ATSE

SUBMISSION TO THE

Innovation and Science Australia's 2030 Strategic Plan Issues Paper

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SUBMISSION TO INNOVATION AND SCIENCE AUSTRALIA'S 2030 STRATEGIC PLAN ISSUES PAPER

The Australian Academy of Technology and Engineering (ATSE)[1] welcomes the opportunity to provide input to Innovation and Science Australia's (ISA) 2030 Strategic Plan Issues Paper. ATSE agrees that the six challenges presented in the Issues Paper are important in advancing Australia's innovation, science and research system. While many of these challenges have been posed before, the key for Australia now is to define clear steps for implementation.

Australia needs a suite of complementary measures to incentivise innovation in our business sector, which are delivered at sufficient scale, with sufficient funding, and with the long-term support and stability, to be effective. Government has a major role in delivering effective incentive measures so that business and research organisations are encouraged to engage with each other, leading to improved collaboration, a culture of innovation in Australia's businesses, especially small-to-medium enterprises (SMEs), and ultimately a more productive and robust economy.

ATSE has produced many reports and statements on innovation and collaboration [e.g. 1, 2-5], many of which are referenced in this submission. Australia's research performance is world-class, with high overall scientific performance [6, 7], strong skills base [6], high-ranking universities [8] and high publication rates in top scientific journals [7]. However, the key gap that needs to be addressed is the ability to translate this research for economic and social benefit.

1 ATSE advocates for a future in which technological sciences, engineering and innovation contribute significantly to Australia's social, economic and environmental wellbeing. The Academy is empowered in its mission by some 800 Fellows drawn from industry, academia, research institutes and government, who represent the brightest and the best in technological sciences and engineering in Australia. The Academy provides robust, independent and trusted evidence-based advice on technological issues of national importance. ATSE fosters national and international collaboration and encourages technology transfer for economic, social and environmental benefit. www.atse.org.au

ATSE's recommendations for ISA are as follows:

Challenge 1

- Redefine the responsibilities and goals of the Council of Australian Governments (COAG) to ensure that Australia has effective public procurement policies in place
- Replicate and scale up South Australia's Industry Participation Policy, to give an avenue for smaller local innovative firms to be able to compete with larger and more established national and multinational firms
- Establish a national commission or re-configure the role of COAG to identify legislative and regulatory steps that would encourage companies to invest more for the long term
- Federal, state and territory governments to work together to provide a greater level of funding support to intermediaries
- Examine the data and look at case studies to explore what potential impacts an R&D Tax Incentive cap may have within different sectors
- Enhance a national SBIR-like program by significantly scaling up and funding over the long-term
- Explore and introduce mechanisms to significantly increase Australia's supply chain of engineers

Challenge 2

- Continue investing in NISA over the long-term, with bipartisan support
- Establish a Chief Innovation Officer within each federal agency
- Invest in measures that ensure stronger linkages between health and medical research and the technology-driven delivery of health-care services
- Draw from the innovation strategies taken by the Department of Defence for other sectors to drive innovation
- Invest substantially and over the long-term in advancing Australia digital infrastructure

Challenge 3

- Learn from innovative universities that are disrupting the traditional structure of learning, to ensure that Australia's current universities are in line with the future needs of the nation
- Reinstate and refund the Office of Learning and Teaching (OLT) award program
- Utilise the facilities of the NCRIS scheme to establish high level training programs and innovative postgraduate training programs in areas of potential economic promise
- Market vocational education and training (VET) as a postgraduate qualification for recent graduates to develop employability skills
- Establish specialist cutting-edge infrastructure in technological areas for shared use in higher education and VET programs
- Engage industry and the VET sector on the scope and nature of basic and advanced technical training for enhancing agile innovation in key sectors

- Scale up and provide long-term secure investment for effective programs such as ATSE's Industry Mentoring Network in STEMM (IMNIS)
- Adequately invest in the school education system and commit to ensuring that teachers have the formal training in the subjects that they are teaching
- Include widespread implementation of innovative, relevant, in-curriculum programs such as STELR to help address problems with student engagement in STEM at the secondary school level

Challenge 4

- Introduce a metric-based measure, which is modelled on ATSE's Research Engagement for Australia (REA) metrics, to incentivise and accurately track collaboration by research organisations
- Introduce a loading to the R&D Tax Incentive to encourage businesses to collaborate with research organisations
- Maintain and enhance and broaden current successful collaboration measures, such as STEM+Business Fellowship Program and the Experimental Development Program (EDP), to enable a greater diversity and intensity in collaboration
- Look to overseas collaboration examples, and effective Australian programs of the past, to develop and adapt a comprehensive suite of measures
- Commit and invest properly into the CRC program, at the same level as overseas counterparts
- Create a prominent awareness and education campaign, to showcase to businesses and research organisations the benefits of collaborating
- Include a comprehensive range of measures that incentivise mobility of people between business and research organisations
- Provide greater support for innovation intermediaries across all sectors
- Adjust the Entrepreneurs Program so that grant applicants would receive extra assessment points if their proposals included collaborative work

Challenge 5

- Put in place well-funded business-to-business measures over the long-term to allow firms to work with each other and undertake innovative activities
- Strength existing programs to ensure that they are bringing overseas expertise to Australia
- Ensure that the new Temporary Skill Shortage (TSS) visa is in line with Australia's innovation requirements and encourages and retains international talent into the country to fill skills gaps
- Expand measures, such as the Global Connections Fund, that encourage international collaboration, to link the nation to a globalised market and improve international competitiveness
- Look at combining datasets from ASIC, the Office of the Chief Economist and the ATO to investigate which foreign companies are working within Australia

Challenge 6

- Utilise the Industry Growth Centres, to offer industry sector opportunities for coordinated big initiatives
- Invest properly in the NBN, by creating a fibre-to-the-premises network to assure the future of Australia's innovative industries
- Include research infrastructure and the NCRIS as part of ISA's 2030 Strategic Plan
- Continue the Rural RDC initiative, and adopt the model in other sectors to maximise industry benefits from research
- Introduce an Australian New Zealand Standard Industrial Classification (ANZSIC) code for advanced manufacturing
- Expand Australia's agriculture sector by developing sophisticated packaging for premium food products to ensure food safety and quality

Challenge 1: Moving more firms, in more sectors, closer to the innovation frontier

Research from the European Union suggests that demand-side policy tools are 50-100 per cent more effective as drivers of innovation compared with other policy tools [9]. In order to create economic benefits for its investment in research and knowledge creation, the government can support firms to become highly innovative by focusing on three demand-side tools: procurement, regulation activity and cluster initiatives.

Public procurement

Public procurement is an important means for implementing government policy to encourage innovation-led economic growth. Public government procurement, whereby governments at different levels buy goods and services from private firms, represents a significant proportion of economic activity. It has substantial positive effects on innovation success and therefore economic development [10].

The Council of Australian Governments (COAG) has the role of managing matters of national significance; however it has not proven to be an effective mechanism for supporting Australia's firms and encouraging innovation. As there are a significantly greater proportion of small local firms compared with large national or multinational firms in Australia [11] and as these small firms are restricted in their ability to innovate owing to a lack of resources and infrastructure [12-15], COAG has the responsibility to ensure that Australia has effective public procurement policies in place.

South Australia has made a significant step forward in encouraging innovation within firms, through the Industry Participation Policy. The policy specifies that for all expenditure above $33,000, the South Australian Government must determine if there is a business in the state or the region that can deliver the product or service [16]. ATSE recommends that this policy is replicated and scaled up to a national-level and across all states, to give an avenue for smaller local innovative firms to be able to compete with larger and more established national and multinational firms.

Regulatory reform

Regulatory reform is a powerful stimulus to further innovation within specific sectors and technology [17, 18]. Regulating business cost will generate a competitive market for industries, thereby promoting economic efficiency and increasing the quality of the products [19-21]. Firms are pressured to demonstrate short-term financial performance, which leads to less long-term business investment in the foundations of innovation [22]. Thus, any regulatory reform and innovation policy needs to include measures to counter this pressure. ATSE recommends the establishment of a national commission or re-configuration of the role of COAG to identify legislative and regulatory steps that would encourage companies to invest more for the long term.

Cluster initiatives

Evidence shows that when firms and people are located near one another together in cities and industrial clusters, innovation grows [23-25]. Clusters can succeed in both metropolitan and regional areas [26], which is especially valuable for Australia's large number of regional cities. Innovation intermediaries play an important role in facilitating knowledge spillover and creating the regional knowledge capabilities needed for an innovation cluster [27].

There are a wide range of innovation intermediaries that enhance geographic interaction, including industry associations, technology precincts, business incubators and accelerators, science and

technology parks and industry clusters. Co-location is one of the most effective mechanisms for enhancing collaboration and can result in creation of ideas, sharing of expertise, research translation and economic benefits. ATSE recommends that Federal, state and territory governments work together to provide a greater level of funding support to intermediaries. This would assist in bridging the geographic divide and integrate the research and private sector more fully.

R&D Tax Incentive

Australia's innovation policy relies heavily on indirect support for firms, mainly through the R&D Tax Incentive. This is in contrast to some of the world's highest R&D investment countries, such as Germany, Switzerland, Sweden and Finland, which provide incentives through direct and indirect measures [28].

The R&D Tax Incentive has been particularly beneficial to biotechnology companies, as the concession has enabled them to stay in Australia and translate medical research into innovation [29]. The commercialisation of drugs and medical devices requires lengthy and expensive clinical trials before revenue can be achieved. There are a number of Australian companies undertaking trials, which have the potential to be revenue earning companies in the relatively near term.

The proposed changes to the R&D Tax Incentive by the 'Ferris, Finkel, Fraser' Review, which include a $2 million cap and the 'intensity threshold' would potentially result in significant negative impacts to certain sectors such as biotechnology, through reduced ability to employ staff and graduates, reduced capacity to attract investment and loss of global competitiveness [30]. ATSE was therefore pleased to see that the 2017 Federal Budget did not prematurely include a blanket cap for the R&D Tax Incentive. The Government has recognised the importance of the R&D Tax Incentive in supporting the innovative 'gazelles', especially within the biotechnology industry. ATSE strongly encourages ISA to examine the data and look at case studies to explore what potential impacts a cap may have within different sectors.

Direct procurement measures

Australia needs a stable suite of measures to support and encourage firms, which are well-funded over the long term and are based on best practice models. An excellent model program is the US Small Business Innovative Research (SBIR). SBIR is a highly competitive procurement program that encourages SMEs to engage in federal research or R&D that has potential for commercialisation. The program has been continuously funded by the US Congress with bipartisan support. This longevity and consistency has been fundamental to the success of the program [31-34].

ATSE was pleased to see that the National Innovation and Science Agenda (NISA) has put in place a small-scale trial of SBIR, called the Business Research and Innovation Initiative (BRII) [35, 36]. Advance Queensland is also conducting an SBIR-like trial – the Small Business Innovation Research (SBIR) pilot, and there have already been positive outcomes from the scheme, such as Planet Ark Power and Grey Innovation [37]. These trial programs are a positive step in the right direction and evaluations of the programs will ensure that they are generating the required outcomes. For any real long-term change to occur, a national program must be significantly scaled up and funded over the long-term.

Supply chain of engineers

Currently, universities are not adequately preparing graduates on how to successfully convert research into commercial innovative outcomes [38]. Table 1 illustrates the poor levels of engineering graduates in relation to IT and sciences graduates in Australia, compared with other innovative countries [39]. Currently, over 60 per cent of Australia's engineering jobs are filled by overseas

candidates, owing to the shortage of local engineers [40]. In comparison, countries such as China and South Korea, which are world-leaders in high-technology business development, invest heavily in producing and recruiting engineering graduates. Clearly, if Australia is to develop into a more high-technology advanced manufacturing country, it needs to significantly increase its supply chain of engineers.

Table 1: Ratio of engineering to science and IT graduates within innovative countries

Country	Engineering: Science and IT Graduates
China	2.5
Singapore	2.1
South Korea	2.1
Finland	2.2
Japan	2.4
Taiwan	1.8
Poland	1.0
Canada	0.6
USA	0.4
Australia	0.4

Challenge 2: Moving, and keeping, Government closer to the innovation frontier

The need for government to be innovative is a recurring theme and there have been various measures to encourage innovation over the years. However, while billions of dollars has been spent, very few of these measures have produced the desired long-term outcomes. ATSE is in strong support of the implementation of NISA and the creation of ISA, which will together help tackle the nation's weakness in public sector infrastructure for managing innovation. NISA provides an opportunity to develop an innovation system that can be measured. It is a platform that covers the full scale of innovation, from research to industry development. Thus, Australia must continue investing in NISA over the long-term, with bipartisan support.

Balancing risks versus reward

There is considerable risk averseness in Australian Government organisations making decisions on investments in new facilities and infrastructure [41]. A formal process in economic terms should be developed to balance the risks involved in sponsoring Australian developments against the advantages to be gained from developing Australian industrial competencies. An example of how federal agencies can focus on innovation is to establish a Chief Innovation Officer within each federal agency. This person would be responsible for ensuring that the agency was at the forefront of innovation opportunities and measures relevant to its portfolio.

Health sector

The health sector is one of the biggest procurement spenders in Australia. The Federal Government provides substantial funding to the health sector through, for example, the National Health and Medical Research Council (NHMRC), the Health and Hospitals Fund, CSIRO, ARC and the newly developed Medical Research Future Fund. The Government also launched the Biomedical Translation Fund in August 2016, which will provide $500 million worth of funding to accelerate the development and translation of Australian biomedical discoveries.

The health and medical sector has undergone a number of major reviews, the most recent being *Strategic Review of Health and Medical Research* [42]. Most of the reviews lamented the lack of flow-through of medical research to clinical and commercial outcomes. Australia has a particular strength in medical research, within its research institutes, universities and companies [42, 43]. However, the growing pressure on health services has restricted research activity in the health system and created barriers for research translation into evidence-based clinical and health interventions [42].

The overarching message is that Australia needs stronger linkages between health and medical research and the technology-driven delivery of health-care services.

Defence sector

The defence sector is a leading model of how government agencies can collaborate with industry and researchers to innovate. There is strong evidence from the defence sector to illustrate how industry involvement can lead to substantial contribution to the Australian economy [e.g. 44, 45]. The sector has recently undergone significant policy changes, with the release of the First Principles Review of Defence [46] and subsequently the 2016 Defence Industry Policy Statement [47]. The Department of Defence recognises that Australia's defence industry should be a fundamental input to defence capability.

In 2016, the Centre for Defence Industry Capability (CDIC) was created to provide strategic leadership to the defence sector and to help build the capability and capacity of the industry to support the Australian Defence Force [47]. CDIC involves a close collaboration between private industry, Defence and AusIndustry. It offers a range of services, to fund new industry development, critical skilling and export programs, as well as facilitate access to Defence's new innovation programs for SMEs. ATSE recommends that the innovation strategies taken by the Department of Defence are drawn from for other sectors to drive innovation.

Digital infrastructure

The critical element in digital infrastructure is high-quality reliable and fast internet. Fast and reliable digital infrastructure has become a necessity across all industries and is especially important to Australia's large agriculture sector, with many businesses being located in remote or regional areas. Thus, Australia needs an internationally competitive NBN.

Unfortunately, the Government has not been willing to properly invest in the technology and the outcomes are already becoming evident. NBN complaints have more than doubled in a year [48] and most parts of Australia are still a few years off from even gaining access to the NBN. The government procurement program with NBN Co Limited has resulted in over $49 billion of costs, a minimal number of sustainable IP-based jobs in industry and a product that is inadequate to the future needs of Australia [49].

Highly efficient and capable digital infrastructure is a necessity if Australia is to be a globally competitive innovator. Without a competitive digital infrastructure system, Australia's ability to attract and retain firms will be diminished and it will fall behind in the innovation frontier.

Adoption of 5G mobile technology is critical to provide Australia with the necessary digital infrastructure to embrace the economic opportunities enabled by emerging digital opportunities in areas like the Internet of Things, autonomous vehicles and digital supply chains. It is promising that Telstra and the Gold Coast Commonwealth Games are running 5G trials. It is important that Australia is an early adopter of 5G technology, to prevent the need for new and existing firms to relocate to other jurisdictions and to prevent the associated loss for the Australian economy. ATSE recommends significant investment and a long-term commitment in advancing Australia digital infrastructure, to be world-class.

Challenge 3: Delivering high-quality and relevant education and skills development for Australians throughout their lives

The major job types that will grow in demand over the next decade are expected to require skills of engineers, technology professionals, scientists and technicians. Jobs will become more interdisciplinary and require not only technical skills and knowledge but also broader transferable skills [50].

While engineering graduates seem to quickly gain employment after completing their degree [51], current unemployment figures for undergraduate science students are poor, with only half of graduates seeking full-time work finding it 4 months after completing their degrees [52]. Likewise, postgraduate students are still not properly being prepared for a career outside of academia, with most students experiencing little to no interaction with industry [38]. The stronger universities by 2030 will look fundamentally different to the current models, with a stronger link to industry and a greater focus on innovation and future economic growth. Australia can learn from innovative universities that are disrupting the traditional structure of learning, such as the computer-programming school *42* [53].

Furthermore, without the proper transitional mechanisms in place, many workers will soon find themselves out of a job owing to the rise of automation and Australia may experience a significant shortage of resources at the technician level [54, 55].

It is unfortunate that the fellowships and project grants programs of the Office of Learning and Teaching (OLT) have been discontinued. Over the past decade, these programs have contributed to significant improvements to teaching methodologies in the STEM disciplines across the whole of the higher education sector. Effectively addressing future students' learning challenges in the face of changes in the workforce, industry and economy, will be greatly enhanced by continuing collaborative work between the universities that the OLT fellowship and project grants programs had initiated. ATSE recommends that these programs be reinstated and refunded alongside the transfer of the OLT award program to Universities Australia.

Tertiary education and training

Australian graduates in engineering and IT are increasingly finding rewarding positions as high level engineers and IT professionals developing and operating novel plant. High level training programs and innovative postgraduate training programs should be established in areas of potential economic promise. Facilities established under the NCRIS scheme can provide excellent host environments for advanced training as they typically contain cutting edge equipment.

Significant investments must be made in adequately training and preparing undergraduates, postgraduates and VET students for the jobs of the future. For many positions in industry those graduating from the higher education lack employability skills and can benefit from additional vocational training. VET marketed as a postgraduate qualification would have the additional benefit of lifting the relative esteem in which the community holds the sector.

Australia's VET sector currently has very limited capacity in technology areas, with very low numbers of training courses offered within science, technology and engineering compared with trades training at the Diploma and Advanced Diplomas level. ATSE sees benefit in specialist cutting-edge infrastructure in technological areas being established for shared use in higher education and VET programs.

The VET system has an opportunity to provide retraining to people within specific technologies, such as advanced manufacturing, to ensure that there is enough capacity to keep up with the growing demand. Currently the pathways from VET qualifications into university degrees are constrained by the absence of mathematics in most skills training packages. It would be highly desirable to engage industry and the VET sector on the scope and nature of basic and advanced technical training for enhancing agile innovation in key sectors.

There are a number of successful pilot programs, which showcase how to incorporate broader transferable skills training into universities, such as ATSE's Industry Mentoring Network in STEM (IMNIS), MITACS in Canada and the UK Vitae Researcher Development Framework [38]. IMNIS is an award-winning initiative of ATSE that connects motivated second year PhD students (mentees) with outstanding industry leaders (mentors) [56]. These programs illustrate a range of methods for successfully developing broad knowledge bases, strong integrative skills and strong management and leadership capabilities. Successful programs like IMNIS need to be scaled up and have long-term secure investment from government.

School education

Lifelong education starts at early childhood and if it is not invested in properly, then problems will occur later on. Compared with other nations, Australia has low expenditure on primary and secondary education as a GDP and it is below the OECD average [57]. Demand for STEM skills in Australia is clear – 75 per cent of the fastest growing occupations require significant STEM skills and knowledge. STEM-based employment is projected to grow at almost twice the pace of other occupations. Yet currently 41 per cent of employers are having difficulty recruiting STEM- skilled technicians, as a result of falling student demand and therefore reduced funding to technical courses within the VET sector. [58].

Additionally, as too few school leavers are choosing to undertake engineering and IT or computing degrees, 26 per cent of employers struggle to recruit STEM-skilled professionals and managers. Consequently, there is an over-reliance on skilled migration, with about 70 per cent of Australia's engineering positions filled by skilled migrants [59]. These skills shortages will increase if no action is

taken. The government must adequately invest in the school education system and commit to ensuring that teachers have the formal training in the subjects that they are teaching.

In order to actively address the problem of low STEM participation rates at the upper secondary school level, ATSE developed the STELR (Science Technology Education Leveraging Relevance) initiative [60]. ATSE recognised that one major reason for low participation rates in STEM subjects is that students do not perceive and appreciate the relevance of science in their lives. STELR addresses this by relating STEM subjects to highly relevant issues affecting all students. PwC recently recognised the STELR Program as one of the best STEM Education programs in Australia, awarding it a place in their $2.5 million 21st Century Minds Accelerator Program. Government support for widespread implementation of innovative, relevant, in-curriculum programs such as STELR would help to address problems with student engagement at the secondary school level.

Challenge 4: Maximising the engagement of our world class research system with end users

Collaboration is strongly linked to innovation, which is essential for ensuring that Australia can meet its current and future geographic, economic and labour challenges. Australia needs to provide incentives to encourage firms and research organisations to interact and provide mechanisms for dealing with the cultural and structural barriers that are holding back collaboration.

Measuring research engagement

An important element in encouraging collaboration is to measure and track collaboration performance and adjust the level of funding based on performance. ATSE developed a new measure of engagement in 2015, Research Engagement for Australia (REA). REA focusses on developing metrics from existing data collections of Australian university research, which can serve as indicators for research engagement, knowledge transfer and/or collaboration. The metric uses external income from industry and other ends users attracted to support research in universities, as a direct measure of research engagement. Taken alongside rigorous evaluations of research quality such as Excellence in Research for Australia (ERA), REA provides a more complete picture of universities' research activities. ATSE recommends that a metric-based measure, which is modelled on REA, be introduced to incentivise and accurately track collaboration by research organisations.

R&D Tax Incentive

While the R&D Tax Incentive has helped encourage innovation within firms that have low cash flow, it does little to encourage business-research collaboration. ATSE therefore recommends that the Government adopt the recommendation of the '3 F's Review' to introduce a loading to the R&D Tax Incentive to encourage businesses to collaborate with research organisations. Of 13,500 companies that were registered under the R&D Tax Incentive in 2013–14, only 1,800 businesses were involved in Commonwealth funded collaboration programs [1]. This demonstrates that the R&D Tax Incentive is not effective at supporting business investment in collaboration. Belgium, France, Iceland, Italy, Hungary and Japan already offer R&D tax incentives to businesses that collaborate, and Australia can learn from these. Creating a tax incentive in Australia that requires collaboration will readily and substantially improve business-research collaboration.

Stable collaboration measures

Australia needs a wide range of collaboration measures, to assist all involved groups and encourage all forms of collaboration. Innovation reports [e.g. 61, 62] state clearly that a one-size-fits-all approach

is not appropriate. Australia needs to execute a comprehensive approach and include a range of measures that explicitly require businesses and researchers to engage. Measures that are implemented should individually be able to deal with specific barriers and issues in the system and when combined, create a strong, highly effective model for promoting business-research collaboration.

ATSE recommends that current successful measures, such as STEM+Business Fellowship Program and the Experimental Development Program (EDP) as part of the Science and Industry Endowment Fund (SEIF), are maintained and enhanced with additional funding and broadened to enable a greater diversity and intensity in collaboration. ISA should also look to overseas examples, and effective Australian programs of the past, such as Building on Information Technology Strengths Program (BITS) and Researchers in Business (RiB), to develop and adapt its own comprehensive suite of measures.

CRC Program

The CRC Program is Australia's most substantial and longstanding public-private partnership program, provides a valuable mechanism for pooling intellectual and other research resources in government, research institutions, industry and universities to achieve higher quality outcomes than they could alone. It is a very well-reviewed program and there is clear evidence of its benefits [63-65]. However, its greatest weakness is that it receives substantially less funding compared with similar overseas programs. Australia must commit and invest properly into the program, at the same level as overseas counterparts, in order to grow as a competitive and innovative economy.

Promoting the value of collaboration

Major cultural barriers for industry-research collaboration in Australia are differing motivations and attitudes between researchers and businesses, lack of trust and understanding on the value to collaborate, misaligned timeframes and the perception that collaborating with industry is damaging to an academic career [12, 25, 66].

To deal with these issues, ATSE recommends that a prominent awareness and education campaign is introduced, to showcase the benefits of collaborating to businesses and research organisations. The ARC and NHMRC are funding 4,283 research projects valued at $1.8 billion in 2017 and these projects involve perhaps 20,000 researchers. A proportion of these projects are focused on basic science, but intermediaries need to trawl the output of this basic science for promising innovations or specific scientific skills that can be used to foster a better innovative connections in Australia. The number of individual projects funded each year is likely to continue into the foreseeable future. If a method for highlighting projects that have the potential to be transformed into innovations was introduced, collaboration would be more easily fostered by firms. The REA metrics, which incorporate existing data from the ARC, provide a useful and simple model from which to develop a system to enable greater industry-research collaboration.

Furthermore, a more comprehensive range of measures are needed that incentivise mobility of people between business and research organisations. Universities must be encouraged to be more flexible in allowing people to move in and out of the research system. Ready mobility of personnel between the public and private research sectors needs to be strongly fostered by working with universities on their promotional criteria.

Innovation intermediaries

There is also significant room for improvement in more effectively utilising innovation intermediaries to promote collaboration. Innovation intermediaries, such as the Australian Mineral Industries Research Association Limited (AMIRA), have been shown to be successful at facilitating links between

researchers and industry [67, 68]. Greater support is needed for innovation intermediaries across all sectors.

Entrepreneurs Program

It is vital that firms are provided with incentives to collaborate with researchers. One simple and cost effective way of doing this is to make a small adjustment to the Entrepreneurs Program. Currently, grant applicants are given extra assessment points if research fits within the priority industry growth sectors. This method could also be utilised for encouraging collaboration, whereby grant applicants would receive extra points if their proposals included collaborative work.

Challenge 5: Maximising advantage from international knowledge, talent and capital

Studies show that innovation is mostly carried out by large firms compared with SMEs, owing to their ability to exploit large economies of scale in production, distribution, management and R&D [69]. For instance, In 2011, only 3.1 per cent of Australian SMEs collaborated with universities, compared with 5.8 per cent of large firms [70]. Small business expenditure on R&D represents only 17 per cent of total business expenditure on R&D [1] and only about 3.6 per cent of SMEs aged 0–1 years have joint R&D arrangements in place [71]. This is despite the fact that based on numbers from 2010–11, SMEs cumulatively account for 70 per cent of private sector employment and contribute 57 per cent of industry value added in Australia.

Encouraging business-to-business R&D

With a disconnect between the dominance of small firms in Australia's economy and the limited R&D conducted by small compared with large firms, there is clearly a need to reshape Australia's innovation system to encourage greater participation of small firms within R&D. Australia needs an innovation system that easily enables firms, especially SMEs, to engage in business-to-business R&D, both between Australian firms and between Australian and overseas firms. Investment in an SME by a large multinational can provide the capital, know-how and support to grow and expand into global markets.

Textor Technologies provides an excellent case study of how SMEs can effectively engage with international firms to innovate. By working alongside CSIRO and focusing on optimising production technology and techniques with assistance from the Commonwealth Government's Textile Clothing and Footwear (TCF) Strategic Investment Program and Strategic Capability Program, the company was able to become a preferred supplier to multinational Kimberly-Clark, and was awarded 'Global Supplier of the Year' in 2011. In 2010, the Researchers in Business program led to a highly successful research partnership with CSIRO's textile laboratories in Geelong which has enabled Textor to function in the global value chain in hygiene fabrics [25]. ATSE recommends that well-funded measures, such as the TCF program, need to be put in place over the long-term to allow firms to work with each other and undertake innovative activities.

Attracting global talent

Existing programs need to be strengthened to ensure that they are bringing overseas expertise to Australia, rather than simply providing Australian skills to overseas corporations. Australia must be able to attract talent globally. Universities often have difficulty with recruiting staff from overseas, which results in reduced global competitiveness, with Australia ranking 26th out of 138 for innovation [72]. The changes to the 457 visa will mean that it will be significantly more difficult to attract and retain

skilled people, who have specialist skills and international knowledge and talent. The Academy urges the government to ensure that the new Temporary Skill Shortage (TSS) visa is in line with Australia's innovation requirements and encourages and retains international talent into the country to fill skills gaps.

International engagement

Compared with other countries, Australia has invested very little funding into measures that are focused on enhancing international engagement [73]. The Academy strongly supports the actions of NISA for introducing a number of international collaboration mechanisms. ATSE recommends that Australia expand its measures that encourage international collaboration, to link the nation to a globalised market and improve international competitiveness. Successful programs, such as the Global Connections Fund [74] and the Global Innovation Linkages program, which address unmet demand and encourage international collaboration, need to be reviewed and scaled up.

Programs that support international postgraduate research candidates and that recognise the candidates as conducting valuable research work, rather than as simply completing studies, will strengthen Australia's ability to attract young and talented innovators [38]. Measures targeted towards international collaboration between businesses and researchers will attract foreign investment, extend Australia's global influence and facilitate access to new knowledge.

Learning from international companies in Australia

In order to understand what Australia's innovation strengths and weaknesses are internationally, it is important to know which international companies are working within Australia and how they may be influencing the level and type of public research. Currently, foreign entities that wish to carry out business in Australia must register as a foreign company through the Australian Securities and Investments Commission (ASIC). However, the data on registered foreign companies and the type and scale of work that they do does not appear to be publicly available.

The Swedish Embassy keeps regular track of innovative Swedish businesses in Australia and coordinates a business climate survey. A similar approach could be utilised by ISA to strengthen international business relations in Australia. ATSE recommends that ISA look at combining datasets from ASIC, the Office of the Chief Economist and the Australian Tax Office to investigate which foreign companies are working within Australia, what is the sectoral breakdown, how much are they investing in R&D and collaboration and what are their innovation outputs.

Challenge 6: Bold, high-impact initiatives

High-impact initiatives such as the Square Kilometre Array program are already proving effective in enhancing collaboration between industry and researchers throughout a variety of sectors, and thereby encouraging innovation. Where possible, these bold innovative programs should be further encouraged in Australia by identifying strategic gaps that will have spill-over effects for a number of sectors. Existing Australian groups, such as the Academies, Industry Growth Centres, or other national organisations, should draw on their nation-wide expertise to develop these bold, high impact initiatives. With the launch of the Sector Competitiveness Plans from each Industry Growth Centre, the Centres are now well-placed to offer industry sector opportunities for coordinated big initiatives. ATSE highlights below key initiatives and areas that ISA can further advance to prepare Australia for the economic, geopolitical, environmental and social challenges ahead.

National Broadband Network

The NBN is the obvious and key bold initiative that Australia needs. As mentioned earlier in the submission, a high-quality fast and reliable internet is mandatory for Australia's future. The Government must re-evaluate its decision to create an inferior NBN, which will ultimately set Australia back. There is a great opportunity for the Government to invest properly in the NBN, by creating a fibre-to-the-premises network to assure the future of Australia's innovative industries.

Research infrastructure

Innovation is highly dependent on high quality research and access to first-class research infrastructure is essential for globally competitive research. Notably, the Australian Government released the 2016 National Research Infrastructure Roadmap in May. Its recommendations, particularly on e-Research facilities and the desirability of national research infrastructure facilities being available for use by industry, will impact on the innovation landscape and have the potential to promote a more collaborative environment between public and private sector researchers in Australia. The facilities funded by the National Collaborative Research Infrastructure Strategy (NCRIS) are not only important for scientific advancement, but are also a useful opportunity for training. As such, research infrastructure and the NCRIS should be part of ISA's 2030 Strategic Plan.

Health sector

There is significant opportunity for high-impact innovation in health, as this is a large growth sector [75-77]. Today's healthcare system is technology dependent, and many future advances will not only depend on medical expertise, but on collaborative contributions from engineers and scientists. Innovation in this sector should not only focus on technology, but also on governance practices, medical services, and employment practices. To realise innovative growth, the Australian health sector needs to increase its ability to translate research into commercially viable solutions for global markets, which will improve access to global value chains. Funding should support the commercialisation of medical technologies, services, and practices from medical research institutes, universities, and start-up firms.

Agriculture sector

Australia's agriculture industry will face significant challenges in the lead-up to 2030, including climate change, biosecurity, consumer expectations, foreign investment, and food security [76, 78]. Overcoming these challenges will increasingly require step-changes in production and technology practices. Fundamental research will be needed to allow for this progression, allowing increased productivity, sustainability, and natural resource management practices, and therefore greater competitiveness.

The agriculture sector recognises the importance of cutting-edge R&D to remain competitive, and established the Rural Research and Development Corporations (Rural RDCs) to ensure ongoing innovative agricultural research. The Rural RDC model is a targeted approach from within the agriculture sector to increase targeted agricultural R&D, and is effective in the implementation of research outcomes and the capture of benefits from that research [79]. The Rural RDC initiative should be continued, and the model could be adopted in other sectors to maximise industry benefits from research.

The agricultural workforce will need to be digitally competent with appropriate business skills to adopt future new technologies, communications, and knowledge systems. Measures will need to be in place to ensure access to capital, infrastructure, and tailored programs for small-scale producers necessary for sector-wide adoption of technological advancements.

Manufacturing

Manufacturing already attracts the largest share of global R&D spending, and has spill-over benefits for national economies [80]. It is important to Australia's economy, but faces increasing challenges, such as growing availability of cheaper products overseas, high labour and energy costs, and small local market volume relative to Asian counterparts [9, 80-82]. The 2016 Global Manufacturing Competitiveness Index shows Australia's manufacturing competitiveness ranking has declined from 16th to 21st out of 40 countries [83]. In order to combat these issues and reinvigorate Australia's manufacturing industry, one simple solution is to introduce an Australian New Zealand Standard Industrial Classification (ANZSIC) code for advanced manufacturing. This will enable the government to understand with much greater accuracy who is conducting advanced manufacturing and where are the potential gaps. By adopting technological innovation, the Australian manufacturing sector can develop high-value products and services for a global market [80].

Examples of potential high-impact projects

There may be potential to further expand Australia's agriculture sector by developing sophisticated packaging for premium food products to ensure food safety and quality. This may require innovative collaboration between the agriculture, communications and design, engineering, environment, and transport sectors, resulting in a high-quality, sustainable exportable product. An investment in food packaging innovation would align with the challenges of feeding a growing global population, climate change impacts and ensuring environmentally sensitive energy generation. Australia should take the opportunity to utilise internationally competitive advantage of a vast, well-established and innovative agriculture sector to invest in developing innovation solutions for food packaging.

A range of industry sectors may benefit from a collaborative grid-scale energy storage initiative. Incorporating energy storage into the energy grid requires collaboration between energy storage researchers and developers, manufacturers, raw material suppliers, software developers, regulators, grid management organisation, and energy dispatchers. This technology is in increasing demand globally, so any energy storage solutions could become an exportable commodity.

The Academy would be pleased to assist ISA in any way on the Strategic Plan, and the expertise of the Academy and its Fellows remain available to ISA. Should you require any further assistance, the contact at ATSE is Dr Milla Mihailova, Research and Policy Officer (Milla.Mihailova@atse.org.au or (03) 9864 0920).

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