsw.edu.au/news/science-tech/200-times-faster-ever-speediest-quantum-operation-yet>

30 This 'Post in a Box' can fit into two carry-on suitcases; be deployed in under 24 hours; connect to any network, satellite, cable or wireless internet system; support up to 100 users; and be up and running in hours. It has been successfully used in Morocco, at the Pacific Islands Forum and in Tehran. Department of Industry, Science, Energy and Resources. (2020). Diplomacy in your carry-on. www.industry.gov.au/news-media/public-sector-innovation-network-news/diplomacy-in-your-carry-on; and Department of Foreign Affairs and Trade. (2019). Priority 7: Provide a secure and effective overseas presence. www.dfat.gov.au/about-us/publications/corporate/annual-reports/Pages/department-of-foreign-affairs-and-trade-annual-report-2018-19.aspx/annual-report-2018-19/home/section-2/provide-a-secure-and-effective-overseas-presence/index.html

31 CSIRO. (2018). CSIRO tech accelerates hydrogen vehicle future. <https://www.csiro.au/en/News/News-releases/2018/CSIRO-tech-accelerates-hydrogen-vehicle-future>

32 Non-R&D innovation includes investment in new or significantly improved product, process, marketing and organisational practices that are broader than R&D alone. More information about the economic benefits of non-R&D innovation can be found in Innovation and Science Australia. (2020). Stimulating business investment in innovation. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf

33 The Statement of Expectations, dated 19 February 2019, can be found at www.industry.gov.au/sites/default/files/2019-10/isa-statement-of-expectations-2019.pdf

34 For this report, Australian Government refers to the Australian Commonwealth Government. References to state and territory government investments are referenced separately throughout the report.

35 For this assessment, effectiveness is defined as the ability of public resources to achieve a given set of objectives, as defined in European Commission. (2009). An analysis of the efficiency of public spending and national policies in the area of R&D, Directorate-General for Economic and Financial Affairs. https://ec.europa.eu/economy_finance/publications/pages/publication15847_en.pdf

36 Australia's ISR system has been well studied, with over 20 reviews in the past 18 years. Recurring themes and findings across these reviews include the importance of the Government's role in supporting ISR and the widespread and important economic, social and environmental benefits generated; Australia's strengths in knowledge creation and the significant room for improvement in knowledge application, including collaboration with the private sector and commercialisation of Government-funded research; the need to optimise and reform measures to stimulate additional business R&D and innovation; the degree of fragmentation and lack of scale in the Australian Government's ISR investments including the absence of whole-of-government decision making frameworks and priorities directing the investment; and the lack of an overarching, whole-of-government approach to performance management and evaluation.

Why the Government invests in ISR

The Government invests in ISR for a variety of reasons, including to:

- Underpin the research base that creates intellectual capital.
- Support applied research and the translation or commercialisation of this research to strengthen the economy.
- Support R&D and non-R&D innovation in the business sector to build productivity, increase competitiveness, and generate jobs and growth.
- Ensure the Government's own needs are met, including the development of evidence for robust policymaking, and for defence and national security purposes.
- Ensure that Australia has the human capital and physical infrastructure required to deliver on the four objectives above.

Government's traditional ISR role of stepping in only to address market failures and asymmetries is being challenged internationally. In the United Kingdom (UK) and Europe in particular, there is increasing recognition of the key 'entrepreneurial' role government plays in ISR.³⁷ The Commonwealth Government could equally adopt a key entrepreneurial role to ensure Australia's long-term prosperity and resilience through its ISR investments.

Who invests in and performs ISR in Australia

The relative ISR investment contribution from government, business, higher education, publicly funded science and research agencies (PFRAs), and not-for-profits varies greatly between countries. This reflects differences in each country's national priorities and innovation systems. For example, the Canadian Government directs a high proportion of its funding to government research organisations and this balance is expected to become even more apparent as R&D spending in external sectors is decreased this year.³⁸ Conversely, the UK provides a high proportion of government investment to business. The balance of the UK's R&D investments is currently being reviewed, given its target of raising the total R&D investment to 2.4 per cent of gross domestic product (GDP) by 2027.³⁹ These different approaches to Government ISR investment reflect the social and economic drivers and priorities that are constantly shaping national innovation systems.

Like most countries around the world, the Commonwealth Government both funds and performs ISR; however data is most commonly available for the Government's R&D investments. The Commonwealth Government funds R&D performed by all of the major R&D performing sectors: business, higher education, PFRAs, states and territories, private non-profit and others. These Commonwealth investments are complemented by R&D funding from other government and non-government entities (Figure 1). The Commonwealth performed 7 per cent of Australia's total R&D by value, business performed 53 per cent and higher education performed 34 per cent.⁴⁰

Figure 1 shows that the Commonwealth was the primary funder of R&D performed by the Commonwealth sector (87 per cent) and was a substantial funder of private non-profit R&D (39 per cent). Figure 1 also shows that while 95 per cent of business performed R&D in 2016-17 was initially funded by business, 16 per cent of this funding was offset under the R&D Tax Incentive (R&DTI).⁴¹

37 United Kingdom Department for Business, Energy and Industrial Strategy. (13 September 2019). Policy paper: The Grand Challenge missions. <https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions>

38 Statistics Canada. (2019). Federal government spending on science and technology, by performing sector. Table 2. <https://www150.statcan.gc.ca/n1/daily-quotidien/190401/dq190401a-eng.htm>

39 The Royal Society. (2019). Investing in UK R&D. <https://royalsociety.org/-/media/policy/projects/investing-in-uk-r-and-d/2019/investing-in-UK-r-and-d-may-2019.pdf>

40 This analysis only includes investment in R&D as limited data is available on non-R&D innovation expenditure across all of the actors in the Australian system. Previous IISA analysis found that business investment in non-R&D innovation is at least as widespread as its investment in R&D. Data has been taken from ABS, 8104.0 – Research and Experimental Development, Businesses, Australia, 2017-18; 8109.0 – Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2016-17; 8111.0 – Research and Experimental Development, Higher Education Organisations, Australia, 2016. Note the ABS surveys those entities that perform R&D (businesses, institutes, universities, etc.) in order to identify the amount they spend on R&D activities that they perform in a given year. BERD data was estimated from an average of 2015-16 and 2017-18 BERD data.

41 This estimate is from ABS BERD data and only includes business R&D. It does not include business non-R&D innovation, which was estimated at \$15-19 billion in 2016-17. Innovation and Science Australia (2020). Stimulating business investment in innovation. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-innovation.pdf

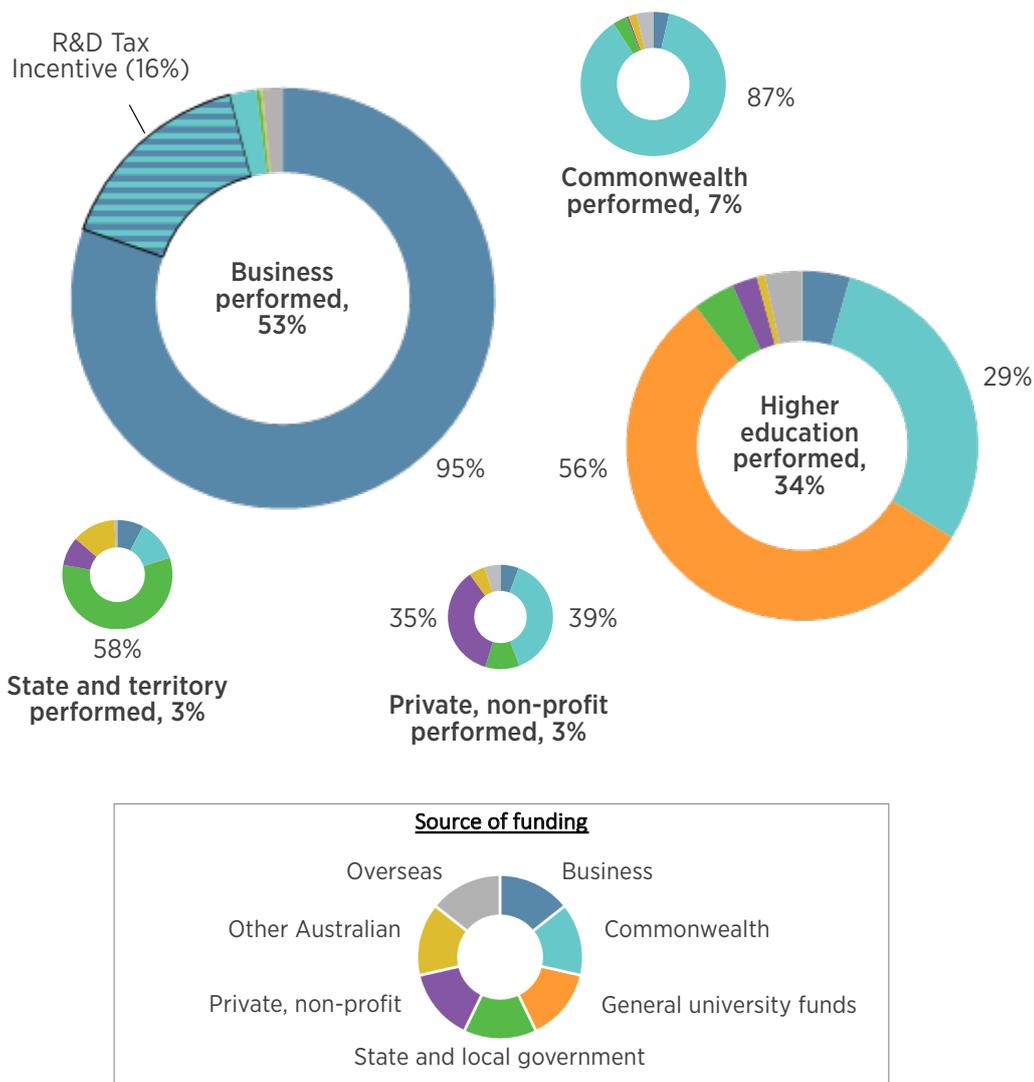


Figure 1 Source of funding for Australian performed R&D, 2016-17⁴²

As shown in Figure 1, General University Funds (GUF) accounted for 56 per cent of higher education R&D expenditure. GUF represents university funds used for R&D, a significant portion of which is from international student fees.⁴³ GUF includes both Commonwealth and non-Commonwealth sources of funding, which could not be separated due to limitations in data granularity.⁴⁴ It should also be noted that the total Commonwealth funding of higher education performed R&D in 2016 is likely to be greater than the 29 per cent represented in Figure 1, as a portion of Commonwealth funding is also included in GUF.

42 In this analysis 'Commonwealth' funding includes 'Commonwealth competitive funds' and 'Other Commonwealth Government' (defined as targeted research funding from Commonwealth agencies (e.g. CRC grants) and funding for the Research Training and Support Programs. 'General university funds' represents university funds that are used for R&D, sourced from both Commonwealth Government funding (other than competitive grants, targeted research funding, or funding identified as 'Other Commonwealth Government') and non-Commonwealth funding (such as fees and charges, income relating to Higher Education Contribution Scheme liabilities, income from non-research specific donations, bequests and foundations, investment income, reversions from provisions accounts, loans drawn down, income from the institutions commercial operations and from sale of products or assets). 'Other Australian' funding includes any Australian sources not captured by other descriptors as well as funds from joint business/government, donations and bequests. ABS, 8104.0 - Research and Experimental Development, Businesses, Australia, 2017-18; 8109.0 - Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2016-17; 8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2016. Note the ABS surveys those entities that perform R&D (businesses, institutes, universities, etc.) in order to identify the amount they spend on R&D activities that they perform in a given year. BERD data was estimated from an average of 2015-16 and 2017-18 BERD data.

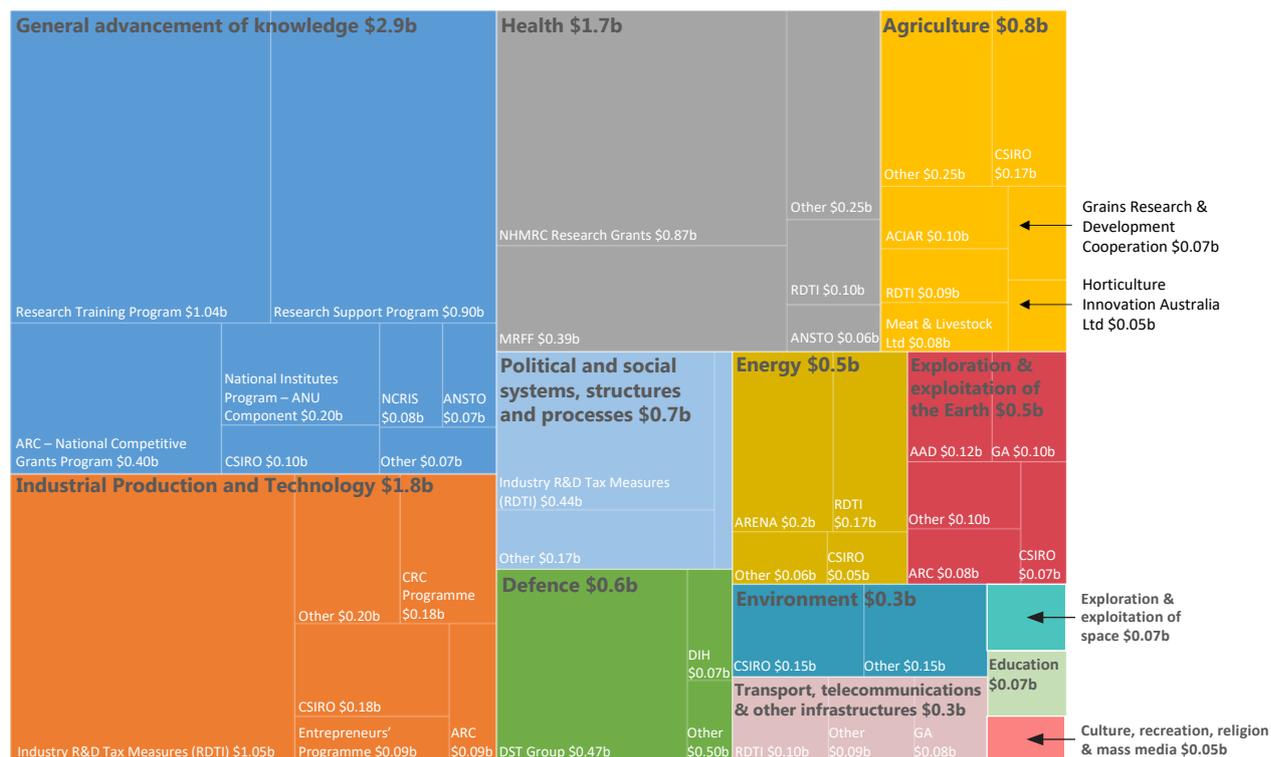
43 Based on expert advice.

44 'General university funds' represents university funds that are used for R&D, sourced from both Commonwealth Government funding (other than competitive grants, targeted research funding, or funding identified as 'Other Commonwealth Government') and non-Commonwealth funding (such as fees and charges, income relating to Higher Education Contribution Scheme liabilities, income from non-research specific donations, bequests and foundations, investment income, reversions from provisions accounts, loans drawn down, income from the institutions commercial operations and from sale of products or assets).

A snapshot of the Commonwealth Government investment in ISR

The Commonwealth Government's science, research and innovation (SRI) Budget Tables show that, at the time of writing, the Government's total ISR investment in 2019–20 was estimated to be \$10.1 billion,⁴⁵ or 0.51 per cent of GDP.

Figure 2 shows that, in 2019–20, just over a quarter (28 per cent) of the total Commonwealth Government ISR investment was dedicated to the socio-economic objective⁴⁶ of general advancement of knowledge. Most of this investment is in early stage basic research and related support programs which are difficult to assign to a specific outcome. The remainder of the Government's ISR investment, a little less than three quarters, is allocated to specific outcomes, with the highest proportion for industrial production and technology (18 per cent) and health (17 per cent).



⁴⁵ 'Other' groups any program of less than \$50 million in 2019–20 within each socio-economic objective.

⁴⁶ AAD, Australian Antarctic Division; ACIAR, Australian Centre for International Agricultural Research; ANSTO, Australian Nuclear Science and Technology Organisation; ANU, Australian National University; ARC, Australian Research Council; ARENA, Australian Renewable Energy Agency; CRC, Cooperative Research Centres; CSIRO, Commonwealth Scientific and Industrial Research Organisation; DIH, Defence Innovation Hub; DST, Defence, Science and Technology; GA, Geoscience Australia; MRFF, Medical Research Future Fund; NCRIS, National Collaborative Research Infrastructure Strategy; NHMRC, National Health and Medical Research Council; RDTI, Industry R&D Tax Measures (Refundable and Non-Refundable).

Figure 2 The Government's current \$10.1 billion ISR investment achieves a range of different socio-economic objectives, 2019–20⁴⁷

⁴⁵ Note: this figure is based on budget estimates only. Department of Industry, Science, Energy and Resources. (2019). Science, Research and Innovation Budget Tables. www.industry.gov.au/data-and-publications/science-research-and-innovation-sri-budget-tables

⁴⁶ Socioeconomic Objective (SEO) is a useful way of categorising R&D activity according to the intended purpose or outcome of the research, rather than the processes or techniques used in order to achieve this objective. These categories include processes, products, health, education and other social and environmental aspects that R&D activity aims to improve within Australia. However, SEO data is not currently available for the Government's investments in non-R&D innovation activities. It should be noted that some programs deliver against multiple socio-economic objectives while other programs deliver against just one.

⁴⁷ The 2019–20 SRI Budget Tables use the 14 socio-economic objectives described in: Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris. <https://doi.org/10.1787/9789264239012-en>. In our analysis we grouped the two General advancement of knowledge socio-economic objectives. 'Other' groups any program of less than \$50 million in 2019–20 within each socio-economic objective.

Scope and approach

In the Government's Statement of Expectations, Minister Andrews requested the Board "provide high level advice on the Government's overall mix of investments at a system level, to determine if there are duplications or gaps, and with a focus on assessing the degree of alignment of policies across the system and the effectiveness of the Government's spend."⁴⁸ IISA's scoping analysis of Australian and international ISR systems showed that evidence of unplanned duplications,⁴⁹ gaps or a lack of policy alignment across the system are symptoms, rather than the cause, of a system that could be more effective.

IISA also found that effective government investment in ISR is characterised by five best-practice principles (Table 2). IISA has used these principles to frame the analyses, findings and recommended actions contained herein to ensure the Government's ISR investment is future-fit, capable of reflecting changes in the broader environment and can deliver maximum benefit to our economy, particularly during times of economic uncertainty.

This report, and its appendices,⁵⁰ examines the effectiveness of the Commonwealth Government's investment in ISR, based on an evaluation of previous Australian and international literature, and quantitative analyses based on the available data. The quantitative analyses presented within this report, and the discussion that follows, are based on data available as at 30 June 2020. During the quantitative analysis, IISA found some existing datasets had significant limitations (see Appendix G).

IISA's analysis also considers overlaps of, and gaps in, the Government's ISR investment through the analysis of a sub-sector of the ISR system, to obtain insights representative of the broader system. The 'space' sector⁵¹ was selected as an exemplar of an emerging government priority with significant potential to deliver economy-wide spill-overs (see Box 1).

The following chapters outline three recommended actions and an overview of the evidence base for these actions. Additional analyses and evidence are provided in the appendices. An ISR system performance scorecard is provided in Appendix H.

48 The Statement of Expectations, dated 19 February 2019, can be found at www.industry.gov.au/sites/default/files/2019-10/isa-statement-of-expectations-2019.pdf

49 It should be noted that duplication, in and of itself, is not a sign of an ineffective ISR system. Duplication of ISR investment may be intentional by design. For example, multiple teams have been funded to develop a COVID-19 vaccine to ensure an effective outcome for a time critical problem. However, unplanned duplication may indicate that the Government's ISR investment is not as effective as it could be.

50 Innovation and Science Australia. (2020). Driving effective Government investment in innovation, science and research—Appendices.

51 For this analysis we have defined 'space' as including earth observation, precision navigation and timing, satellite communications, space situational awareness and debris monitoring, access to space, robotics and automation, leapfrog R&D, and relevant fundamental research.

Table 2 Best-practice ISR investment principles

Aligned to priorities

ISR investments at the system level should be closely aligned to regularly updated government priorities, which are flexible enough to support innovative research pathways but stable enough to foster long-term planning.

Delivers impact

Effective ISR investments demonstrably achieve their intended outcomes. ISR investments should be transparently designed with clarity about their purpose, expected outcome, key performance indicators, evaluation processes, return on investment (financial, economic or social), and user/target. They should also be subject to regular and rigorous monitoring and evaluation at all levels of the system by an independent evaluator.

Sustainable

ISR investments should be ongoing and predictable, unless rigorous evaluation proves they are not effective, or when short-term programs are demonstrably required (e.g. pilot programs). The system should be funded and stable enough to develop long-term ISR strengths and outcomes.

Coordinated

ISR investments and policies, as well as the ISR itself, should be well coordinated across government.

Strategically balanced

ISR investments should be strategically balanced across several factors. Specifically:

- **Phases and pipeline**—where investments are balanced between basic, applied and translational ISR and where ISR can move seamlessly along the innovation pipeline.
- **Scale**—where ISR investments are appropriately scaled and funded to achieve meaningful impact.
- **Risk**—where the risks of ISR investments are assessed, accepted and incorporated into the initial design and balanced across the investment portfolio.
- **Investment mechanisms**—where investments are balanced between targeted and broad-based funding mechanisms.
- **Resourcing**—where ISR investments are balanced between the costs of research, researchers, administration, infrastructure and operating costs.

Box 1: Spotlight on space

Australia's investment in space ISR is projected to create substantial benefits for Australia, with Australia's earth observation capabilities valued at US\$20.2 billion in 2019.⁵² The Australian satellite communications and astronautics sector is expected to grow at 7.4 per cent from 2020–2025 to reach \$8 billion by 2025.⁵³ The application of knowledge gained in the space domain is already benefiting many sectors ranging from healthcare through to financial services.^{54,55,56,57}

The Government's space ISR investments currently include major projects through the Department of Defence, CSIRO and Geoscience Australia. These are complemented by smaller, targeted investments in businesses and business-to-research collaboration, for example through the SmartSat CRC. Australia is also a key partner in international space activities as hosts of the National Aeronautics and Space Administration (NASA) and European Space Agency deep space communications earth stations, and with a role in the USA's Moon to Mars exploration approach, including NASA's Artemis lunar program.

The creation of the Australian Space Agency (ASA) to deliver a “globally responsible and respected space sector that lifts the broader economy, and inspires and improves the lives of Australians”⁵⁸ attests to the Government's commitment to grow this emerging sector to protect and advance national interests. The establishment of the ASA and the development of the Australian Civil Space Strategy have provided an enduring focus of investment and activity for the Government's investment in space. Australia now has an opportunity to capitalise on this renewed focus in the civil space sector, as well as growing the defence space sector, to ensure its ISR investments are effective.

The space sector was chosen as an exemplar of an emergent Government priority. The compilation of Government space ISR investment data by IISA has informed qualitative and quantitative analyses of the scale, distribution and nature of the government's space investments. Consultations with Government funders and performers in the space sector provided further input to the qualitative analysis.

52 Also includes value of marine observations. Australian Government and APEC. (2019). Current and Future Value of Earth and Marine Observing in the Asia-Pacific Region. www.industry.gov.au/data-and-publications/current-and-future-value-of-earth-and-marine-observing-to-the-asia-pacific-region

53 IBISWorld. (2020). Satellite Communications and Astronautics in Australia. <https://my.ibisworld.com/au/en/industry-specialized/od5545/about>

54 Australian Space Agency. (2019). Advancing Space: Australian Civil Space Strategy 2019–2028. <https://publications.industry.gov.au/publications/advancing-space-australian-civil-space-strategy-2019-2028.pdf>

55 Australian Government and APEC. (2019). Current and Future Value of Earth and Marine Observing in the Asia-Pacific Region. www.industry.gov.au/data-and-publications/current-and-future-value-of-earth-and-marine-observing-to-the-asia-pacific-region

56 OECD. (2019). The Space Economy in Figures: How Space Contributes to the Global Economy. www.oecd-ilibrary.org/science-and-technology/the-space-economy-in-figures_c5996201-en

57 Australian Space Agency. (2019). Advancing Space: Australian Civil Space Strategy 2019–2028. <https://publications.industry.gov.au/publications/advancing-space-australian-civil-space-strategy-2019-2028.pdf>

58 Australian Space Agency. (2019). Advancing Space: Australian Civil Space Strategy 2019–2028. <https://publications.industry.gov.au/publications/advancing-space-australian-civil-space-strategy-2019-2028.pdf>

Recommended Action 1:

Whole-of-government ISR priorities that drive investment decisions

Government investment in ISR is effective when it achieves its intended outcomes.⁵⁹ Effective ISR investment creates impact through its ability to respond to Government priorities.

Recommended Action 1

The development of whole-of-government ISR priorities could be used to drive investment decisions by ensuring:

1. All new ISR investments, and planned reviews of existing investments, are tied to whole-of-government priorities.
2. Such ISR priorities should:
 - a) Provide system-level stability; be reviewed every 10 years, or when significant changes occur; and be responsive to societal, economic, and environmental challenges.
 - b) Be aligned with other Commonwealth Government priorities (such as short-term stimulus and long-term economic growth priorities).
 - c) Support both R&D and non-R&D innovation.
 - d) Support ISR excellence.

Government ISR priorities that drive investment

Identifying the ultimate goals of national research policy is important, because without any consensus about what they should be, it becomes impossible to answer a key question: how much ISR should we currently do as a nation, and how much do we need to do?⁶⁰ Whole-of-government ISR priorities are important mechanisms for signalling how Government ISR investment supports the Government's national priorities, which in turn, can influence actors across the system. For example, ISR priorities can inform and shape policy activity across government to drive effective ISR outcomes, focusing efforts in areas such as skills and capability development, policy settings, regulatory settings and investment attraction.

Currently, a number of different Commonwealth Government prioritisation policy instruments exist. These could be reviewed, updated and coordinated as they do not presently drive Government ISR investment at a system level. Government ISR prioritisation instruments at the system level currently include the 2015 National Science and Research Priorities (NSRPs)⁶¹ and the 2017 National Science Statement.⁶²

The NSRPs (Table 3), and corresponding Practical Research Challenges, are designed to identify areas of immediate and critical importance to the nation, and Australia's place in the world, by focusing Government investment for science and research on the most important challenges. The NSRPs also help science and research efforts reflect the needs of industry, the economy and the community.⁶³ The National Science Statement is designed to articulate a long-term approach to achieving a strong science system and provides guidance for government investment and decision making.⁶⁴

59 European Commission. (2009). An analysis of the efficiency of public spending and national policies in the area of R&D, Directorate-General for Economic and Financial Affairs. https://ec.europa.eu/economy_finance/publications/pages/publication15847_en.pdf

60 The British Academy. (2019). Lessons from the History of UK Science Policy. www.thebritishacademy.ac.uk/sites/default/files/Lessons-History-UK-science-policy.pdf

61 The NSRPs and associated practical challenges can be found at Department of Industry, Science, Energy and Resources. (2015). Science and Research Priorities. www.industry.gov.au/data-and-publications/science-and-research-priorities

62 Australian Government. (2017). Australia's National Science Statement. <https://publications.industry.gov.au/publications/nationalsciencstatement/index.html>

63 As stated in Department of Industry, Science, Energy and Resources. (2015). Science and Research Priorities. www.industry.gov.au/data-and-publications/science-and-research-priorities

64 As stated in Australian Government. (2017). Australia's National Science Statement. <https://publications.industry.gov.au/publications/nationalsciencstatement/index.html>

Table 3 Commonwealth Government's National Science and Research priorities

Priority	Priority description
Food	Research will aim to optimise food and fibre production and processing, enhance food safety and minimise waste. Research will also be critical to preserve our hard won reputation for clean, safe and sustainable production.
Soil and water	Research should focus on critical assets such as the Great Barrier Reef, Northern Australia, key agricultural regions, aquifers and urban catchments, and build capacity for improved accuracy and precision in predicting change. Research will lead to better decision-making strategies in the context of potentially conflicting demands between development, the environment and landscape management.
Transport	Research will be critical to developing low cost, reliable, resilient and efficient transport systems that meet the needs of businesses and enable sustainable mobility, while lowering carbon emissions and other pollution.
Cybersecurity	Research in cybersecurity including quantum technologies will position Australia as a leader in fast moving and emerging areas such as distributed network management, machine learning, and intelligent and secure data management and retention.
Energy	Research will lead to the development of reliable, low-cost, sustainable energy supplies that are resilient to sudden shocks, as well as decadal trends in demand and climate, and to technologies that use energy more efficiently.
Resources	Research will lead to a fundamental understanding of the structure, composition, and processes governing the formation and distribution of resources in Australia. This knowledge will support the exploration, the potential discovery of major new sources, production, distribution of the traditional resources such as strategic metals and minerals, coal and gas and those in increasing demand such as rare earth elements and groundwater.
Advanced manufacturing	Research will be critical in developing and supporting existing industries while enabling the development of a new and advanced manufacturing sector.
Environmental change	Research will build Australia's capacity to respond to environmental change. It will require the integration of research outcomes from biological, physical, social and economic systems.
Health	Research will be essential to building healthy and resilient communities throughout Australia. It will capitalise on Australia's strengths in science and technology to generate wider economic benefits through improved knowledge translation and commercialisation, and partnerships with industry.

The NSRPs and National Science Statement are supplemented by other Government priorities, such as priority industry growth sectors.⁶⁵ Priority growth sectors include: advanced manufacturing, food and agribusiness, medical technologies and pharmaceuticals, mining equipment technology and services and oil, gas and energy resources, and cybersecurity.⁶⁶ While priority growth sectors influence investment decisions beyond ISR investments, they also influence some Government ISR investments through programs such as the Entrepreneurs' Programme (EP) and the CRC Program.^{67,68} In contrast, investments made through the R&DTI are agnostic to the priority growth sectors due to the indirect design of the initiative.

65 As identified through the Industry Growth Centres, see www.industry.gov.au/strategies-for-the-future/industry-growth-centres

66 AustCyber, About us. www.austcyber.com

67 Australian Government. (2016). Entrepreneurs' Programme, Accelerating Commercialisation, Customer Information Guide.

68 Australian Government. (2020). Cooperative Research Centres Grants, CRC Program Fact Sheet. www.business.gov.au/Grants-and-Programs/Cooperative-Research-Centres-CRC-Grants#program-documents

Despite the existence of these whole-of-government ISR prioritisation policy instruments, the incentives to align ISR activities to government priorities are limited, and the process of alignment is complex. A recent ARC review found that there are multiple processes in place to prioritise research funding across the system, ranging from science and research agency-level priorities through to NSRPs.⁶⁹ The Government's ISR investments are largely driven by agency, institution or research community priorities, based on the priorities and mandates of the organisation, their level of independence and in accordance with their existing funding arrangements. This means that investment decisions are made in silos, where similar objectives between organisations are seldom capitalised on. For example, the Australian Public Service (APS) Review found over 170 purpose statements that reinforce agency priorities, rather than whole-of-government priorities.⁷⁰ IISA's analysis of key documents⁷¹ across Government departments also found inconsistent approaches to reporting ISR policies, priorities and investments with regards to the level and type of information reported.

While the NSRPs may guide some funding decisions,⁷² they are not explicitly designed to direct ISR investment. Rather, the NSRPs are designed to highlight opportunities and challenges facing Australia.⁷³ Given the Government's recent focus on building Australia's space sector (Box 2), and that defence⁷⁴ and political and social systems, structures and processes⁷⁵ currently account for 5.3 per cent and 6.5 per cent of Government's overall ISR investment, respectively,⁷⁶ the NSRPs may no longer fully capture Australia's ISR investment priorities.

ISR priorities could provide system-level stability while remaining responsive to a changing landscape through the use of periodic reviews

Whole-of-government ISR priorities that set the agenda for the short, medium and long-term ensure system-level stability. ISR priorities also need to remain relevant in fast-changing environments. Designing a suite of enduring and flexible ISR priorities, with appropriate review mechanisms for each, is important.

The APS Review underlined the need to consider and prioritise investments at a whole-of-government level that considers both short and long-term investments. The Review highlighted that the customary four-year investment period, coupled with the budget offset rule, leads to a number of long-term unintended consequences.⁷⁷ These include a stifling of new ideas and transformational investment for innovation—an area where a focus on short-term solutions and outcomes are ultimately less cost efficient. This can result in missed opportunities for Government to consider ambitious investments to deliver on its priorities. The four-year horizon also encourages more small-scale projects that fall within specific portfolios, rather than adopting a cross-government approach with broader and larger benefits. Collectively, these findings suggest that the inclusion of longer-term ISR investment strategies would be beneficial.

69 Australian Research Council (2018). Snapshot: Research Priorities in Australia. www.arc.gov.au/about-arc/consultations/national-science-and-research-priorities-review

70 Department of the Prime Minister and Cabinet. (2019). Our Public Service, Our Future. Independent Review of the Australian Public Service. <https://pmc.gov.au/sites/default/files/publications/independent-review-aps.pdf>

71 Such as Corporate Plans and Portfolio Budget Statements.

72 For example, the NSRPs are used to assess CRC applications for rounds that are not targeted to address a specific problem, Australian Government. (2020). Cooperative Research Centres Grants, CRC Program Fact Sheet. www.business.gov.au/Grants-and-Programs/Cooperative-Research-Centres-CRC-Grants#program-documents

73 Australian Government. Science and Research Priorities. (2015). www.industry.gov.au/sites/default/files/2018-10/science_and_research_priorities_2015.pdf?acsf_files_redirect

74 Given the increasing importance of collaborations between Higher Education and defence to meet the ISR needs of defence and national security, there will be spill-overs of this research for civil applications, such as quantum computing and space. More detail about this engagement can be found at Department of Defence, Science and Technology. (2020). Partner with us: University. www.dst.defence.gov.au/partner-with-us/university

75 This investment is aimed at improving the understanding of and supporting the political structure of society; public administration issues and economic policy; regional studies and multi-level governance; social change, social processes and social conflicts; the development of social security and social assistance systems; and social aspects of the organisation of work.

76 These figures have been taken from the 2019–20 Science, Research and Innovation budget tables at www.industry.gov.au/data-and-publications/science-research-and-innovation-sri-budget-tables

77 Australian Government. (2019). Our public service, our future. Independent review of the Australian public service. <https://pmc.gov.au/sites/default/files/publications/independent-review-aps.pdf>

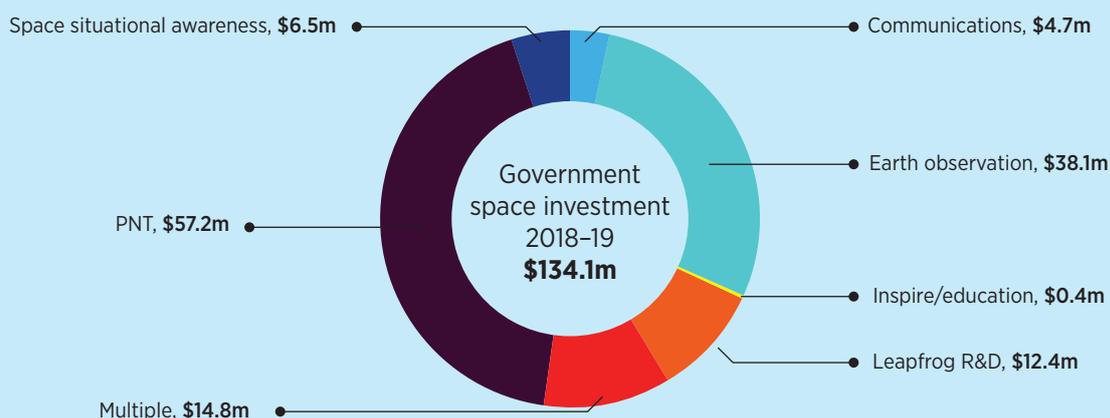
Box 2: Investment prioritisation case study: the space sector

The Government's commitment to transform and grow a globally respected Australian space industry that lifts the broader economy has resulted in the creation of the Australian Space Agency, the Civil Space Strategy and an estimated \$134.1 million investment in 2018-19.⁷⁸ This investment was distributed across many of the Agency's civil space priority areas⁷⁹ (below), but is concentrated in positioning navigation and timing (PNT) and earth observation. Early indications from 2019-20 data suggest that the total Government ISR investment in space will be increased, with a shift toward multisector investments.

'Space' has not been explicitly identified as a whole-of-government ISR priority through either the NSRPs or the Industry Growth Centres. Priority Industry Growth Centre sectors influence investment decisions in other initiatives, such as EP⁸⁰ and the CRC Program.⁸¹ This approach has had mixed impact on the space sector as not all ISR investment programs have been flexible enough to prioritise investment in the sector to date. Historically, the CRC has supported space-related investments and continues to do so including through the SmartSat CRC and related CRC Projects with the Australian Space Agency now providing advice to the CRC review process.

It is unclear how the relative priority of space ISR investments are determined across government, and at the project level. Historically, it has been driven by bottom-up investment resulting from a range of representative groups communicating with 'one voice' to government. Greater clarification about the Government's investment prioritisation would benefit the whole of Australia's space scientific and research community.

The current space investment landscape creates an opportunity for Government to consider how its space sector investment focus is reflected in broader ISR priorities. The Australian Space Agency and the Civil Space Strategy are providing greater certainty for the sector by attracting international partners and investors, driving increased investment by states and territories and opening doors internationally for industrial development purposes, greater alignment and coordination. Further building on this momentum and bringing together civil, defence, industry and research ISR stakeholders to co-design ongoing government space ISR investment strategies and policies could promote investment at scale, reduce duplication and clearly identify priority strategic gaps for future investment.



78 Estimates exclude Defence (KPMG January 2020 estimated \$11.75b over 20 years or approximately \$400-575m annually); Investment in the Australian Space Sector), and smaller investments including those at AIMS, BoM, ANSTO and AAD. Research and Development Tax Incentive (R&DTI) estimates include registrations for the 2018-19 income year lodged to 21 May 2020; submissions close 30 September 2020. Note, ARC grant values per financial year are estimates only, due to variable grant start and end dates.

79 Australian Space Agency (2019). Advancing Space: Australian Civil Space Strategy 2019-2028, Canberra: Commonwealth of Australia, April; available at: www.space.gov.au

80 Australian Government. (2016). Entrepreneurs' Programme, Accelerating Commercialisation, Customer Information Guide.

81 Australian Government. (2020). Cooperative Research Centres Grants, CRC Program Fact Sheet. www.business.gov.au/Grants-and-Programs/Cooperative-Research-Centres-CRC-Grants#program-documents

IISA has found that the Government does not have an effective regular mechanism to update existing ISR priorities to ensure they align with new national objectives. A recent Organisation for Economic Co-operation and Development (OECD) review of science and technology policies examined the ISR initiatives of 12 countries.⁸² Over half of these countries have successful long-term or enduring ISR strategies (including funding commitments), ranging in duration of up to almost 20 years, organised under overarching priorities, pillars or goals that are regularly reviewed.⁸³

These strategies often combine more traditional national ISR approaches, such as sectoral, technology, or national competitiveness-based priorities, with cross-cutting ‘challenge-based’ approaches aimed at resolving longer-term societal challenges with an associated outcome or target.⁸⁴ Specifically, 94 per cent of OECD countries highlight the importance of specific scientific research, technologies or economic fields in their priority mix, and 91 per cent have strategies to address specific societal challenges.⁸⁵ Canada’s approach, for example, is based on a long tradition of ISR policy settings that develop practical applications which build on the nation’s natural, financial, scientific and human resource advantages to address national challenges.⁸⁶

Ireland’s 2012 Research Prioritisation process aligned the majority of competitively awarded public research investment with 14 priority areas under six broad themes (see Table 4).⁸⁷ A scheduled 2018 review process amended the priorities, while the broad themes remained in place. These amendments enabled the Irish Government to pivot their investment strategy and adapt to significant developments such as Brexit and the introduction of disruptive technologies. Ireland’s prioritisation approach deliberately excluded categories of expenditure including higher education ‘block grants’, which support broader research costs, funding for in-company performed ISR and broader policy and knowledge research.

82 Paic, A. and C. Viros (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://doi.org/10.1787/2b3bc558-en>

83 OECD. (2019). Governance of Science and Technology Policies—Case Studies. OECD Science, Technology and Industry Policy Papers. <https://community.oecd.org/docs/DOC-161275>

84 Paic, A. and C. Viros (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://doi.org/10.1787/2b3bc558-en>

85 Paic, A. and C. Viros (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://doi.org/10.1787/2b3bc558-en>

86 Government of Canada. (2017). Investing in Canada’s Future, strengthening the foundations of Canadian Research http://cins.ca/docs/ScienceReview_April2017.pdf and Canadian Government. (2014). Seizing Canada’s Moment: Moving Forward in Science, Technology and Innovation 2014. [www.ic.gc.ca/eic/site/113.nsf/vwapj/seizing_moment_ST-I_summary-eng.pdf/\\$file/seizing_moment_ST-I_summary-eng.pdf](http://www.ic.gc.ca/eic/site/113.nsf/vwapj/seizing_moment_ST-I_summary-eng.pdf/$file/seizing_moment_ST-I_summary-eng.pdf); and Government of Canada. (2007). Mobilising Science and Technology to Canada’s Advantage. [www.ic.gc.ca/eic/site/113.nsf/vwapj/STsummary.pdf/\\$file/STsummary.pdf](http://www.ic.gc.ca/eic/site/113.nsf/vwapj/STsummary.pdf/$file/STsummary.pdf)

87 Government of Ireland. (2018). Research Priority Areas, 2018–2023. <https://dbei.gov.ie/en/Publications/Research-Priority-Areas-2018-to-2023.html>

Table 4 Ireland's research themes and priority areas: 2018–2023

Theme 1: ICT

- Future Networks, Communications and Internet of Things
- Data Analytics, Management, Security, Privacy, Robotics and Artificial Intelligence (including Machine Learning)
- Digital Platforms, Content and Applications, and Augmented Reality and Virtual Reality

Theme 2: Health and well-being

- Connected Health and Independent Living
- Medical Devices
- Diagnostics
- Therapeutics

Theme 3: Food

- Food for Health
- Smart and Sustainable Food Production and Processing

Theme 4: Energy, climate action and sustainability

- Decarbonising the Energy System
- Sustainable Living

Theme 5: Manufacturing and materials

- Advanced and Smart Manufacturing
- Manufacturing and Novel Materials

Theme 6: Services and business processes

- Innovation in Services and Business Processes
-

ISR priorities should not be developed in a vacuum

ISR priorities should be designed to align with broader government economic, environmental and social objectives, maintain Australia's competitive and comparative advantages, and ensure the Government's own national and sovereign needs are met. ISR investments are more likely to effectively address large-scale issues, such as economic growth or good health and well-being, if they are vertically aligned with national, as well as state and territory, priorities early in the design process.^{88,89} One of the key findings from the UK is that science policy does not operate in a vacuum, but is related to other realms of public policy.⁹⁰

IISA's analyses of socio-economic objectives (SEOs) data identifies both overlaps and differences between the intended ISR investment outcomes by both the Commonwealth and states and territories.⁹¹ For example, health was the top SEO objective for both the Commonwealth and state and territory governments in 2016–17, comprising \$3,837 million and \$461 million of R&D expenditure, respectively.⁹² Environment was another highly ranked SEO objective for both levels of government. SEOs that align with national objectives, or in areas where businesses are unlikely to invest, were ranked higher in terms of R&D expenditure by the Commonwealth Government as compared to state and territory governments. These included SEOs such as the general advancement of knowledge, defence and agriculture.

Historically, there has been limited coordination of ISR investments between the different levels of government. More recently, greater coordination is being addressed in response to the COVID-19 crisis, with the establishment of the National Cabinet, and through initiatives such as the inaugural Digital Economy and Technology Ministers' Roundtable, held in May 2020.⁹³ Enduring implementation of initiatives such as these should be considered across the ISR system to ensure that Commonwealth and state and territory level priorities and ISR investments are complementary to increase their effectiveness at all levels of government.

Internationally, challenge-based approaches are being used to ensure alignment with national social, economic and environmental objectives, and foster collaboration between a broad range of stakeholders, including the public. Challenge-based approaches also accelerate innovation as they seek to solve big problems, and generate national passion and pride in innovation and science achievements. Challenges could be used as a mechanism for the Commonwealth Government to promote whole-of-government ISR priorities.⁹⁴

Internationally, ISR priorities are generally expressed as themes, goal-oriented objectives or cross-cutting challenges spanning several themes. Framing a priority as a challenge, or an aspirational goal, can simplify the monitoring and evaluation process by providing a pathway to a clear end point. Some examples of approaches to ISR prioritisation are provided in the Implementation strategies section.

IISA's proposed ISR prioritisation alignment model (Figure 3) suggests ISR priorities should include a combination of enduring, broadly focussed whole-of-government ISR priorities and shorter-term, and often more specific, subsidiary priorities. Both of these sets of priorities should interact with, and be responsive to, Government's national priorities. If implemented well, these priorities should be regularly reviewed, in consultation with ISR-system stakeholders.

88 OECD. (2011). Opportunities, Challenges and Good Practices in International Research Cooperation between Developed and Developing Countries. OECD Global Science Forum. www.oecd.org/sti/inno/47737209.pdf

89 United Nations. Harnessing Science, Technology and Innovation to achieve the Sustainable Development Goals. <https://sustainabledevelopment.un.org/tfm>

90 The British Academy. (2019). Lessons from the History of UK Science Policy. www.thebritishacademy.ac.uk/sites/default/files/Lessons-History-UK-science-policy.pdf

91 The SRI Budget Tables and ABS use different definitions of socio-economic objectives. The 2019–20 SRI Budget Tables use the 14 socio-economic objectives described in the OECD's Frascati Manual 2015 (OECD, (2015). Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities. OECD Publishing, Paris. <https://doi.org/10.1787/9789264239012-en>) while the ABS uses the 17 divisions of socio-economic objectives described by the Australian and New Zealand Standard Research Classification (ANZSRC) (1297.0 - Australian and New Zealand Standard Research Classification (ANZSRC), 2008, (cat. no.1297.0).

92 For this analysis, Commonwealth R&D expenditure towards SEOs included both Commonwealth and higher education R&D expenditure given the Commonwealth funds 85 per cent of higher education R&D expenditure. ABS Source: 8109.0 - Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2016–17; ABS 8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2016.

93 Innovation Australia. (18 May 2020). Andrews drives new ministerial tech council. http://www.innovationaus.com/andrews-drives-new-ministerial-tech-council/?utm_medium=email&utm_campaign=Newsletter%20389%20-%2019%20May%202020&utm_content=Newsletter%20389%20-%2019%20May%202020+CID_da757c26fa25a8ba3ed99060363f928f&utm_source=Email%20marketing%20software&utm_term=Andrews%20drives%20new%20ministerial%20tech%20council

94 Innovation and Science Australia. (2017). Australia 2030: Prosperity through Innovation. www.industry.gov.au/sites/g/files/net3906/f/May%202018/document/pdf/australia-2030-prosperity-through-innovation-full-report.pdf

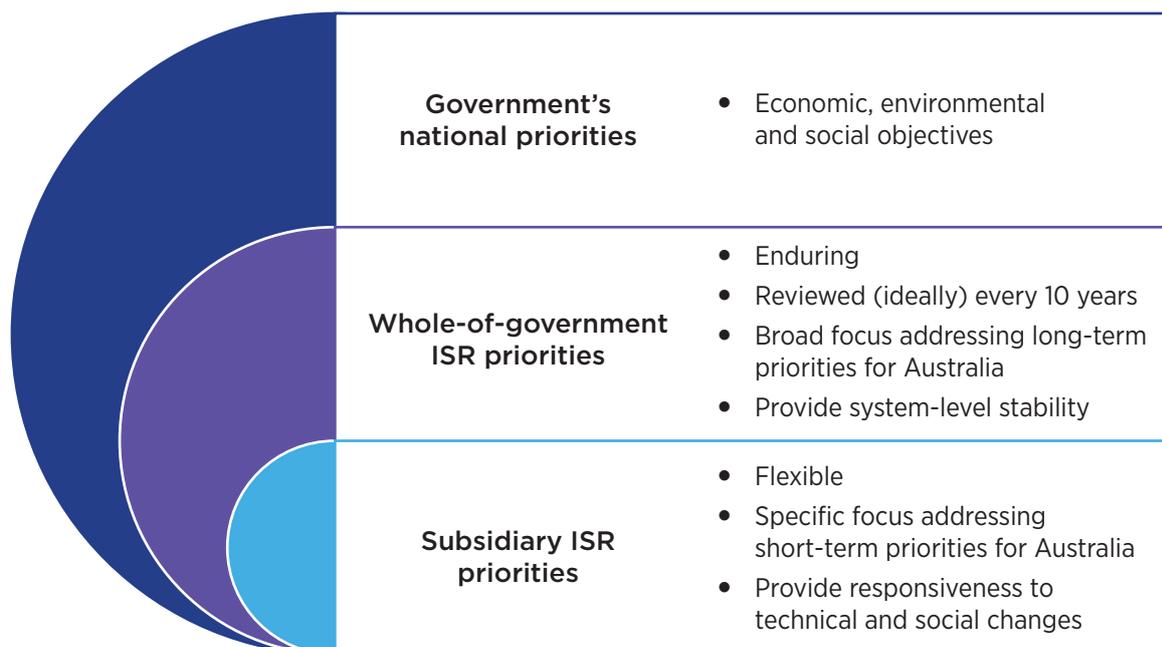


Figure 3 Schematic of IISA's proposed model to align ISR priorities with national priorities

ISR priorities should support both R&D and non-R&D innovation

To ensure best-practice approaches are implemented, Government should invest in both R&D and non-R&D innovation to deliver innovative solutions which address multi-dimensional issues and problems.⁹⁵ While non-R&D innovation has always been a part of Government-funded research, it has not received the same attention and funding as Government-funded R&D. While the spill-over benefits of R&D innovation are historically well documented, new research shows that non-R&D innovation can also spur economic growth.⁹⁶ Although Government-funded R&D has been recorded since 1979–80, Government-funded non-R&D innovation investment has only been captured in the SRI budget tables since 2018–19.⁹⁷ To ensure non-R&D innovation expenditure data reflects the true level of Government non-R&D investment, it should be captured and analysed in a more systematic way. This improved data could then be used to guide an appropriate balance of Government investment in ISR.⁹⁸

The focus of Government investment in R&D is also reflected in the development of Government policies, with many focussed on R&D investment, but few that explicitly focus on non-R&D innovation. For example, the NSRPs, National Science Statement and R&DTI focus on the role of science, research, and development, rather than broader forms of innovation. Given the economic benefits of non-R&D innovation,⁹⁹ ISR priorities should support both R&D and non-R&D innovation.

95 That is investment in new or significantly improved product, process, marketing and organisational practices that are broader than R&D alone.

96 Innovation and Science Australia. (2020). Stimulating business investment in innovation. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf

97 As described in the 2019–20 SRI budget tables, www.industry.gov.au/data-and-publications/science-research-and-innovation-sri-budget-tables

98 IISA found that a number of non-R&D innovation investments have not been captured in the SRI Budget tables. For example, many of the investments reflect in the Public Sector Innovation Awards are not currently captured in these tables.

99 As detailed in Innovation and Science Australia. (2020). Stimulating business investment in innovation. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf

ISR priorities should also support ISR excellence

Research excellence is often an integral component of ensuring world-leading research. While there is no equivalent approach to incentivising ISR excellence at a system level, for example between science and research agencies, there is an opportunity to learn from approaches used to achieve research excellence.¹⁰⁰

The OECD found that over two-thirds of OECD countries have research excellence schemes, with most established since 2004.¹⁰¹ More recently, research excellence policies involve large-scale and long-term competitive funding to build research capacity, develop critical mass in specific areas, and generate a strong research base, particularly by training young researchers, to ensure international competitiveness.¹⁰² Research excellence policies often combine goals of scientific excellence, the development of key technologies to support competitiveness, and resolving societal challenges.¹⁰³

In Australia, the Government's Excellence in Research for Australia framework identifies and promotes excellence across the spectrum of research activity in Australia's higher education institutions.¹⁰⁴ It measures excellence using international benchmarks and identifies emerging research areas and opportunities for development. More recently, an Engagement and Impact Assessment process has been implemented as a companion to the Excellence in Research for Australia framework. In 2018, the inaugural assessment found that Australian university research produced a broad range of tangible benefits beyond academia.¹⁰⁵ In the Excellence in Research for Australia research quality evaluation, 24 per cent of Australian university submissions at the broad discipline level, and 40 per cent at the sub-discipline level, performed well above world standard.¹⁰⁶

Additional analysis relating to Recommended Action 1 is provided in Appendix B.

100 Watt. (2015). Review of research policy and funding arrangements - report. <https://docs.education.gov.au/node/38976>

101 OECD. (2014). Promoting Research Excellence: New Approaches to Funding, OECD Publishing. <https://doi.org/10.1787/9789264207462-en>

102 Guimón, J. (2019). Policy initiatives to enhance the impact of public research: Promoting excellence, transfer and co-creation, OECD Science, Technology and Industry Policy Papers, No. 81, OECD Publishing. <https://doi.org/10.1787/a4c9197a-en>

103 Paic, A. and C. Viros (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://doi.org/10.1787/2b3bc558-en>

104 Australian Research Council. (2020). Excellence in Research for Australia. www.arc.gov.au/excellence-research-australia

105 Australian Research Council. (2020). Engagement and Impact Assessment. www.arc.gov.au/engagement-and-impact-assessment

106 Australian Research Council. (2019). State of Australian University Research 2018-19, ERA National Report. <https://dataportal.arc.gov.au/ERA/NationalReport/2018/>

Recommended Action 2:

A 10-year investment plan, that is aligned with ISR priorities, coordinated at the whole-of-government level, and has effective evaluation processes

Government investment in ISR is effective when it is stable enough to develop long-term ISR strengths and outcomes. Effectiveness is further enhanced when ISR investments are coordinated at the whole-of-government level thus ensuring the alignment of system priorities with investments made within agencies, institutions and the research community. The application of system-wide evaluation processes which include consistent and transparent performance measures, objectives and outcomes across all ISR investments are integral to ensuring ISR investments demonstrably achieve their intended outcomes.

Both the Australian and international literature have observed enduring challenges with the sustainability of Australia's ISR investments, coordination of these investments at a whole-of-government level, and the demonstrated impact of these investments.^{107,108,109,110}

Recommended Action 2

A 10-year ISR investment plan, that is aligned with the Government's ISR priorities, coordinated at the whole-of-government level, and has effective evaluation processes could increase investment effectiveness by ensuring investments are:

1. Coordinated through centrally-facilitated engagement between Commonwealth Government funders and performers.
2. Designed with clarity of purpose and well-defined milestones, expected outcomes, key performance indicators, return on investments (societal, economic or environmental) and user/targets. This information should be used to underpin evaluations which assess investment effectiveness at a whole-of-government level, through a coordinated evaluation process. Evaluation outcomes should be used to enhance investment effectiveness and inform investment plan updates.
3. Reviewed on a rolling three-yearly basis to provide investment certainty, unless rigorous evaluation proves they are ineffective, or they are pilot investments.

The importance of a 10-year investment plan

Long-term rolling ISR investment plans (as per Germany, Japan and Sweden) increase the effectiveness of government investment by providing continuity and supporting coordination through a consistent structure. These plans often put forward quantitative targets, primarily linked to total expenditure on R&D, such as Germany's High-Tech Strategy target of 3.5 per cent of GDP.

107 OECD. (2017). OECD Economic Surveys: Australia 2017. OECD Publishing, Paris. www.oecd-ilibrary.org/economics/oecd-economic-surveys-australia-2017_eco_surveys-aus-2017-en

108 Senate Economic References Committee. (2015). Australia's innovation system. www.aph.gov.au/Parliamentary_Business/Committees/Senate/Economics/Innovation_System/Report

109 Watt. (2015). Review of research policy and funding arrangements - report. <https://docs.education.gov.au/node/38976>

110 House of Representatives Standing Committee on Employment, Education and Training. (2018). Inquiry into funding Australia's research report: Australian Government Funding Arrangements for non-NHMRC Research. https://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024212/toc_pdf/AustralianGovernmentFundingArrangementsfornon-NHMRCResearch.pdf;fileType=application%2Fpdf

These international rolling investment plans provide continuity to the business and research sectors, and support coordination and efficiency within government through a consistent structure. They also limit the turnover of investment measures unless rigorous evaluation proves they are ineffective. Within this construct, shorter investments can be focussed on pilot initiatives that can be incorporated into longer-term programs, if successful.¹¹¹

While most Australian ISR programs are based on shorter-term investments, longer-term investment commitments are increasing. For example, in 2017 the Commonwealth Government committed \$2.3 billion over 10 years to support a national network of research infrastructure through the National Collaborative Research Infrastructure Strategy (NCRIS).¹¹² The NCRIS planning process includes a collaboratively developed research infrastructure roadmap of long-term needs and a corresponding 10 year whole-of-government investment plan.¹¹³ The legislated endowment structure of the Medical Research Future Fund (MRFF) has enabled the government to outline a \$5 billion, 10-year investment plan which provides secure funding to support lifesaving research, create jobs, strengthen industry, and reaffirm Australia's global reputation in medical research.¹¹⁴ The Government's 10-year Defence Integrated Investment Plan will guide defence investment as it grows to \$58.7 billion by 2025–26, with a high priority placed on maximising the innovation potential of the Australian economy.¹¹⁵ Defence's long-term planning processes include all capital and related investments such as material, estate and facilities, workforce and information and communications technology.

An investment plan that is coordinated at the whole-of-government level

A more strategic whole-of-government approach is required for Government's ISR investment to ensure investment decisions are coordinated at a system level. The APS Review found that the APS typically works in silos and rigid hierarchies.¹¹⁶ The proliferation of programs, with different objectives, funding rules and processes (see Box 3 and Box 4) undermines the efficiency and effectiveness of the Government's investment, and ultimately reduces the likelihood that the outcomes desired by Government will be achieved. For example, one submission to a House of Representatives inquiry noted:

*'The 2018 Australian Competitive Grants Register (ACGR) includes 12 active ARC schemes, 34 active NHMRC schemes, and 34 other active schemes (including Rural R&D schemes). These schemes have non-aligned guidelines, submission and assessment processes, and non-coordinated deadlines, imposing significant administrative overhead. These schemes operate alongside contracts, consulting, international funders, trusts and CRCs (categories 2–4), many of which fund related areas and projects. As a result, there are frequently schemes or funding opportunities announced ad hoc, with short notice for submission of applications (4–6 weeks), and frequently with new guidelines and applications processes. This fragmentation does not allow for sustained, long term investment and planning in research priorities.'*¹¹⁷

In addition, an audit by the Council of Australian Governments identified 552 policy and program initiatives to stimulate business investment in ISR.¹¹⁸ The recent *Stimulating business investment in innovation* report¹¹⁹ found that the number of government programs available to support business ISR overwhelmed a high proportion of businesses. Many businesses were unaware of the programs available to them, or found the administrative process (specifically the significant duplication in applications) burdensome. Businesses were also often unsure how Commonwealth and state and territory grants interacted with one another.

111 Paic, A. and C. Viro (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://community.oecd.org/docs/DOC-161275>

112 Australian Government. (2017). Australia's National Science Statement. <https://publications.industry.gov.au/publications/nationalsciencestatement/index.html>

113 Department of Education, Skills and Employment. (2018). Research Infrastructure Investment Plan. <https://docs.education.gov.au/documents/research-infrastructure-investment-plan>

114 Department of Health. (2020). Medical Research Future Fund 10 year Plan. www.health.gov.au/sites/default/files/documents/2020/01/medical-research-future-fund-mrff-10-year-investment-plan.pdf

115 Department of Defence (2016). Defence White Paper: Defence Industry. www.defence.gov.au/Whitepaper/docs/Defence-Industry.pdf

116 Department of the Prime Minister and Cabinet. (2019). Our Public Service, Our Future. Independent Review of the Australian Public Service. <https://pmc.gov.au/sites/default/files/publications/independent-review-aps.pdf>

117 Australian National University, Submission 31, p. 1. House of Representatives Standing Committee on Employment, Education and Training. (2018). Inquiry into funding Australia's research report: Australian Government Funding Arrangements for non-NHMRC Research. https://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024212/toc_pdf/AustralianGovernmentFundingArrangementsfornon-NHMRCResearch.pdf;fileType=application%2Fpdf

118 In 2017, the Council of Australian Governments (COAG) took a snapshot of policy initiatives and programs, across all levels of government, directed at industry ISR.

119 Innovation and Science Australia. (2020). Stimulating business investment in innovation. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf

Box 3: An analysis of the coordination and alignment of a subset of DISER programs

The Department of Industry, Science, Energy and Resources (DISER) has a suite of programs which support research, foster innovation and enhance commercialisation opportunities to improve the productivity and competitiveness of Australian business and industry.

A subset of these investments were analysed to assess the degree of alignment, overlap or gaps using several comparison points: policy intent; eligibility and merit selection criteria and assessment process.

The investments analysed included CRCs and CRC-Ps (CRC-Projects), EP and the Industry Growth Centres Initiative (IGCs) which span multiple phases of the innovation cycle from research translation and collaboration through to business innovation support.

This analysis revealed that:

- At a high level, there is some potential for overlap in the policy objectives of the programs, but in practice, the programs are complementary. For example, CRCs and EP's Innovation Connections are both intended to encourage small and medium-sized enterprises (SMEs) participation in collaborative research, however Innovation Connections supports SMEs through facilitators assessing their needs to engage with researchers, whereas CRCs support research engagement through industry-led collaborations with the research sector.
- There is the potential for unintended duplication and overlap between some investments which focus on sectors of competitive strength, particularly between CRCs and IGCs with similar objectives or in similar domains. This overlap can be constructive, for example where the CRC may have a more niche focus within the domain. There is also potential for duplication, such as between the Innovative Manufacturing CRC and Advanced Manufacturing Growth Centre, due to their strategic role and breadth of activity. It is important to leverage and maximise the connection between investments through the use of industry intelligence and networks to increase understanding and mitigate potential overlaps and duplications.
- All programs analysed require that investments are focused to some degree on Government priorities to align investment decisions. Current Government investment requirements include an eligibility requirement,¹²⁰ to provide additional merit in assessment¹²¹ if operating in one or more of the growth sectors,¹²² or linking to Government priorities more generally. Government priorities in these contexts are broadly defined as Science and Research Priorities, Industry Knowledge Priorities or any other science and research priorities identified by the Commonwealth Government.¹²³ There is an opportunity to provide more focus and greater alignment of investments by using one consistent set of Government priorities.

A number of constraints were highlighted by those designing and delivering investments which limit the Government's capacity to respond to challenges in the broader environment.

Opportunities for reform exist in the following areas:

- Developing a strategic approach to priority-themed investment rounds to ensure program objectives can be met while also addressing Government's priorities. Where priority rounds are used, they should provide advance notice to applicants, and limit fragmented responses and attrition of existing investment funds.

120 As per eligibility requirement for Entrepreneurs' Programme – Innovation Connections and Business Management.

121 As per merit selection criteria for the Entrepreneurs' Programme – Accelerating Commercialisation.

122 Advanced manufacturing; Food and agribusiness; Medical technologies and pharmaceuticals; Mining equipment, technology and services; and Oil, gas and energy resources.

123 Under the CRC & CRC-Ps merit criteria, additional assessment points are awarded for linking to Government priorities.

Box 3: An analysis of the coordination and alignment of a subset of DISER programs (cont'd)

- Introducing a flexible funding approach between individual investments to enhance the Government's ability to provide support and respond. For example, providing a single funding allocation for all investments focused in a thematic area (e.g. business and industry) to offer improved funding flexibility between investments and funding years.
- Improving the coordination between investments to provide a more joined-up approach and enhance the end-user experience. While some coordination does already happen, there is an opportunity for the Government to be more proactive in facilitating this coordination.
- Enhancing communication of existing Government investments, rather than creating new investments, to provide better visibility and ease of navigation to end-users. Journey maps were cited as one way to achieve this.¹²⁴

Some steps have already been taken to improve implementation-side funding administration processes for Australian business grant programs. For example, the 2015 Streamlining Grants Administration Programme was designed to improve the delivery of grants across the Commonwealth, lowering delivery costs and improving the experience for businesses.¹²⁵ The recently completed EP user-centred redesign and implementation reform process also identified opportunities to improve program effectiveness by simplifying customer processes and better connecting business assistance across government.

The OECD recommended Australia develop a more integrated, whole-of-government approach to its ISR to boost R&D outcomes.¹²⁶ Internationally, countries are employing a range of whole-of-government methods to ensure connectedness and coordination across their ISR systems. This includes creating a 'one-stop-shop' to reduce the number of funding agencies (such as Denmark's Innovation Fund¹²⁷), decreasing the number of programs to reduce fragmentation and duplication, and increase efficiency (such as Canada's Innovation and Skills Plan)^{128,129} and developing a public portal to increase visibility and ease of navigation (e.g. European Horizon 2020 portal¹³⁰).

The OECD also found that whole-of-government coordination of national ISR investment, including broad ministerial involvement and interdepartmental monitoring, was often a key success factor for ISR governance. In particular, ISR commitment at the highest level of government was found to drive inter-agency coordination of priorities and programs. This research has shown that OECD countries coordinate policy action through a range of mechanisms, such as research and innovation councils, national research and innovation strategies or plans, or inter-agency joint programming.¹³¹ For example, the US Government Accountability Office has a legislated mandate to identify and report on all federal entities and initiatives across government that have duplicative goals or activities, identify areas that are fragmented or overlapping and report on opportunities to achieve cost savings or enhance revenue collection.¹³²

124 Queensland Government. (2018) Innovation Journey. www.publications.qld.gov.au/dataset/innovation-journey/resource/ce4aa1c2-48a1-4cc9-9750-047f93cdf152

125 Department of Industry, Innovation and Science. (2019). Business Grants Hub Service Offer and Catalogue. www.industry.gov.au/sites/default/files/2019-11/business-grants-hub-service-offer-and-catalogue.pdf

126 OECD. (2017). OECD Economic Surveys: Australia, March. www.oecd.org/eco/surveys/Australia-2017-OECD-economic-survey-overview.pdf

127 European Commission. Research and Innovation Observatory – Horizon 2020 Policy Support Facility. Innovation Fund Denmark. <https://rio.jrc.ec.europa.eu/en/organisations/innovation-fund-denmark>

128 OECD. (2018). OECD Science, Technology and Innovation Outlook 2018: Adapting to Technological and Societal Disruption, OECD Publishing, Paris. https://doi.org/10.1787/sti_in_outlook-2018-en

129 OECD. (2019). Governance of science and technology policies – Case studies. OECD Science, Technology and Industry Policy Papers. <https://community.oecd.org/docs/DOC-161275>

130 European Commission. Horizon 2020 Research & Innovation. <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/h2020>

131 OECD. (2018). OECD Science, Technology and Innovation Outlook 2018: Adapting to Technological and Societal Disruption, OECD Publishing, Paris. https://doi.org/10.1787/sti_in_outlook-2018-en

132 US Government Accountability Office. (2019). Additional Opportunities to Reduce Fragmentation, Overlap, and Duplication and Achieve Billions in Financial Benefits. www.gao.gov/reports/GAO-19-285SP/

Box 4: Coordination of government space ISR investments

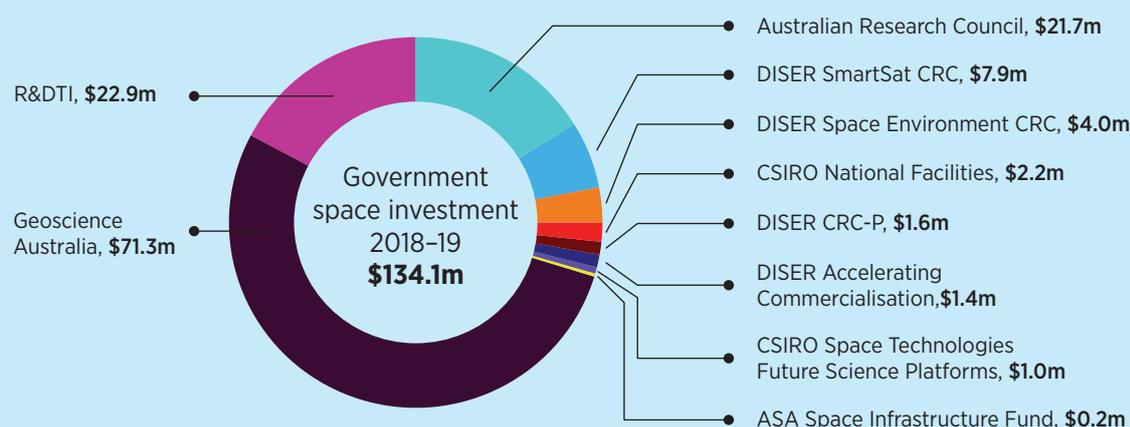
IISA's analysis shows Government investment in space ISR in 2018-19 was distributed across numerous programs, grants and incentives (see below).¹³³

While some of these investments are large in scale, such as Geoscience Australia's \$56.2 million National Positioning Infrastructure and \$15.0 million Digital Earth programs, others are small. For example, IISA estimates that 88 active ARC grants across 10 funding streams averaged just \$180,000, and 39 businesses lodged space-related R&DTI registrations averaging \$587,000 in 2018-19.¹³⁴ Funding complexity has continued to grow, including the \$5.85 million announcement of the 2020 space-sector CRC-Ps.¹³⁵

The Australian Space Agency, the Space Coordination Committee (SCC), and its working groups perform a key civil space sector coordination role, providing longer-term certainty through frameworks such as the Civil Space Strategy and by engaging with international space agencies. However, there is currently no single mechanism or entity coordinating the Commonwealth Government's space sector ISR investment and policies, and international ISR engagement beyond the Agency is achieved on an ad hoc basis. Space ISR investment decisions are largely made in isolation across Government while policies and ISR activities are coordinated through a range of government and community (joint government, industry and academia) mechanisms.

This historical fragmentation of space ISR is also reflected in the lack of a whole-of-government space ISR investment evaluation mechanism to effectively feed investment evaluation outcomes back into a holistic investment planning process, despite the internationally recognised value of doing so.¹³⁶

While existing investment and coordination mechanisms have served Australia to date, the increasingly ambitious aims for, and value of investments in, this emerging priority sector suggests there is an opportunity to maximise impact by improving coordination and streamlining space ISR investment and evaluation processes across government. This would reduce the future potential for overlapping or duplicative investments and avoid missed investment opportunities caused by poor visibility across the Government's investment portfolio. The long-term Civil Space Strategy and the SCC's State of Space report¹³⁷ are important mechanisms for improving the visibility of space ISR activities across government, including planned investments and reporting of outcomes in alignment with the Strategy.



133 Estimates exclude Defence (KPMG January 2020 estimated \$11.75b over 20 years or approximately \$400-575m annually); Investment in the Australian Space Sector), and smaller investments including those at AIMS, BoM, ANSTO and AAD. Research and Development Tax Incentive (R&DTI) estimates include registrations for the 2018-19 income year lodged to 21 May 2020; submissions close 30 September 2020. Note, ARC grant values per financial year are estimates only, due to variable grant start and end dates.

134 NB: each business' R&DTI registration can include multiple projects; this estimate includes 49 projects averaging \$467,000.

135 Australian Government. (2020). CRC Projects selection round outcomes.

www.business.gov.au/Grants-and-Programs/Cooperative-Research-Centres-Projects-CRCP-Grants/CRC-Projects-selection-round-outcomes

136 OECD. (2019). The Space Economy in Figures: How Space Contributes to the Global Economy. www.oecd-ilibrary.org/science-and-technology/the-space-economy-in-figures_c5996201-en

137 Australian Space Agency. (2020). State of Space Report. www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf

An investment plan that has effective evaluation processes

To ensure Australia's ISR investments continue to be well targeted and achieve high-impact outcomes, it is important to incorporate the outcomes of robust evaluation processes into the investment allocation process.

International best-practice has shown that ISR investments should:

- have clearly defined targets, indicators, benchmarks and evaluation stages (such as Canada's Innovation and Skills Plan);
- use templates and consistent scoring techniques;
- consider the economic, environmental and social outcomes of the program;
- use different types of assessors (such as self-assessment, board, external experts);
- require different levels of detail depending upon the investment level (i.e. system, priority, program level);
- have evaluations at a range of points in time to assess ongoing effectiveness and long-term impact, which may not be realised for several years (such as Sweden's Vinnova and Finland's Tekes¹³⁸); and
- ensure evaluations include an assessment of risk taking, including rapidly identifying failed initiatives and scaling-up successful pilot programs.¹³⁹

The Australian Government currently has no system-level ability to independently evaluate the performance of its ISR investments or effectively collate system-wide ISR investment data, despite calls for this since 2015 (see Appendix G).¹⁴⁰ While evaluations do occur in some parts of the ISR system, they are not coordinated at the system level. For example, individual university teaching and research programs are subject to external quality assurance, professional accreditation and program review processes by professional and government bodies. However, the outcomes of these reviews are not acted upon in a coordinated manner. In response, some universities have established their own procedures to plan for and streamline their engagement with these processes.¹⁴¹

The OECD recommends that Australia assess its research outcomes and impacts in a consistent manner across public-sector research organisations in order to boost its R&D outcomes.¹⁴² For example, the Canadian Policy on Results (see Box 5) legislatively implements consistent evaluation processes across government and publicly reports evaluation results, enabling system-wide investment optimisation and ensuring accountability.

138 Paic, A. and C. Viros (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://community.oecd.org/docs/DOC-161275>

139 Glennie, A. and Bound, K. (2016). How Innovation Agencies Work: International lessons to inspire and inform national strategies. Nesta. https://media.nesta.org.uk/documents/how_innovation_agencies_work.pdf

140 Watt. (2015). Review of research policy and funding arrangements—report. <https://docs.education.gov.au/node/38976>

141 For example, Quality Assurance: Learning and Teaching at the University of Adelaide www.adelaide.edu.au/learning/quality-assurance

142 OECD (2017). OECD Economic Surveys: Australia, March. www.oecd.org/eco/surveys/Australia-2017-OECD-economic-survey-overview.pdf

Box 5: International example of effective and accountable ISR funding governance—Canada

In recent decades Canadian Government financial reporting and accountability framework has evolved to include reporting on results.¹⁴³ In its 2016 Budget, its government stated “By focusing on outcomes for Canadians and making evidence-based decisions that are anchored in meaningful data and indicators, the Government is moving to a culture of measurement and impact, and is putting in place the tools to deliver on priorities, align resources to programs and activities that deliver real value for Canadians, and provide meaningful information to Canadians and Parliament.”¹⁴⁴

The Policy on Results (and supplementary Directive) legislates accountability requirements for Canadian federal departmental performance information and evaluation. Departments are required to provide the Treasury with annual departmental evaluation plans and deliver evaluations of ongoing investments with five-year average actual expenditures of \$CAD 5 million or greater. These evaluations include a common assessment of the relevance, effectiveness and efficiency of investments. Key elements include departmental delivery with central leadership, an emphasis for both monitoring and evaluation and well-defined rules and expectations for performance measurement and evaluation.¹⁴⁵

Departments are expected to measure and evaluate performance, using the resulting information to manage and improve programs, policies, and services and allocate resources based on performance to optimise results. The approach is having some success in informing policy and operations in government. A 2019 policy implementation audit in one department found programs were starting to integrate results information in operational planning and program management.¹⁴⁶

Outcome metrics (and associated targets) are commonly used in the evaluations. ISR examples include percentage growth in revenue and employees for businesses supported under the National Research Council of Canada’s entrepreneurship programs, and investment in R&D infrastructure.¹⁴⁷ Evaluation results are made available through a public government InfoBase¹⁴⁸, an interactive data-visualisation tool that provides infographics and data on federal finances, people management and evaluation results in a searchable format.

Currently, it is not possible to determine if the Commonwealth Government’s ISR investments are delivering effective ISR outcomes, due to inconsistent and incomplete system-level data (see Appendix G), varying approaches to evaluation, and little transparency with evaluation results both across government and to the public.¹⁴⁹ Some steps have been taken to improve the evaluation of components of Government-funded ISR. Lessons from these evaluations could be used to inform evaluation approaches in other parts of the system.

143 Government of Canada. (2020). Policy on Results. www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=31300 and Government of Canada. (2010). About the Centre of Excellence for Evaluation (archived). www.canada.ca/en/treasury-board-secretariat/services/audit-evaluation/centre-excellence-evaluation/about-centre-excellence-evaluation.html

144 Government of Canada, Department of Finance. (2016). Budget 2016, Chapter 7: Open and Transparent Government. www.budget.gc.ca/2016/docs/plan/ch7-en.html

145 Library of Parliament, Canada. (2019). Research Publications: Does reporting on results make a difference? https://lop.parl.ca/sites/PublicWebsite/default/en_CA/ResearchPublications/201904E

146 Government of Canada. (2019). Audit of the Implementation of the Policy on Results. www.canada.ca/en/canadian-heritage/corporate/publications/audits/audit-policy-results.html#a8

147 Government of Canada. (2020). National Research Council of Canada, Departmental Results Report 2018-19. <https://nrc.canada.ca/en/corporate/planning-reporting/departmental-results-report-2018-19/>

148 GC Infobase. <https://www.tbs-sct.gc.ca/ems-sgd/edb-bdd/index-eng.html>

149 While the Government’s SRI budget tables were found to be a valuable source of surveyed time series data for Australian Government investments in R&D, particularly for the system-level analysis of investments within Australian Government departments, they are not suitable for a detailed analysis of government investment in ISR due to insufficient data detail and some data inaccuracies. In addition, although the ABS data can only be used for a system level analysis as it does not have enough detail, such as the recipient of funds, to examine gaps and overlaps in the system.

The Engagement and Impact assessment of university research and the Excellence in Research for Australia framework and the 'Evaluation Ready' process for a number of ISR programs delivered by the Department of Industry, Science, Energy and Resources (DISER) are examples of recently improved government ISR evaluation processes.¹⁵⁰ The Evaluation Ready process is a monitoring and evaluation framework which ensures that programs are prepared for future evaluations and is compulsory for many programs entering through the whole-of-government Business Grants Hub.¹⁵¹ The Evaluation Ready process ensures data is collected and appropriate evaluations are scheduled to help determine whether a government program is working as intended. Early lessons from this process indicate a need for a strong culture of evaluation among the APS as a whole, supported by evaluation champions and clear strategic evaluation plans.¹⁵²

To ensure there is appropriate evaluation of government programs across the system, there have been calls for the establishment of a whole-of-government evaluation office, akin to the auditor general. The intent of this office would be to ensure evidence-based policymaking across government.¹⁵³ In the Republic of Korea, a national institute performs a centralised, legislated ISR performance evaluation function.¹⁵⁴ The breadth of the institute's function ranges from collecting internationally comparable national ISR data, evaluating national R&D programs and science agencies, through to diffusing best practice performance measurement. While some elements of this approach may not translate directly to the Australian context, an approach such as this could inform the development of a centralised performance evaluation and monitoring process in Australia.

Existing models for whole-of-government investment performance monitoring and evaluation can also inform the design of effective ISR evaluation and investment frameworks. In 2018, the NSW Government adopted a legislated approach to Outcome Budgeting.¹⁵⁵ This approach facilitates performance-focused investment decision-making and promotes transparency and reporting on the performance of NSW Government agencies. The NSW Government has progressively refined the framework, observing that achieving a long-term cultural change towards outcomes-focused decision making across Government, and from policy design through to evaluation, has been challenging.¹⁵⁶

The OECD has shown that evaluations are increasingly important for justifying public investment in ISR. Continuous evaluations and ensuring recommendations are implemented are both critical factors in the success of ISR initiatives.¹⁵⁷ Programs should operate in cycles of adoption—implementation—evaluation—adjustment, with major programs being adjusted in accordance with the findings of previous evaluations.

150 Office of the Chief Economist, Department of Industry, Innovation and Science (2018). Evaluation Strategy 2017–2021. www.industry.gov.au/sites/default/files/May%202018/document/pdf/department_of_industry_innovation_and_science_evaluation_strategy_2017-2021.pdf?acsf_files_redirect

151 The Business Grants Hub is designed to streamline and standardise end-to-end delivery services across the grants program lifecycle. For more information see: www.industry.gov.au/government-to-government/grant-design-and-delivery-services

152 Office of the Chief Economist, Department of Industry, Innovation and Science (2018). Evaluation Ready: Ensuring Evaluability. Presentation to AES18, International Evaluation Conference September 21 2018. <https://aes18.sched.com/event/Erob/evaluation-ready-transforming-government-processes-and-ensuring-evaluability>

153 Gruen, N. (2016). Why Australia needs an evaluator-general. The Mandarin, May 9 2016. www.themandarin.com.au/64566-nicholas-gruen-evaluator-general-part-two/

154 Korea Institute of S&T Evaluation and Planning, Evaluation of national R&D program performance. www.kistep.re.kr/en/c2/sub1_4.jsp

155 NSW Treasury. Outcome Budgeting www.treasury.nsw.gov.au/budget-financial-management/reform/outcome-budgeting

156 Jenkins, S. (2020). Outcome budgeting calls for cultural and behavioural shift, NSW Treasury says. The Mandarin, March 12 2020. www.themandarin.com.au/127142-outcome-budgeting-calls-for-cultural-and-behavioural-shift-nsw-treasury-says/?utm_source=TheJuice&utm_medium=email&utm_source=newsletter&utm_type=mandarin

157 Paic, A. and C. Viros (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://doi.org/10.1787/2b3bc558-en>

An investment plan that is reviewed on a rolling three-year basis

A whole-of-government ISR investment plan underpinned by robust investment performance evaluation and review processes, similar to international best-practice models, would enable the Commonwealth Government to align investments with, and optimise performance against ISR priorities. These processes should be driven by robust investment performance evaluation data and information collection mechanisms to inform subsequent ISR investment cycles and ensure that investments are coordinated, efficient, effective and achieving their intended outcomes (see Implementation strategies section for more detail).

A regular investment review cycle, which utilises ISR investment evaluation outcome data and information as inputs, would provide decision makers with the flexibility to revise the investment plan to ensure the appropriate allocation of funding against ISR priorities, and to respond to changes in those priorities and environmental factors over time. Such a review cycle would also enable evidence-based decisions to either divest ineffective investments, amend investments for greater impact, or seek budget renewal for high-impact programs within the customary funding investment cycle.¹⁵⁸

Effective investment reviews are well designed, and carefully analyse what has worked well and what has not worked in previous investments. As these reviews can be resource-intensive, it is also key that reviews are designed to be as cost effective as possible at the outset. Well-designed reviews can ensure Government investments grow sustainably, particularly in priority areas. It is crucial that investment reviews are used as an instrument for prioritisation, rather than cost reduction.¹⁵⁹

Additional analysis relating to Recommended Action 2, including evaluation and data collection details, is provided in the Implementation strategies section and in Appendices C, D and E.

¹⁵⁸ It is acknowledged a three-year timeframe may not be enough time for some ISR investments to have concluded and/or show impact but interim evaluation still provides useful information, for example, on implementation.

¹⁵⁹ OECD Working party of senior budget officials. (2013). 3rd Annual Meeting of OECD Senior Budget Officials Spending Reviews. [www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=GOV/PGC/SBO\(2013\)6&doclanguage=en](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=GOV/PGC/SBO(2013)6&doclanguage=en)

Recommended Action 3:

An investment plan that is strategically balanced across the Government's investment portfolio

A balanced investment portfolio is a key feature of best-practice ISR investment.^{160,161,162} However, the precise balance of investment should be determined within the context of broader Government priorities. Government should approach its ISR investment in a similar manner to the way in which an investor would approach a share portfolio; investments should be balanced across the portfolio to ensure they have the appropriate level of exposure. This balance should be considered in light of the broader environment and should be formulated to provide resilience in times of economic uncertainty.

IISA has identified a lack of detailed and consistent investment data as a barrier to understanding how effectively the Government's ISR investment is balanced (see Appendix F). Improved investment data quality could more fully reveal the current ISR investment balance, and identify opportunities to re-balance those investments to improve their overall effectiveness.

Recommended Action 3

A strategically balanced, whole-of-government ISR investment plan could ensure there are returns in the short, medium and long-term by:

1. Supporting both R&D and non-R&D innovation.
2. Ensuring investment in basic research does not fall below current levels (22 per cent of overall R&D investment) so that it can underpin future commercial opportunities.
3. Scaling and coordinating research commercialisation programs, particularly those which embed researchers in businesses.
4. Ensuring the technical and commercial risk profile of the Government's ISR investment is higher than would be acceptable in the private sector to enable breakthrough ISR in priority areas.
5. Ensuring the scale of the Government's overall ISR investment is sufficient to achieve its priorities, and individual ISR investments are appropriately scaled to achieve maximum impact.
6. Ensuring the costs of conducting research (including researchers, administration and infrastructure) are met by Government or other investors.
7. Ensuring ISR priorities are achieved using more targeted support measures for business and higher education-performed ISR, while flexible measures are in place across the system to address emerging priorities.

The sections below highlight IISA's key findings against the parameters across which Government's ISR investments should be balanced (see Table 2).

160 Productivity Commission. (2017). 5 Year Productivity Review, Supporting Paper No.12: An overview of innovation policy. www.pc.gov.au/inquiries/completed/productivity-review/report/productivity-review-supporting12.pdf

161 The Advisory Panel for the Review of Federal Support for Fundamental Science. (2017). Investing in Canada's future: Strengthening the Foundations of Canadian Research. http://cins.ca/docs/ScienceReview_April2017.pdf

162 UK House of Commons. (2019). Report on the review of Balance and Effectiveness of Research and Innovation Spending. <https://publications.parliament.uk/pa/cm201719/cmselect/cmsctech/1453/1453.pdf>

Supporting both R&D and non-R&D innovation

While elements of non-R&D innovation are included in Government-funding, it has not received the same attention and funding as Government-funded R&D. However, this trend is starting to change. In 2017–18, the three-year, \$500 million Public Service Modernisation Fund (PSMF) was established to modernise and enhance the productivity of the public sector.^{163,164} This fund included \$350 million for transformation and innovation, funding 21 projects to modernise and enhance public sector productivity and innovation. The fund also included \$150 million for agency sustainability, funding an additional 21 projects to support agencies' transitions to more modern and sustainable models of operation. Another example of Government investment in non-R&D innovation is the two-year \$1.5 million Supersonic Deposition 3D printer pilot program, a worldfirst program that has installed Australian-made 3D printers on Australian Navy vessels to streamline maintenance processes.¹⁶⁵

The impact of investment in non-R&D innovation programs has been recognised in the Public Sector Innovation Awards,¹⁶⁶ including PSMF programs such as the Behavioural Economics Team of the Australian Government (BETA), the Digital Library Infrastructure Replacement Program, and the Defence Industry and Innovation Program.

Previous analyses have shown that little government investment is directed at supporting non-R&D innovation for businesses. Despite the increasing recognition of the role that non-R&D innovation plays in business productivity, government support for businesses is primarily (90 per cent of all support, and 96 per cent of broad-based support) focussed through the R&DTI, which excludes many aspects of non-R&D innovation by design. This analysis also showed that firms which invested in non-R&D innovation outperformed firms that did not invest in innovation. For example, small and medium-sized enterprises (SMEs) with a high growth in technology spending increased their revenue by an additional 3.5 percentage points per year faster, and employment by an additional 5.2 percentage points faster than those with low technology spending.¹⁶⁷

The OECD has found that non-R&D innovation also plays a significant role in increasing business value. For example, between 1995 and 2010, US spending on R&D rose from 2.3 to 2.4 per cent of value added across the economy, while spending on non-R&D innovation increased from 8.5 to 11.2 per cent of value added across the economy.¹⁶⁸ Non-R&D innovation can also spur economic growth as some forms of innovation (such as software and designs) can be replicated at almost no cost and this can lead to increasing returns on scale.

Given the potential for non-R&D innovation to boost productivity, jobs and growth, it is imperative that government accelerates its support for non-R&D innovation both to businesses and government. However, care needs to be taken not to do so at the expense of effective investment in innovation stemming from R&D.

Ensuring a core of funding for basic research

Australia's research performs well globally and is responsible for 2.7 per cent of the world's scientific output, while being home to 0.34 per cent of the world's population. In terms of the overall quality and quantity of its scientific publications, Australia ranked tenth globally in 2018.¹⁶⁹ Previous reviews have highlighted a need for significant improvement in knowledge application, including collaboration between publicly funded researchers and businesses as well as the commercialisation of Government-funded research.¹⁷⁰

163 Australian Government. (2017). Agency resourcing: budget paper no. 4: 2017–18, p. 2. https://archive.budget.gov.au/2017-18/bp4/Budget2017-18_BP4.pdf

164 More information can be found at: Parliamentary Library. (2017). The Public Sector Modernisation Fund: A quick guide. Research paper Series 2017–18. https://parlinfo.aph.gov.au/parlInfo/download/library/prspub/5347385/upload_binary/5347385.pdf;fileType=application%2Fpdf#search=%22library/prspub/5347385%22

165 The Hon Melissa Price MP, Minister for Defence Industry. (2019). World first deployable 3D printers for Defence. Press release 21 November 2019. www.minister.defence.gov.au/minister/melissa-price/media-releases/world-first-deployable-3d-printers-defence

166 Institute of Public Administration Australia. (2020). Public Sector Innovation Awards—2020 Awards. www.act.ipaa.org.au/innovation-awards

167 Noting the difficulty of measuring non-R&D innovation, the Government's ISR investment is currently heavily weighted toward R&D, with the 2019–20 SRI Budget Tables showing just \$488 million of expenditure on non-R&D innovation, or just 4.9 per cent of its total investment. Further details can be found at Innovation and Science Australia. (2020). Stimulating business investment in innovation. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf

168 OECD. (2013). New sources of growth: knowledge-based capital key analyses and policy conclusions synthesis report. p. 13. <https://www.oecd.org/sti/inno/knowledge-based-capital-synthesis.pdf>

169 Tang, E. (2019). Global benchmarking shows innovation skills power Australian prosperity. Australian Trade and Investment Commission, Economic Analysis News 2 May 2019. www.austrade.gov.au/news/economic-analysis/global-benchmarking-shows-innovation-skills-power-australian-prosperity

170 Innovation and Science Australia. (2016). Performance review of the Australian Innovation, Science and Research System. www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf

Figure 4 shows Australia's gross expenditure in R&D (GERD), which encompasses both basic research, and applied research and experimental development, as a percentage of GDP.¹⁷¹ It also shows expenditure by type of R&D across key ISR actors, as a percentage of total R&D expenditure. This figure shows the overall level of basic research being performed in Australia has been relatively stable from 2000 to 2016. This equates to an average of 22.3 per cent of the total R&D expenditure invested by all ISR actors over the period. Sixty two per cent of all basic research was performed by the higher education sector.

In contrast, applied research and experimental development are performed at much higher levels than basic research; this trend is particularly marked in the business-performed R&D sector. While the level of applied research and experimental development has been steadily decreasing in some sectors (government and business performed R&D), it still remains significantly higher than basic research. In the higher education sector, however, there has been an increase in the amount of applied research and experimental development as a percentage of total R&D expenditure (two-fold over the period 1992 to 2016), where this type of research overtook the level of basic research performed by the higher education sector in 2006.

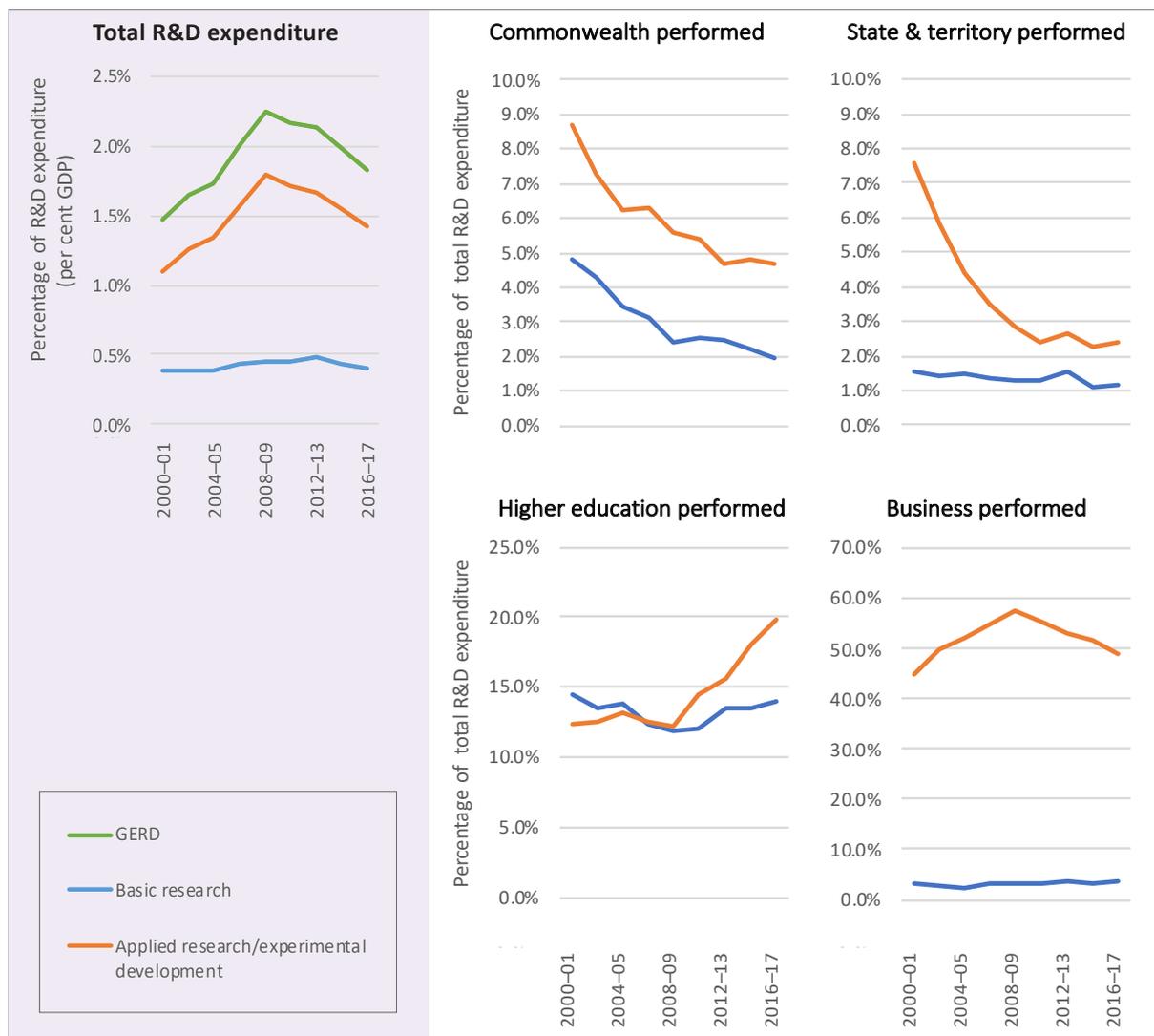


Figure 4 Comparison of R&D expenditure in basic research with applied research and experimental development across key ISR sectors

¹⁷¹ This analysis is based on ABS data, where basic research in this figure is the sum of pure basic and strategic basic research. This data has been taken from ABS, 8104.0 - Research and Experimental Development, Businesses, Australia, 2017-18; 8109.0 - Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2016-17; 8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2016. Note the ABS surveys those entities that perform R&D (businesses, institutes, universities, etc.) in order to identify the amount they spend on R&D activities that they perform in a given year.

Investment in basic research is important to ensure Australia develops both a foundation of technological innovation and the ability to ensure successful applied and commercialised research.¹⁷² The OECD has shown that basic research in particular drives long-term productivity growth. Government funding of basic research is particularly important to address inherent under-investment in basic research by businesses due to the high costs involved and the potential for large knowledge spill-overs.¹⁷³ Government funding of basic research is also needed to ensure Australia develops world-leading technologies.¹⁷⁴

Improving business-research collaboration and commercialisation outcomes

While Australia is globally ranked as above average at knowledge creation, there is substantial scope to improve the effectiveness of Australia's knowledge translation and commercialisation. There are proven benefits of industry-research collaboration and government has invested in multiple measures to directly stimulate the commercialisation of publicly funded research including CRCs/CRC-P's, ARC Linkage Projects, National Health and Medical Research Council (NHMRC) Development Grants, Innovation Connections, Industry PhDs through CSIRO, the CSIRO Innovation Fund, the CSIRO ON science and technology accelerator program, and the Australian Postgraduate Research Intern program. However, the commercialisation of publicly funded research and innovation continues to prove challenging. In particular, drawing an idea through the innovation pipeline, from prototyping through to realising a commercially viable opportunity. Australia continues to lag behind its international partners on measures such as the percentage of higher education expenditure on R&D funded by industry, and business expenditure on R&D.¹⁷⁵

Strong collaboration between government researchers and business has been identified by the OECD as a critical element of successful ISR. Strengthening links between the public and private research sectors through commercialisation of public research, technology transfer, open innovation, and collaborative networks of multi-disciplinary teams are particularly crucial.¹⁷⁶ The success of these approaches is dependent on the scale and stability of associated funding, the capacity of researchers and companies to understand each other's interests, and the establishment of clear collaboration agreements—particularly around intellectual property.¹⁷⁷

The Australian literature notes further barriers to the commercialisation of government research. These include the availability of staff with relevant commercial skills, and limited internal and external incentives for researchers to prioritise engagement in commercial activity alongside other research and teaching obligations.¹⁷⁸ As researcher-to-business collaborations drive stronger productivity growth and more novel innovations, improved networks for researcher-to-business collaboration and innovation should support improvements in successful research commercialisation.¹⁷⁹ In addition, there should be a focus on ensuring researchers have time to focus on commercialisation and have the relevant commercial skills to achieve this.

172 House of Representatives Standing Committee on Employment, Education and Training. (2018). Inquiry into funding Australia's research report: Australian Government Funding Arrangements for non-NHMRC Research. https://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024212/toc_pdf/AustralianGovernmentFundingArrangementsfornon-NHMRCResearch.pdf;fileType=application%2Fpdf

173 OECD. (2015). The innovation imperative – contributing to productivity, growth and well-being. www.oecd.org/publications/the-innovation-imperative-9789264239814-en.htm

174 House of Representatives Standing Committee on Employment, Education and Training. (2018). Inquiry into funding Australia's research report: Australian Government Funding Arrangements for non-NHMRC Research. https://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024212/toc_pdf/AustralianGovernmentFundingArrangementsfornon-NHMRCResearch.pdf;fileType=application%2Fpdf

175 Innovation and Science Australia. (2017). Australia 2030: Prosperity through Innovation. www.industry.gov.au/sites/g/files/net3906/f/May%202018/document/pdf/australia-2030-prosperity-through-innovation-full-report.pdf

176 Paic, A. and C. Viros (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://doi.org/10.1787/2b3bc558-en>

177 Guimón, J. (2019). Policy initiatives to enhance the impact of public research: Promoting excellence, transfer and co-creation. OECD Science, Technology and Industry Policy Papers, No. 81, OECD Publishing. <https://doi.org/10.1787/a4c9197a-en>

178 House of Representatives Standing Committee on Employment, Education and Training. (2018). Inquiry into funding Australia's research report: Australian Government Funding Arrangements for non-NHMRC Research. https://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024212/toc_pdf/AustralianGovernmentFundingArrangementsfornon-NHMRCResearch.pdf;fileType=application%2Fpdf

179 Australian Government. (2017). Australia's National Science Statement. <https://publications.industry.gov.au/publications/nationalsciencstatement/index.html>

Some actors in the ISR system are better placed and incentivised to deliver commercialisation and collaboration outcomes than others. For example, research commercialisation brokers facilitate research-industry collaboration, research translation and commercialisation outcomes by acting as an independent adviser providing objective and unbiased advice to all parties. The Government's Innovation Connections program assists businesses to understand their research needs, connect with the research sector and fund collaborative research projects.¹⁸⁰ These broker arrangements can help university or government-based researchers understand businesses research strategy and objectives better, in order to select the best industry partner and address any tangible needs during negotiations. Brokers can also help businesses identify which research institutions are active in their field of interest, which researchers to collaborate with, and which groups are best equipped to collaborate to jointly agreed timelines. Brokers could also facilitate researchers and businesses participating in collaborative research programs which embed researchers within business.

In Australia, approximately 30 per cent of researchers are based in industry.¹⁸¹ This is low by international standards; for example 80 per cent in Korea, 73 per cent in Japan and 71 per cent in the US.¹⁸² Programs that embed researchers within businesses are one effective way to increase the number of researchers in industry and stimulate researcher-to-business collaboration. International higher degree by research industry placement programs such as the French Convention Industrielle de Formation par la Recherche (CIFRE)¹⁸³ and the UK's Knowledge Transfer Partnerships (see Box 6) demonstrate that longevity, stability and scale are key to the success of such programs. In Australia, IISA has identified at least five different programs of varying sizes and duration where researchers can apply to be embedded in a business.¹⁸⁴ However, there is little coordination between these programs, and eligibility is largely limited to PhD students. Broadening the program scope to make these opportunities available to more experienced researchers (as in the MRFF's Researcher Exchange and Development within Industry initiative), and ensuring these programs are coordinated and appropriately scaled will improve collaboration and commercialisation outcomes.

180 Australian Government. (2020). Innovation Connections. www.business.gov.au/Grants-and-Programs/Innovation-Connections

181 Note: Software developers or programmers; and executives and directors involved in the planning or management of scientific and technical aspects of R&D projects are also classified as researchers (BERD) and postgraduate students are classified as researchers (HERD, 2016). Source: ABS, 8104.0 - Research and Experimental Development, Businesses, Australia, 2017-18; 8109.0 - Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2016-17; 8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2016.

182 OECD. (2016). Main Science and Technology Indicators. https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB

183 French Government, Ministry of Research. (2019). How CIFRE works. www.anrt.asso.fr/sites/default/files/cifre_plaquette_2019_eng.pdf

184 These are Innovation Connections, Industry PhDs through CSIRO, the Australian Postgraduate Research Intern program, the National Research Internships Program (NRIP), and the Researcher Exchange and Development within Industry (REDI) initiative.

Box 6: International example of effective ISR commercialisation

The UK's 40-year-old Knowledge Transfer Partnerships (KTP) program is designed to increase the competitiveness and productivity of UK businesses through better knowledge, technology and skills transfer between government researchers and businesses.¹⁸⁵ It is a three-way partnership between a UK-based business or a not-for-profit organisation; UK university or research organisation and a graduate capable of leading a strategic business project.¹⁸⁶

In this business led program, a graduate is selected to work on a specific knowledge-transfer project that is central to the business' development.¹⁸⁷ The graduate is jointly supervised and typically commits half a day per week to a KTP project, based mainly at the business.¹⁸⁸ This physical co-location is important to build and maintain relationships and an understanding of the project environment.

KTP projects are usually two years in duration, but can last between 12 and 26 months. KTPs are funded by a co-contribution from business, where the level of co-contribution depends on the size of the business. SMEs contribute 33 per cent and large companies contribute 50 per cent of the costs. KTPs support businesses with both R&D and non-R&D innovation,¹⁸⁹ and about three quarters involve businesses that employ less than 250 people.¹⁹⁰

Over 70 per cent of graduates are offered full-time employment with the host business on completion of their KTP, indicating that this program supports graduate employment and contributes to the ongoing development of an innovation culture for businesses.¹⁹¹ An independent evaluation of the effectiveness of the KTP Programme identified £7.5-£8 of net gross value added generated for every £1 of grant funding invested, alongside positive income outcomes reported by the majority of research participants, and a closer relationship between research and industry participants.¹⁹²

185 Innovate UK. Knowledge Transfer Partnerships <http://ktp.innovateuk.org/>

186 UK Government. Knowledge Transfer Partnerships: what they are and how to apply. www.gov.uk/guidance/knowledge-transfer-partnerships-what-they-are-and-how-to-apply

187 Hughes. (2015). Review of approaches to the commercialisation of university research and support for university industry collaboration in the UK. Report for Securing Australia's Future Project "Translating research for economic and social benefit: country comparisons" on behalf of the Australian Council of Learned Academies. <https://acola.org/wp-content/uploads/2018/08/13-uk.pdf>

188 University of Leicester. (2020). Information for Academics. <https://le.ac.uk/enterprise/development/innovation-hub/support-for-smes/ktp/academics>

189 For example, management KTPs were introduced in 2019, with a specific focus on introducing transformational change through improved management strategy and processes. More information can be found at www.ktp-uk.org/mktp/

190 Hughes. (2015). Review of approaches to the commercialisation of university research and support for university industry collaboration in the UK, on behalf of the Australian Council of Learned Academies. <https://acola.org/wp-content/uploads/2018/08/13-uk.pdf>

191 KTP. (2020). The Flagship Knowledge Transfer Programme. www.ktp-uk.org/academics/

192 Warwick Economics and Development. (2015). KTP Programme - The impacts of KTP Associates and knowledge base on the UK economy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/467142/KTP_Report_July_2015_Exec_summary__1-SEP-15_.pdf

Ensuring the Government's ISR risk profile achieves effective outcomes

A strategically balanced portfolio must actively evaluate risk, ensuring that high-risk and high-reward breakthrough ISR is encouraged, while continuing to support more conservative incremental ISR programs. Traditionally, most governments have focussed their innovation efforts towards incremental or 'enhancement-oriented' innovation.¹⁹³ Highrisk and high-reward ISR classically includes novel, potentially disruptive ISR that has significant societal impact. Governments are increasingly (and successfully) supporting breakthrough innovation and entrepreneurial ISR, for example through the creation of government-supported technology which allowed the creation of the iPhone.^{194,195}

A positive risk culture is increasingly being recognised as both an innovation enabler and an essential tool to identify and address program risk.¹⁹⁶ IISA found no evidence of a government-wide framework or dataset to inform ISR investment risk considerations. However, IISA did find that risk management processes have been established for some complex Commonwealth Government-funded ISR initiatives, such as Department of Defence acquisitions.¹⁹⁷

Effective policies for fostering high-risk and high-reward research are being developed internationally, however, this work is still in its early stages.¹⁹⁸ To date, government risk literature has focussed on the role it should play in supporting ambitious approaches to large challenges that enable breakthrough ISR. Governments often take the role of investing in ISR that other sectors (businesses in particular) deem too risky and uncertain for sustained investment, and in areas where governments have a higher risk tolerance compared to the private sector.¹⁹⁹

While the whole-of-government risk assessment framework is currently incomplete, the Government has already moved to invest in higher-risk ISR. Examples of government investments which support higher-risk, often early-stage innovative ISR, include the MRFF Frontier Health and Medical Research initiative, NHMRC Ideas grants and CSIRO's Main Sequence Ventures.

Internationally, governments are also funding high-risk breakthrough innovation which would likely be rejected by other investors. For example, Israel's Office of the Chief Scientist considers that a failure rate of less than 30 per cent in their high-risk grants represents an 'institutional failure' indicative of insufficient risk-taking and a 'crowding out' of private sector investment.²⁰⁰ UKRI's Smart Grants, Canada's 'Challenge Programs', Japan's disruptive technologies IMPACT program, and Singapore's National Research Foundation Investigatorships are other examples of mechanisms implemented specifically to support high-risk breakthrough innovation.²⁰¹

193 OECD Observatory for Public Sector Innovation. (2019). Embracing Innovation in Government: Global Trends 2019. <https://trends.oecd-opsi.org/embracing-innovation-in-government-global-trends-2019.pdf>

194 Egli, F., Johnstone, N. and Menon, C. (2015). Identifying and inducing breakthrough inventions: An application related to climate change mitigation. OECD Science, Technology and Industry Working Papers, No. 2015/04, OECD Publishing, Paris. <https://doi.org/10.1787/5js03zd40n37-en>

195 Mazzucato. (2015). What is government's role in sparking innovation? www.weforum.org/agenda/2015/04/what-is-governments-role-in-sparking-innovation

196 Hehir, G. (2018). Strategic governance of risk: Lessons learnt from public sector audit. 31 July 2018 presentation by the Auditor General to the Internal Auditors-Australia 'Public Sector Internal Audit Conference. ANAO. www.anao.gov.au/work/speech/strategic-governance-risk-lessons-learnt-public-sector-audit

197 Defence Science and Technology Group publishes its Technical Risk Assessment Handbook which provides Defence personnel and relevant stakeholders with a process and best-practice guide to the assessment of technical risks for major capital acquisition programs. It provides the framework in which DSTG Project Science and Technology Advisers report the technical risks identified and assessed in major capital acquisitions. DST Group. (2010). Technical Risk Assessment Handbook. www.dst.defence.gov.au/sites/default/files/basic_pages/documents/Technical-Risk-Assessment-Handbook_2.pdf

198 In March 2020, the OECD Global Science Forum held a workshop to examine effective policies to foster high-risk and high-reward research. <https://community.oecd.org/docs/DOC-170560>

199 OECD. (2010). Ministerial report on the OECD innovation strategy – innovation to strengthen growth and address global and social challenges. <https://www.oecd.org/sti/45326349.pdf>

200 Glennie, A. and Bound, K. (2016). How Innovation Agencies Work: International lessons to inspire and inform national strategies. Nesta. https://media.nesta.org.uk/documents/how_innovation_agencies_work.pdf

201 Paic, A. and C. Viros (2019). Governance of science and technology policies. OECD Science, Technology and Industry Policy Papers, No. 84, OECD Publishing, Paris. <https://doi.org/10.1787/2b3bc558-en>

Ensuring scale, and funding the full cost of ISR

A key element of a strategically balanced government investment ISR portfolio is appropriately scaled investments which deliver meaningful impact by achieving critical mass. A recurring theme in the literature is that Australia's ISR investments lack scale, both at a program and the overall system-level (see Box 7 for a sectoral example). The Government's investment in ISR in 2019–20 was \$10.1 billion, or 0.51 per cent of GDP. ISR investment as a percentage of GDP has gradually declined since 2011–12, when the total Government investment in ISR was 0.68 per cent of GDP.²⁰²

In 2019–20 the Government's ISR investment was split across 202 programs and 13 portfolios.²⁰³ Numerous reviews have observed the negative impacts resulting from this fragmentation,^{204,205} compounded by the lack of an overarching investment strategy. These impacts include reduced scale and uncoordinated investments across agencies and funding sources. This degree of fragmentation in ISR funding administrative processes has also been identified as inefficient, costly and time consuming for Australian researchers and businesses.²⁰⁶ Internationally, collective administrative arrangements, such as the UK's Industrial Strategy, have improved investment scale and reduced program fragmentation by grouping smaller-scale activities under each Grand Challenge, which are directly supported by the significant Industrial Strategy Challenge Fund.²⁰⁷

To ensure that all components of the ISR system are appropriately resourced, the direct cost of research and innovation activity, researchers, administration, infrastructure and operating costs must be carefully considered. Effectively investing in national research infrastructure is critical to Australia's research proposition, as knowledge creation is increasingly dependent on access to large-scale capital equipment, digital technologies and expert operators. An effective level of infrastructure investment also underpins Australia's ability to take up global scientific and commercial opportunities. However, despite a 2018 Commonwealth Government funding commitment for national research infrastructure, funding for costs associated with conducting research, including the broader indirect costs of research, remains broadly unaddressed.

202 Note: The increase in ISR investment in 2017–18 was predominantly due to increases in a number of areas including NCRIS, the Reef Trust, and the Pawsey High Performance Computer.

203 Note: this figure is based on budget estimates only. Australian Department of Industry, Innovation and Science. (2019). Science, Research and Innovation Budget Tables 2019–20. www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

204 Senate Economic References Committee. (2015). Australia's innovation system. www.aph.gov.au/Parliamentary_Business/Committees/Senate/Economics/Innovation_System/Report

205 Innovation and Science Australia. (2017). Australia 2030: Prosperity through Innovation. www.industry.gov.au/sites/g/files/net3906/f/May%202018/document/pdf/australia-2030-prosperity-through-innovation-full-report.pdf

206 House of Representatives Standing Committee on Employment, Education and Training. (2018). Inquiry into funding Australia's research report: Australian Government Funding Arrangements for non-NHMRC Research. https://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024212/toc_pdf/AustralianGovernmentFundingArrangementsfornon-NHMRCResearch.pdf;fileType=application%2Fpdf

207 United Kingdom Research and Innovation (UKRI). (2019). Industrial Strategy Challenge Fund. www.ukri.org/innovation/industrial-strategy-challenge-fund

Box 7: A strategically balanced space investment—scale and resourcing

The Commonwealth Government's introduction of targeted investment programs for the space sector have been well received by industry participants, and are regarded as appropriately subscribed, relative to the current scale of program investment.

As the space industry base grows and its investment needs evolve over the longer-term, there will be an opportunity to re-consider the scale of government support for this sector. This might include improving connections between space-specific support and the broader ISR granting environment, scaling successful programs, or combining overlapping initiatives and appropriately resourcing administrators to meet industry needs to achieve the greatest impact. The Australian Space Agency's current work to map the Australian space industry will provide some insight about the required scale and type of support needed to grow the capacity of the sector in the future.

The scale of space ISR investments outside the Agency's programs is more difficult to assess, particularly within Publicly Funded Research Agencies (PFRAs). While larger PFRA programs with dedicated funds are relatively easy to identify and quantify (e.g. Digital Earth Australia), smaller programs funded within annual agency appropriation budgets are less visible.

Internationally, space agencies similar to the Australian Space Agency (in UK, Canada, France, and Norway) suggest that the scale of investments required to grow and diversify the economy is in the order of 0.016–0.070 per cent of GDP.²⁰⁸ In Australia this would have equated to an investment in the order of \$250 million per annum, pre-COVID-19. While the scale of Australia's support for industrial space ISR investments is currently broadly fit-for-purpose, this international comparison suggests that supporting initiatives at scale may be required in the future to support the sector's participation in the global space economy.

The Australian space sector also faces challenges navigating the Government's variable levels of support for the indirect costs of research. While PFRA funding makes few distinctions between research, development and agency operations, government funding for universities clearly separates research, infrastructure and operational support, including for indirect research costs. This disparity has created differences in funding objectives, and challenges in transitioning research between national research infrastructure funding models, for example when operationalising earth observation data via Government-funded research facilities.

Challenges in accessing Government-funded space assets and infrastructure at an acceptable cost was also observed. While the Government's new space infrastructure funding is welcomed by the sector, the previously identified need for ongoing public funding for such facilities, including to cover ongoing running costs (such as staffing, maintenance and depreciation) for a diverse commercial and non-commercial user base, was confirmed through consultation.

208 Expert Reference Group to Review. (2018). Review of Australia's Space Industry Capability: Report from the Expert Reference Group for the Review. www.industry.gov.au/sites/default/files/June%202018/document/pdf/review_of_australias_space_industry_capability_-_report_from_the_expert_reference_group.pdf?acsf_files_redirect

Australia's two-stream ISR funding approach for higher education and health and medical research provides separate streams of funding for direct project costs and indirect costs. This funding structure has created inequitable, inconsistent and inadequate approaches across the system.²⁰⁹ For example, for every one dollar of university research funding provided through the Government's block grants, universities have been required to provide between 85 cents and \$2.35 to cover broader research costs, often from general revenue. Stakeholders continue to call for timely and adequate support for the broader costs of research.²¹⁰

Securing appropriate funding for the indirect costs of government-performed research has also proved challenging. The APS Review recommended APS capital, including research facilities, be fully funded, sustainable and fit for purpose, and capable of delivering policy and services as intended by the Government.²¹¹ The Department of Finance has commenced development of reforms consistent with this recommendation.

The issues associated with dual-stream funding are also commonly observed internationally. In Canada, despite broader research costs being estimated at 40–60 per cent of the cost of research, the government reimbursed only 21.6 per cent of these costs. A recent review recommended that the government gradually increase the reimbursement rate to 40 per cent for all eligible institutions. In contrast, the UK does not measure the administrative costs of research as a percentage of direct costs but has instead successfully implemented a centralised model that funds 80 per cent of the full economic costs of research.²¹²

Insufficient investment scale could undermine Government-funded ISR efforts at all levels. The Government should ensure that the overall scale of its ISR investment is sufficient to achieve impact. While some small investments can deliver highly targeted impacts, there is also a risk that small programs could fail simply due to insufficient scale. Consolidating the Commonwealth's ISR programs to build scale and better focus its innovation policy could yield significant benefits.

Balancing targeted and broad-based investment across sectors and priorities

Achieving an effective mix of targeted and broad-based investment mechanisms is another key aspect of balancing the Government's ISR investment portfolio. Targeted funding, such as direct industry grants, delivers priority outcomes but can have opportunity costs and significant administrative overheads. Conversely, broad-based funding mechanisms, such as R&D tax incentives, can foster innovation and promote experimentation and are efficient to administer, but are less effective at delivering priority outcomes and can be high cost.²¹³ Balancing the use of targeted and broad-based ISR investment mechanisms should maximise the benefits of each method, while minimising the limitations.

209 Association of Australian Medical Research Institutes. (2014). Submission to the inquiry into Australia's Innovation System, Senate Economics References Committee. https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Economics/Innovation_System/Submissions

210 House of Representatives Standing Committee on Employment, Education and Training. (2018). Inquiry into funding Australia's research report: Australian Government Funding Arrangements for non-NHMRC Research. https://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024212/toc_pdf/AustralianGovernmentFundingArrangementsfornon-NHMRCResearch.pdf;fileType=application%2Fpdf

211 Recommendation 34. Australian Government. (2019). Our public service, our future. Independent review of the Australian public service. <https://pmc.gov.au/sites/default/files/publications/independent-review-aps.pdf>

212 The Advisory Panel for the Review of Federal Support for Fundamental Science. (2017). Investing in Canada's future: Strengthening the Foundations of Canadian Research. http://cins.ca/docs/ScienceReview_April2017.pdf

213 Senate Economics References Committee. (2015). Australia's Innovation System. www.aph.gov.au/Parliamentary_Business/Committees/Senate/Economics/Innovation_System/Report

IISA's analysis of the Government's ISR investments^{214,215} show that the weighting of broad-based and targeted investments varies significantly between ISR sectors. Figure 5 shows that over 90 per cent of Commonwealth Government support to the business and higher education ISR sectors is through broad-based mechanisms, while support to government and multisector ISR is primarily through targeted mechanisms (99 per cent and 80 per cent respectively). While some sectors are dominated by a few large funding allocation methods (for example the R&DTI represents 96 per cent of broad-based funding to business), other sectors are funded in more complex ways (see Appendix F for more details).

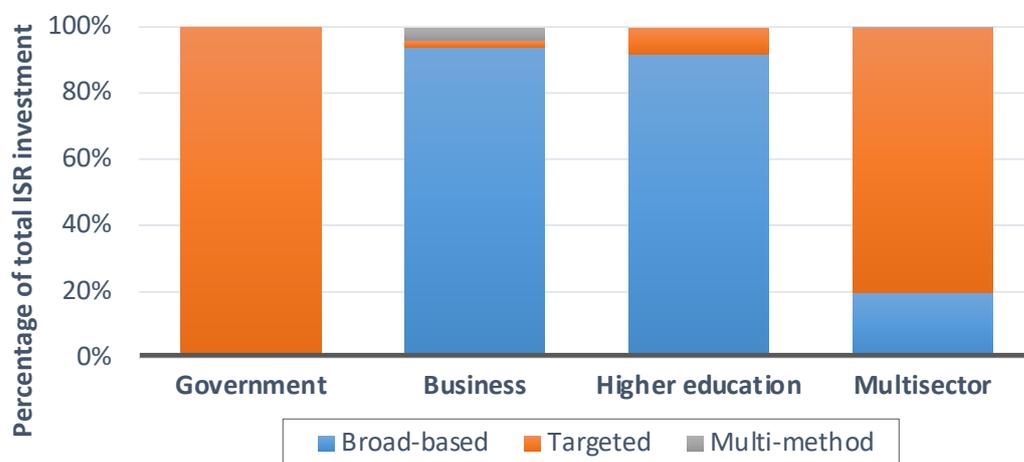


Figure 5 Allocation methods used for Government ISR investment into main R&D sectors, 2019–20

While the Commonwealth Government's targeted funding mechanisms, such as the NHMRC granting process, support priority ISR outcomes, some stakeholders have suggested that the discipline-focussed structure of these mechanisms may also be inhibiting the progression of interdisciplinary ISR. For government-performed ISR, where targeted funding mechanisms are dominant (with the targeting mechanism often being the mandate of each PFRA), there could be merit in allocating a proportion of PFRA funding to stimulate innovation through the use of flexible broad-based measures so that these researchers can address emerging priorities.

The extent to which any country balances targeted versus broad-based support depends on the system scale, research base, extent of available resources and nature of regional economic development strategies.²¹⁶ Growing pressure on budgets has led many governments to increase the proportion of targeted funding mechanisms. Internationally, targeted project-based funding is an important tool for incentivising higher education and public research institutions to contribute to national ISR objectives. Together with institutional block funding, project-based funding accounted for the bulk of funding for higher education and public research institutions internationally, complemented by funding from industry and other segments.²¹⁷

Additional analysis relating to Recommended Action 3 is provided in Appendix F.

214 Australian Department of Industry, Innovation and Science. (2019). Science, Research and Innovation Budget Tables 2019–20. www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

215 For this analysis we have assumed that the SRI categorisations of competitive funding (where applications for funding or entries to a competition are judged by a panel against selection criteria), targeted funding (where funding is allocated in order to address particular challenges or to accomplish particular objectives) and competitive/targeted funding (a combination of the previous two categories) are considered to be targeted investments. There were a few exceptions for some competitive funding investments, which were assessed as being broad-based measures. These exceptions included: CRC, ARC National Competitive Grants Program, Innovation Investment Fund, Inspiring Australia, Public Sector Modernisation Fund, Global Innovation Strategy, and Oversight of Significant Digital and ICT Initiatives programs. Assessment of programs classified as annual, restricted noncompetitive, other or were uncategorised in the 2019–20 SRI Budget Tables were assessed as targeted investments. Broadbased investments included entitlement funding (where an organisation undertaking eligible activities receives prespecified levels of financial assistance from the Australian Government, such as the R&D Tax Measures) and formula funding (where organisations receive an allocation calculated according to a formula based upon their performance against specified metrics, such as performance-based block funding to universities).

216 Council of Canadian Academies. (2017). Science Policy: Considerations for Subnational Governments. https://cca-reports.ca/wp-content/uploads/2018/08/subnatlscipol_fullreport_en.pdf

217 OECD. (2018). OECD Science, Technology and Innovation Outlook 2018: Adapting to Technological and Societal Disruption, OECD Publishing, Paris. https://doi.org/10.1787/sti_in_outlook-2018-en

Implementation strategies

While the three recommended actions described in the chapters above outline a best-practice approach to increasing the effectiveness of Government's ISR investment, consideration should also be given to the way in which these recommended actions could be implemented. Specifying the governance arrangements required to implement these recommended actions is beyond the scope of this report. The approaches described below are intended as broad implementation guidelines, and should be further refined through consultation with key stakeholders across the ISR system.

How could whole-of-government ISR priorities drive investment decisions?

As described in Recommended Action 1, effective ISR investments create impact through their ability to respond to national priorities. The Government's national priorities should be underpinned by a broader contextual assessment, including an evaluation of Australia's sovereign needs and comparative and competitive advantages. Whole-of-government and subsidiary ISR priorities should then be developed as key enablers of the Government's national priorities (Figure 3). These ISR priorities will, when coupled with ISR investment decision making processes, ensure that Government's ISR investments continue to strengthen Australia's resilience, productivity and prosperity.

Australia's whole-of-government ISR priorities should reflect theme-based objectives and focus on areas of immediate and critical importance to Australia's global standing. These could include areas such as health, energy, defence, national security, space, food and agriculture, social prosperity and the environment.²¹⁸

Whole-of-government ISR priorities should also promote broader cross-cutting ambitions such as ISR excellence, and a balance of R&D and non-R&D innovation. Dedicating a proportion of ISR funding to an 'emerging ISR' thematic priority would enable frontier science and technology, basic and blue-sky research, and cutting edge innovation. A dedicated, funded 'emerging ISR' priority would grow a broader pool of ISR talent and an internationally competitive research system which can innovate across and beyond purely priority-driven investments.

Once longer-term whole-of-government ISR priorities are established, shorter-term subsidiary ISR priorities can be developed. These priorities could, at least initially, be based on existing agency, ISR community and Industry Growth Centre sector priorities, and would provide more detailed, implementation-level guidance to ISR investment decision makers and ISR performers. Careful consideration should be given to state and territory ISR priorities and investments when developing these subsidiary priorities to minimise investment gaps and overlaps.

Internationally, ISR priorities are often expressed as themes or goal-oriented objectives. For example, the UK's Industrial Strategy includes cross-cutting Grand Challenges aimed at improving people's lives and national productivity, with dedicated collaborative funding for subsidiary challenges focused on specific problems. In Ireland, the majority of competitively awarded public research investments are aligned to 14 priority areas under six broad themes (see Table 4)^{219,220} Australia's ISR priorities could be expressed as a clear aspirational goal or resolution to a complex societal, technological or environmental issue through mechanisms such as Grand Challenges.

These new ISR priorities could ultimately supersede all extant ISR priorities, including the NSRPs. Investments that do not align with the resultant whole-of-government ISR priorities should be progressively divested from the investment portfolio, providing a pool of funding available for reallocation, while remaining within the existing funding envelope. This divestment should take place during scheduled reviews of existing investments or as appropriate to the investment funding cycle. Investments that include current Government priorities as a part of their underlying policy (such as EP and CRCs) should transition to the whole-of-government ISR priorities as part of planned reviews or as appropriate to their funding cycle.

218 This review should be informed by a mapping of investment priorities currently operating across the ISR system, both national and subsidiary ISR priorities, as expressed in key ISR documents such as NSRPs and decadal plans.

219 Government of Ireland. (2018). Research Priority Areas, 2018–2023. <https://dbei.gov.ie/en/Publications/Research-Priority-Areas-2018-to-2023.html>

220 UK Department for Business, Energy and Industrial Strategy. 2019. The Grand Challenge Missions Policy Paper. <https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions>

The overarching, whole-of-government ISR priorities should be reviewed every 10 years, or when significant changes occur. Subsidiary ISR priorities should be reviewed more regularly, such as every three years (or as required), to ensure they are effective and remain responsive to technological and societal changes. International models, such as Ireland and the UK, are good examples to inform approaches to ISR prioritisation.

Coordination across Government is critical to achieving cross-portfolio commitment to whole-of-government ISR priorities. Such an approach should consider the different accountability and decision making frameworks of Government departments, many of which are legislated, that would have to be altered to make a centralised prioritisation approach work in practice.

There are a number of ways in which the new ISR priorities could be incrementally applied to investments in the existing ISR system. One possibility is to initially apply this process to a current Government priority, followed successively by other priorities. Other options could be to apply priorities across investments in a particular portfolio, apply them to investments in a sub-set of ISR-performers (such as PFRAs), or across all whole-of-government investments (as demonstrated in the UK).

How could a 10-year ISR investment plan be implemented?

A single, unified, 10-year whole-of-government ISR investment plan could give the Government greater visibility of its ISR investments, including the alignment of investments with the Government's ISR priorities and investment performance.

The first step in developing a system wide long-term ISR investment plan is to gather consistent baseline information about all ISR investments. This information should include the purpose, expected outcomes, alignment to ISR priorities,²²¹ key performance indicators (including balance parameters, see Table 2), return on investment (societal, economic or environmental) and user/target. This information should be provided by government funders, in consultation with ISR performers. It should initially be captured as a one-off data collection to support the development of the initial investment plan and then provided to Government regularly during normal reporting cycles.²²² Consideration should be given to the need for a framework or platform to support the reporting of this information to ensure investments, data and outcomes are captured and analysed in a consistent and systematic way across different portfolios.

The ISR priorities, compiled whole-of-government ISR investment information, stakeholder consultation and other contextual data can then be used as inputs when drafting a balanced ISR investment plan. Existing best-practice approaches, such as the Government's 10-year investment planning processes for research infrastructure, defence and the legislated MRFF, amongst others, could provide a useful foundational framework when developing the investment plan.

This investment plan could then be used by Government to determine the strategic coordination of ISR investments, drive effective integration of new and emerging ISR proposals, ensure there is alignment between the Government's strategy and the allocation of its resources, and allow the Government to make trade-offs between ISR proposals. Regularly reported investment information, as well as investment evaluation outcome data (see next) could be used by Government through a centralised process to determine whether forecasts are in accordance with expectations. Adjustments could then be made accordingly. This process should be supported by appropriate governance mechanisms.

The ISR investments within this 10-year plan should be subject to regular evaluations to ensure the effectiveness of the Government's ISR investments. Evaluations should be conducted independently, coordinated across agency and domain-specific evaluation bodies, ensure accountability and be reported publicly. Evaluations would also need to be sensitive to any planned reviews of existing investments to ensure they are coordinated, necessary and mindful of potentially excessive reporting and data collection burden. The coordination and appropriate scaling of existing evaluation bodies could support effective evaluations and these evaluations could be used to inform the Government entity responsible for investment decisions.

221 Where investments are made across priority areas, they should be categorised as joint investments.

222 For example, agency corporate reporting and budget cycles.

ISR investments should be planned over 10-year time horizons, reviewed on a three-year rolling basis, and provide investment certainty unless rigorous evaluation proves they are ineffective, or they are pilot investments. This three yearly review can also be used to assess the effectiveness of the ISR investment balance within the portfolio. A larger scale Government investment review could be undertaken as part of the 10-year investment plan cycle, with a view to re-positioning and re-balancing ISR investments at the system-level in response to priority and environmental changes.

Strategically balancing the ISR investment plan

Balancing the ISR investment portfolio needs to ensure Government's short, medium and long-term needs are met. It is important to acknowledge that there is no 'correct' balance of investments that will persist in the long term. Instead, the most effective balance of investments at any given time will be the one that responds to changing priorities, environmental conditions, and investment portfolio performance outcomes. The balance of investments should be determined by:

1. **Baselining all current investments** to determine the current balance of investment phases and pipeline, scale, risk, investment mechanisms and resourcing across the portfolio.
2. **Developing a suite of investment outcomes that can be used to assess the most appropriate ISR investment portfolio balance within the current environment.** These outcomes could take a number of forms including:
 - The overall scale of the Government's ISR investment creates impact.
 - Investment in basic research should not fall below current levels (22 per cent of overall R&D investment) so that it can underpin future commercial opportunities.
 - Improve research-industry collaborations and commercialisation by providing a suite of effective and coordinated programs of appropriate scale and scope to achieve outcomes, such as increasing the use of research commercialisation brokers and embedding of researchers within industry.
 - High-risk ISR investments should represent five to 10 per cent of government ISR investments, to ensure that high-risk and high-reward ISR is performed.²²³
 - A progressive shift toward direct investment mechanisms to achieve targeted outcomes for business- and higher education-performed ISR.
 - Reduce sub-scale investments and investment fragmentation by requiring justification to be provided in small investment proposals and ensuring pilot initiatives can be extended or incorporated into larger initiatives, should they be successful.
 - Encourage a greater proportion of cross-sectoral or joint multi-agency performed programs with strong governance processes to improve coordination.
3. **Rebalancing investments to meet investment outcomes.** For new investment decisions, and where practical, by adjusting existing and planned investments, gradually shift the balance of ISR investments over time to better meet investment outcomes. There may be legislative constraints about the type of research that can be funded, and how researchers can be funded which may impact upon this re-balancing process. These constraints would need to be considered in the context of the rebalancing exercise.
4. **Iterating the balance of investments over time** using ISR investment information and evaluations to improve the responsiveness of the government-funded ISR investment portfolio to ineffective investment strategies, changing priorities and environmental conditions. Minor revisions of investment outcomes or goals (and derived shifts in investment decision making) could occur as often as performance indicators are released, and major reviews should occur in step with the investment plan review process (see Recommended Action 2). However, care will need to be taken to ensure that any longer-term, or lagging outcomes of re-balancing the investment portfolio are realised. For example if business-performed ISR falls as a proportion of the total government-funded ISR system in a single year, no action may need to be taken; however if falls are observed over a number of years, measures supporting business-performed ISR could be increased in future investment allocation cycles.

²²³ Guided by the US target of "at least 8 per cent for federal agencies budgets should be set aside for discretionary funding... for high-risk, high payoff research". National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2007). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/11463>

Conclusion

The central importance of innovation, science and research to Australia's ability to respond to crises has been demonstrated throughout 2020. Ensuring effective use of Government investment in ISR, particularly in times of economic uncertainty, is key to ensuring Australia's competitiveness, preparedness, resilience and recovery.

IISA's analysis has found that the Government's existing suite of ISR investments includes many highly impactful and well-designed components. However, there is also evidence of a lack of policy alignment and coordination at the system level. This lack of alignment reduces the overall effectiveness of the Government's investment.

Australia's ISR governance processes are complex, with policies developed in accordance with organisational, research community and portfolio needs, rather than system-level priorities. This has resulted in fragmented, sub-scale investments focussed primarily on shorter-term and lower-risk initiatives, and few long-term, or truly transformative programs.

An opportunity exists for the Commonwealth Government to commit to a long-term, balanced, whole-of-government ISR investment strategy to provide stability and certainty to the ISR sector, and stimulate high-impact growth outcomes in areas of strategic national priority.

IISA has developed three over-arching recommended actions for best-practice ISR investment. These are focussed on setting ISR priorities aligned with national objectives, and committing to a long-term, strategically balanced investment plan with regular monitoring and evaluation. There are many international examples of effective ISR prioritisation, planning, evaluation and balancing processes which could be implemented with appropriate modifications to suit the Australian system.

