Synthesis of consultation workshops

Supporting background information for:

Preparing for Australia's digital future: A strategic plan for Information and Communications Sciences, Engineering and related Technologies

February 2018

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DRAFT

1 Consultation workshop feedback

This appendix presents a synthesis of feedback received at the consultation workshops that informed this plan. No attribution to any individual is intended.

This document uses ICSET as shorthand for a broad term referring to information and communication sciences, engineering and related technologies.

1.1Melbourne

5 May 2017

General views

Regarding relevance of this plan, and planning process: there was a strong view that it needs to not be self-serving for academia. This plan is an opportunity to show how ICT enables and facilitates many other fields of human endeavour, and underpins our economy.

Participants generally agreed that, as an overarching observation for the various parts of the sector that were discussed, government should become more of an advocate for the sector and its importance rather than simply a go-to funder. Government funding will play a role, but it needs to be supported with whole-of-government intentions to strengthen Australia's ICSET capabilities, knowing that this will also increase the benefits of single-agency funding programs.

ICSET is set to play a central role in society in any foreseeable or desirable future, and so ICSET needs to be more deeply represented in the future of both research ethics and general societal ethics.

Participants noted that quantum computing needs to be added as an additional technology in the 3D conception of the problem-space.

Research quality and relevance

Participants felt that a key weakness of ICT research was a lack of visibility, and how it relates to 'reality'. The use of the word 'reality' by business representatives was noted for its implication that academic research is inherently not reality. This points directly at the most important difference between researchers and industry: a mindset of possibility in academia, and of immediacy in business.

Regarding visibility of research: the overall level of investment in research has dropped—not so much in government (which has consolidated and concentrated research investment in fewer areas but roughly maintained total spend) but a drop in industry investment in research. Research spend is not to be confused with venture capital availability, which (while related) is generally an innovation translation activity. Recent data regarding venture capital—2016 saw the highest level in Australia—should not be confused with the drop in industry investment in research. This could be an early indication of our innovation pipeline being used up and not replaced.

A major strength of Australian research is our research quality and reputation. Related to this:

- A collective mass of diverse talent exists in particular geographic and thematic areas. Maintaining these hubs is quite difficult in a nation that is geographically dispersed and small.
- Education is a large export that trades on our research reputation. Separation of research from teaching might dilute this reputation and weaken the export value.

Australian culture itself was seen a weakness: average Australians see research as isolated (separate from 'reality', see comment above), 'too hard for me to understand', 'not relevant to my life', etc. Participants noted that Australia does not have a culture that recognises research as something we all do, as a human activity that simply means finding things out and trying stuff. This relates nicely to the current Chief Scientist's observation that Australians need to 'rediscover our culture of tinkering'.

Participants noted that cross-disciplinary research can sometimes be 'token'. Even when it is genuine, it can be seen as token by practitioners in the 'pure' disciplines. As ICSET sweeps across the sciences, the early pioneers may be seen as token until 'ICSET-ized science' completes its transformation and deep application of ICT to other sciences becomes business as usual for those other sciences: at some stage it will no longer be seen as cross-disciplinary.

Regarding policy-relevance: Participants were of the view that legislation (public policy setting) often occurs before consultation, especially at the Commonwealth level, or that consultation is not commensurate with the nature of the issue. Examples include privacy legislation and metadata retention. Participants noted the need to engage at all levels throughout the bureaucratic hierarchy, but that government departments are often opaque.

Research impact

Academic participants reported that they are regularly approached by start-ups interested in research, but it is generally not workable for both sides to find a mechanism to enable to a collaboration. There are many ways for research to have impact, but a lack of viable ways to collaborate with start-ups was seen as a handicapping the very first stage of a direct uptake and impact mechanism. The current lack of financial support (on both sides) for collaboration may be a result of not seeing the system as an ecosystem (refer participants observations about translation).

Participants noted that a major gap in the research part of the innovation ecosystem is the area in which research becomes technology. This is an under-recognised step which has to occur 'between the science lab and the engineering lab'[1], and can be thought of as the forgotten cousin of the 'valley of death' that is recognised for commercialisation. It is almost as if there is a valley of death for 'pre-innovation'. Once again, this is handicapping research impact.

Regarding the research sector's attempts to connect with industry: it was noted by an industry representative that universities generally don't seem to actually engage with industry directly. Industry associations cannot provide the universities with what the universities think they can—they really just represent the interests of their members, and many universities (right down to the level of individual researchers) think they're 'engaging' but actually aren't 'connecting' past the gatekeepers of either companies or associations.

Research infrastructure

Participants felt that favour has been given to 'big bits of kit' rather than truly collaborative infrastructure. The distributed nature of collaboration was raised as both an opportunity and a

[1] Illustrative phrase only: of course engineers also do pure research and scientists also do applied research.

barrier. With respect to computational infrastructure, there are strong arguments both ways. 'Truly collaborative' was seen as genuine connection of both researchers and the facility managers or technical staff. Too often the technical staff aren't seen (by researchers) as able to unlock the potential of the infrastructure. Comparison was made to the some of the staff at the Australian Synchrotron and ANU linear accelerator who add significant value to their facilities.

With respect to data infrastructure: participants were of the strong view that Australia needs a trusted data custodian relevant to government, industry, defence and research. Curation of research data into the future does not appear to be given the consideration and planning that it will likely require.

Participants recognised that past, large investments in research infrastructure has placed Australia in a strong position, but that ongoing assurance of support was risking previous gains. These facilities are much easier to maintain than they are to rebuild should we lose them, and letting funding lapse would be a false economy.

Infrastructure was also seen as both a contributor and a barrier to linking regions and cities. Big bits of kit focus research activity around them, but additional support is also required for the rest of the nation's researchers to use what is notionally a 'national' facility because travel is expensive in Australia.

Innovation and translation

Participants notes no shortage of good researchers, good ideas and good topics, but that researchers find it hard to collaborate with industry. This could be 'step 1' of a lot of translation, but the systems on both sides do not support it. Potential reasons and actions were proposed as:

- Academic performance metrics. If academics take a chance of trying something entrepreneurial, "they often lose their academic career, or their marriage, or both".
- Small ideas are often overlooked and not being shared, despite being the majority of practical innovation. Everybody loves a moon-shot, but small changes to big systems are economically more important (at least in the short term).
- Australian universities seem to be needlessly protective around trivial IP matters: A solution could be to establish a public domain culture—knowing we'll all benefit.
- It is often hard for people outside of a research field, or an industry, to find out what is happening, where. It is then hard to know where to go, or who to talk to, to get new ideas going.
- More inter-disciplinary projects and initiatives were seen as a first step in getting academics to consider ideas from outside their field, which is also necessary for innovation.
- MOOCs (and similar) was suggested as a potential way to get ideas from left-field because they can expose people to academic knowledge who not otherwise have access, and who bring a different and sometimes focussed practical perspective (e.g., farmers).
- Develop entrepreneurial talent and knowhow more generally, across government, academia and business. The higher the general level of knowhow is, the more likely it is that successful teams will come together.
- Participants noted that the Australian innovation and translation ecosystem is missing a key part: a workforce of research engineers.
- Participants from industry noted the presence of an inappropriate fiscal framework that forces Australian companies to do the innovation and the uptake on their own.

Increasing translation could also come from encouraging exchanges: people inside the profession need to go out, and people outside need to come in. Skills transfer isn't just training—it is moving and working in a field too. Participants were of the strong view that Australia needs to support the people who do the translation to do the things that encourage translation to occur, rather than just insist that people 'translate'.

The experience of other countries was noted as a rich source of ideas: Despite the cultural differences, to what extent can we take elements of other approaches from Germany, Estonia, etc?

Education

It was suggested that "people using ipads sometimes think they're IT savvy and don't need training".

The language and promotion of ICSET in Australia was not seen as positive or strong. Participants noted the need to directly tackle the negative messages around IT that strike at people's fear of change—automation stealing jobs, privacy breaches, ransomware attacks, etc. Making parents see the value in early school would help with student choices, and this means selling the value to parents.

Despite Australia's high quality schools and universities, Australia appears to have lost its thirst for public knowledge—skills and knowledge have been removed from our everyday life and it seems to be enough for most Australians to simply know that our universities are full of smart people so we don't have to think ourselves.

Participants noted that Australian universities build great talent pools, but graduates soon find out about the lack of opportunities to build on their skills. If all that is required for a job is "a degree" it is understandable why students take what they see as the easier choice.

Regarding teaching: participants noted that academic qualifications are the primary measure of teacher suitability, but that valuing industry experience in teachers would help them pass on a greater sense of usefulness or relevance of ICT to students.

The workforce

(both education and skills more generally)

The ongoing loss of talent in Australia was seen as a major issue. Participants felt that Australia is good at fostering talent, that then leaves.

There was a sense that too little international R&D is attracted to Australia, and we need more opportunities to attract large companies to conduct their R&D here. There was a perception that Australia seems to be a good place to have a sales office, but not to conduct serious R&D.

The issue of destinations for ICS and related graduates was raised repeatedly as a cause for the loss of Australian talent.

The role of a skilled government was also raised in the context of the ongoing loss of technical skills and deep content knowledge from core agencies, especially in the senior levels of the Commonwealth.

1.2Sydney

16 June 2017

General views

"No field of human endeavour that isn't affected or won't shortly be affected by ICT in some way" (Even the meditation and yoga community are active online).

Seeing the problem-space in a 3D framework broadens how we consider ICT in society and gives us a way to navigate the space. The framework is just a tool – we are still required to do the navigating.

There was a view that research tends to get over-weighted in these sorts of plans. (NB: identifying research priorities is one of the aims of the plan!)

Australia's political organisation is not conducive to providing policy consistency. Inconsistency of policy and resources was seen as undermining what we have been trying to achieve, both by failing to provide industry with a stable investment setting and by failing to provide academia with the stability required for long-term research. The public has grown tired of academics calling for greater job stability, yet this is not necessarily self-serving—the big challenges take a long time to solve. Academia has done a poor job (beyond ICT, this applies to all academia) at communicating this.

At the same time, technology is increasing the pace of change and increasing the immediacy of the pressures of the political system. While we crave stability and a bipartisan commitment to the importance of STEM, we also want policy to respond more quickly. *This trade-off was not noted during the meeting but both demands on government were made within the space of minutes—the fact that policy* ***does*** *change quickly was seen as a source of great frustration.*

A general question about overall sectoral and wider economic strategy was raised: What is going to happen when the ICT transition permeates the whole economy and reaches its end-stages? What kind of economy will we have? We need to make sure Australia is strong in the things that will be important in the post-transformational stages. This may mean acting on uncertain predictions, which would require courage.

Research quality and relevance

Participants felt there was nothing wrong with the quality of Australian research, and it is often conducted in areas that are 'relevant'. A small amount of research that doesn't have an obvious application (the word 'irrelevant' is unfair/unkind to the role of blue-sky research in underpinning the 'directly relevant' research of the future) is not a bad thing—it just has to be proportional to what we can afford to support and of sufficient volume to provide the pipeline of 'relevant' research.

The idea of 'research relevance' is often subjective. It depends on where you sit: on a national scale, large programs (tens to hundreds of millions) are required to be 'relevant' to some of our continental-scale issues. On a problem-scale, small ARC projects (tens to hundreds of thousands) can make progress. This is often unstated in discussions about research relevance, and people fall back to a natural assumption that everyone thinks like they do. There is no 'right relevance', it is simply a matter of perspective.

Research impact

While the research is of good quality, it is often not collaborative enough to facilitate impact and uptake—but this is discouraged by academic performance metrics.

The need for a broader range of academic impact metrics was discussed. No agreement was reached on what those metrics would be—the closest to an agreeable statement is that all metrics have trade-offs and can/will be gamed. Researchers are smart and will game any system.

Participants noted that they generally lacked knowledge of:

- Australia's research and industry strengths across the whole sector. While some areas are quite small (a few people, or even one person) and personal networks can be effective, the isolated pockets of strength are hard to identify and connect with from the outside. Interestingly, those on the inside could not see the problem because they were so well connected. When asked about something out-of-field, they then saw a problem.
- How well matched our research and industry strengths actually are. Strong companies aren't necessarily supported by strong research and vice versa. Australia may benefit from mapping this if we are serious about 'better linking research with industry'—we might find we need to adjust or incentivise change on either or both sides. There could be opportunities to support new industries in areas where we have research strength to support them (equivalent to overcoming an activation barrier in chemistry, after which support is not needed), or to establish research strengths in areas where our existing industries rely too heavily on following overseas innovation.

Research infrastructure

Participants considered that Australia has a current strength in research infrastructure, but worried deeply about the longevity of that strength. Our flipside weakness is that we have a political system in which a once-off investment is considered to have fixed the problem—but in ICT an asset is antique at 4 years and dead or non-competitive at 6. It is possible that there will be a gap of more than 4 to 6 years between the type of investment that created the NCI.

There was considered to be a clear case for collaborative infrastructure—single actors cannot afford the whole investment, but there is no shortage of subscribers to the NCI. NCI is mostly subscribed by Geoscience Australia and the BoM, and the $62m investment in machine room 4 generates $15m per year in subscriptions. Collaborative computational infrastructure investment should not be considered a budgetary drain, and enterprising state governments could capitalise on opportunities to host major facilities in their jurisdiction to attract the economic activity around them.

The neglect of technical and support staff as an essential part of infrastructure was cause for concern. General consensus was that support staff aren't valued (or given job security) compared to the contribution they make, and that the 'big bits of kit' aren't as useful (or are only useful to very few) without them. The need for additional funding for travel as part of operating infrastructure was also raised—Australia has dispersed infrastructure and the tyranny of distance reduces its value if students, EMCRs on restricted budgets, and technicians are not supported to travel to use it. Targeted travel grants for research infrastructure access would be a low-cost initiative with long-term impacts.

Broadening and distributing collaborative infrastructure was seen as a good thing: it makes it harder to sell or cut. A tightly bunched business unit makes it easier to package up and sell.

Innovation and translation

Discussion largely centred on IP. There was a minority view that:

- universities in Australia simply don't patent Australian ideas and inventions. (NB: This assertion is not supported by patent data).
- Australia would benefit from a legislated requirement to keep IP and money in Australia. (NB: This assertion is not borne out by trade modelling)

Participants observed that Australia seems better at harnessing benefits from IP when research is multidisciplinary (but we don't do multidisciplinary research as well as we'd like either), especially in the ICT/health and medical (MedTech) industry. Australia has established industries and innovation translation experience in MedTech, but this appears to have remained in MedTech. There could be opportunities to apply lessons from that field to other fields of endeavour where Australia is research-strong but industry-weak, and vice versa. We could begin with a detailed study to examine the research and business context of MedTech versus other application areas, and by comparison, identify actions to try in other areas.

The CSIRO approach of protecting high value IP was noted. Defending patents carries financial risk because of the legal fees, but it could be argued that all an institution needs is one or two high value successes and the enterprise becomes entirely self-funding or revenue positive.

Extraordinary difficulty obtaining technology licences from Australian universities was noted. Off-the-record quotes included:

- "it is easier to licence something from a university in Any. Other. Country".
- "Two years' worth of legal negotiations over something trivial just isn't worth it. It's a cost we don't get elsewhere. With Princeton it takes 6 days"
- "Why would I want to work with that? And you know what, I don't have to."

The IP question raised a broader philosophical debate about the role of academia in society. Are academics profit-oriented? Should they be? Open access research contributes to faster scientific progress, and a macroeconomic argument could be mounted that we all benefit economically from faster research progress that does not place licencing barriers to uptake.

It was noted that some Australian universities are moving towards open research policies and standard licences to remove arduous licencing negotiations as a barrier to uptake. Anecdotal reports emerged of companies not pursuing IP licences that would otherwise be valuable to them because they would have to deal with a particular university's legal department, and prior experience had warned them off.

Participants noted that academics often over-value their IP and this provides a disincentive to uptake. They are (generally) also not the right people to take an idea or invention through to commercial success, as these are very different skill-sets. Simply applying incentives, or performance pressure, to/on academics to commercialise their work is not likely to alleviate the existing difficulties that business experiences when dealing with universities.

One of Australia's strengths was considered to be that we have lots of smart, inventive people, but we have a flipside weakness in that we build ideas up then sell them so the longevity of the benefit doesn't stay in Australia as much as it could.

Education

Participants noted the need to grow the domestic pool of ICT graduates. Relying on immigration may not be guaranteed, especially as the rest of the world develops more rapidly than us.

The role of career visibility was discussed. There appears to be a strong need to reach students before they get electives in high school, and also to educate the parents who influence student choices. Australia seems be culturally weak at advising students what to study. (Aside: not discussed—this is true also at the university level: funding follows numbers rather than directing numbers, thus placing teenagers in charge of the funding distribution rather than strategists).

Technology parks in some cities were raised as an example of something students need to see more of—they would provide career visibility.

The issue of out-of-field teaching was raised as a reason why students are not inspired.

Universities are both a strength and a weakness for Australia:

- They are seen to be prone to curriculum changes that are not necessarily well thought through—the long-term impact of changes needs to be considered more formally.
- We have lost the technological colleges that once produced high quality technicians, without replacing that role with a suitable training option. Combined with a growing lack of regard and job security for support roles, are skilled techies now being replaced with BSc grads who see it as short-term a fall-back job to gain experience 'for something better'? ('where something better' means more well-regarded and stable).
- The increasing separation of research from teaching was seen as depriving students of what was once great about Australian universities. A general question was posed about how long Australian universities can keep trading on their reputation if this trend continues.

Regarding PhDs:

- The human skills and broader context of research in society is often missing from ICT PhDs. (NB: not discussed—this is not unique to ICT, it is a comment made by most disciplines). In some cases, PhD supervisors are ill-equipped to provide this context as well.
- The length of Australian PhD programs places Australia at a competitive disadvantage with respect to the depth and breadth of education that a PhD can provide. A very small number of universities provide scholarships that are longer than the minimum three years, and (to our knowledge) none provide scholarships that approach the length of a US scholarship. It was noted that the Australian Government provides financial disincentives to universities to allow long PhDs, even when a student is off-scholarship and not costing the government anything.

The workforce

(both education and skills more generally)

Australia has trouble turning good students into good employees that stay put. Example: engineers have a half-life of about 5 years of actually practicing engineering. Usually the way up is to go into management. Career progression most often means getting out of practice. At the same time, participants noted that many managers have little skill at judging technical quality—up to and including the C-suite. The contradiction of this point with the previous (losing skilled people to management) was not noted during the meeting.

Regarding people, NCI reported trouble finding skilled people for the work they do—there are enough IT graduates, but very few have domain knowledge in any of the disciplinary sciences, and very few disciplinary scientists have deep enough ICT training. The view expressed was that we need *all* of:

- More well-rounded education—it was suggested that double degree graduates pick up jobs much faster than single degree graduates. It was also suggested that STEM students need arts and humanities just as art/humanities students need some level of STEM.
    - Educate both students and their parents about what good study options are.
- Greater mobility in professional development
    - The 'outside-in' and 'inside-out' training idea: placing ICT specialists in other roles (with training) for a while, and placing other researchers/professionals (with training) in ICT roles for a while. Training must be sufficient—beware the possible side effect of encouraging bad code.
- More effectively building *small to micro* teams with the relevant skills. This could be as small as pairing people (e.g. the AADIS model was led by a pair: a veterinary epidemiologist and a computer scientist).

The UK idea of half-time appointments between defence and academic roles was noted positively. Experience in the UK found that the performance and motivation of researchers during those appointments increased, and that productivity in the classified portion of their work increased despite it being allocated less time.

Participants noted that our employment culture, along with much of the developed world, appears headed towards an increase in internships, single task arrangements (AirTasker, *et al*), and short-term contracts—the very opposite of the employment conditions that are required for people to tackle problems at scale.

1.3Canberra

18 August 2017

General views

Participants felt that the term ICSET was so broad as to make it difficult to gauge its scope, and very difficult to get a conceptual grasp on. Participants noted that 'information' comes from 'data', which is not explicitly included but should be recognised as the foundation of ICS and ICT.

A comparison was made to a strategic planning process that physics undertook, in which it established (1) does Australia need physics? (in terms of economic impacts), (2) Australia's performance internationally (international context / benchmarks), and (3) the education pipeline. The National Committee for Physics found that Australia's real strength was the education pipeline. It also found that there was very little expectation (from within the research sector or elsewhere) that Australian researchers would find applications within Australia. The same may be true of ICSET researchers, who may not expect uptake at home, yet expectations around applications appear to be much higher and closer to home in the general public (despite the obvious difficulty of Australian ICT product development – small population, no silicon foundry, etc).

Research quality and relevance

In conducting any review of research quality and relevance, there is an implied comparison between Australia and the rest of the world. International performance is the most common, and meaningful, benchmark because there is no ICS or IT context that is purely Australian. It is an international field of endeavour.

For academic research, a possible metric of performance, quality and impact is the number of international citations and the way in which Australian work is cited in international work. Analysis in 2001[2] indicated that while Australia was within ±5% of international norms for most disciplines, ICS and IT publications were cited 20% less than international averages (this speaks to relevance and impact). It was noted that this was about the time that NICTA was established, and that a re-analysis for 2017 would be informative (possible action).

A suggestion was made that quality and relevance were two very different things: Australian research can be excellent research, but is often on the wrong thing. As such, a lack of data collected on basic questions of relevance is a major barrier to effective action.

Given the lack of data on what the problem even is, it would be useful to develop a meaningful metric and apply it consistently for a long time. For example, ABS business surveys simply ask a question like "did you innovate" but cannot test the voracity of the responses. Similarly, the 'new to firm', 'new to country' and 'new to world' classifications of innovation do not have a mechanism to identify and correct for incorrect reporting by companies.

[2] Australasian Science, 22 (8). 2001.

Research impact

Participants posed the question: 'is there something we research here that isn't researched elsewhere?'. (While not discussed in the meeting, this hints at the deeper strategic question of how Australia creates points of differentiation within an international research enterprise—do we deliberately carve out niches by subject matter, or do we focus on excellence in itself and let the niches emerge? It seems Australia is somewhere in the middle).

Regarding setting research priorities to marshal Australian research activity: in the ICSET space Australia has only identified *cybersecurity*. Participants felt that national priorities were assisted strongly through most funding streams, but that having ARC (and NHMRC) able to identify and fund the best research regardless of topic was highly valued (e.g. quote: 'leave ARC alone please'). Participants agreed in-principle on the benefits of being able to marshal Australia's research towards problems that are useful for Australia, yet noted that the process used to generate those priorities would be even more important than the topics themselves. A suggested approach was to consider:

- where the specific technical issues are that Australia cannot afford to neglect, and
- which issues will have sufficient longevity to warrant selection as a national priority (to avoid chasing fashions)

Participants noted that the terms 'product' and 'commercialisation' shows a narrow conceptualisation of the problem space that may limit the effectiveness of any changes that current public policy initiatives could achieve—processes can be just as profitable and are more relevant to some sectors, such as FinTech. In particular, the conceptualisation of impact as 'developing and selling product' or 'commercial success' may not be appropriate in some areas.

With respect to the direct impact of research: there appear to be numerous areas in which there are currently no technical barriers to direct application, hence impact. Examples include using AI for tax advice, some types of mediation, or efficient insurance assessment and settlement. Additionally, technology is available to help older people experiencing cognitive decline to retain access to the internet (a problem set to grow in the coming years).

The long-term impact of ICSET and other research on society was also discussed. This level of research impact is much broader than that considered for individual pieces of research, or even major research programs. Such impacts could include:

- City planning and design will have to adjust to widespread uptake of autonomous cars, yielding both challenges and opportunities for the use of space in the built environment.
- Societal impact of widespread automation and the need to adjust to changing social orders as some jobs are automated before others.
- The need for consumer protections on the use of big data, for example by insurance companies or retailers, where the capability provided by that data and analyses may not be in the public interest.

Participants noted that the research impact of specific projects or programs should be considered in the wider research impact context where possible, despite the inability to attribute causes and effects beyond a certain point.

Innovation and translation

Participants noted that Australia lacks the companies that can/do invest heavily in ICSET R&D (e.g. Google, Amazon, etc). A recent example is in machine vision research—the Amazon picking contest was won by an Australian team, yet that technology has not found application in Australia. Participants were of the firm view that this will take major, long-term cultural change to address. Sweden was raised as an example of a start-up culture that would be desirable to emulate through such a long-term change.

The role of formal brokering between industry and academia was discussed, as well as the potential to learn lessons from countries that have well established and influential formal brokers. Scotland was cited as an example. Formal brokerage was considered potentially beneficial in Australia because the Australian system encourages universities to 'push' yet industry has little incentive to 'pull'.

The role of government as an exemplar was discussed:

- The concept of government as skilled agencies is declining with the progressive non-recognition of higher degree and technical qualifications in specific areas (e.g. most recently veterinarians in the Commonwealth Department of Agriculture and Water), and the drift towards generalist administrative functions. This is not to say that people with high qualifications no longer work in government—they are just no longer recognised or valued as experts and their impact is thus reduced.
- Government procurement almost exclusively focusses on products, as opposed to an approach of procuring solutions to problems, which would encourage innovation. Procuring a product is appropriate when the exact problem and required specifications are known, yet this is not often the case in government agencies that lack recognised experts.

Regarding intellectual property: participants were of the view that there needs to be far less focus on protecting IP, and more focus on getting academics to work more productively with industry (and vice versa).

Participants also noted that the nature of interactions between universities and companies will be different depending on the companies and the universities—either we standardise some aspects of IP management, or we accept that national solutions will not be uniformly effective.

Finally, regarding IP: it is more widely seen as a hurdle by researchers than as an opportunity. The complexity and slow speed of university administration was cited as the main reason.

Education

Regarding skills retention, keeping good international students in Australia after they become qualified was seen as a way of using our education system's strong reputation to attract and retain the best people to Australia. Participants also noted that public policy is currently changing in ways that make it harder to keep people after the end of their course.

Regarding the issue of coding in schools: participants confirmed that coding was a useful skill, but worried about the already-full curriculum and what would have to be sacrificed to make class time for coding—likely the creative skills that are predicted to be important as automation progressively removes the less creative jobs.

Out of field teaching, especially in mathematics but also in most sciences, was raised as a long-term issue that is likely to be having a slow-burn effect on our whole education system—the decline being gradual enough as to never warrant attention as an acute crisis, but the effect being just as profound.

Regarding the education system in general, participants provided a snapshot of the various strengths and weaknesses of each main stage:

- K-12: quality of K-12 teaching and learning outcomes in Australia is perceived to be declining across the board, both by international norms and when compared to our past strong performance.
- Undergraduate: Australian performance is currently on par with global norms, except for mathematics which is declining. (Additional note not discussed: if K-12 is declining and the use of bridging courses for university entry is increasing, how long does Australia have before home-grown university entrants can't keep up with international university entrants? Two outcomes are then possible: (1) quality of Australian Batchelor courses will have to fall, affecting education exports, or (2) a two-tier system in which Australians are inferior. Neither outcome would be acceptable.)
- Masters: there appears to be a gap in the Australian system at Masters level. Participants held the perception that the revenue stream from Masters courses is the primary consideration of universities, rather than educational outcomes.
- Doctorate and higher degrees: Australian performance is currently on par with global norms, noting that:
    - Coursework components to improve IT skills will be increasingly required
    - PhDs should be longer and broader to give Australian PhD graduates equivalent depth as other countries, and to be more immediately employable outside of academia (95 to 98 percent of graduates end up outside academia)
    - Entry pathways to HDR training in Australia needs reform to keep up with global trends, and
    - The same K-12 decline that threatens Australia's undergraduate degree programs will also propagate through to threaten higher degrees.

The workforce

The graduate destination survey (and its post-graduate analogue) could be used to verify an assertion that industry is increasingly hiring PhDs.

The ACOLA review of the higher degree research training system[3] (ACOLA, 2016) found between two and five percent of doctoral graduates find employment in academia (depending on discipline). Participants discussed the value that the remaining 95 to 98 percent of doctoral graduates bring to industry, government or the non-profit sectors. The value is difficult to measure by standard metrics, but its existence and importance was noted. (Not noted during the workshop: the HDR training system therefore is not primarily for research training, it is an indirect training route for myriad other jobs).

The issue of Australia's workforce culture was raised repeatedly, including the need to encourage SMEs and start-ups.

[3] https://www.education.gov.au/review-australia-s-research-training-system

Regarding workforce linkages between academia and industry: German technical universities were given as an example model of academia-industry linkage. Five years' industry experience is a minimum requirement for a position at a technical university, which means any appointee has established networks in industry and is able to place students, start collaborations, etc. This cannot occur in Australia for a range of reasons including publication requirements on ARC and NHMRC grants, and that ERAs strongly drive researcher behaviour despite being of relatively low financial value.

Joint appointments between academia and industry were raised as an example of a nice idea that is spoiled by trying to realise it. The rarity of joint appointments speaks for itself, and the experience of joint-appointees seems to vary wildly. An alternative was proposed: some universities around the world simply allow their academics to take part-time employment elsewhere.

Regarding the issue of IT professionals in scientific or other research, versus scientists and other researchers becoming deeply IT-competent (outside-in versus inside-out), some participants were of the strong view that it is easier to get scientists working on a data-intensive problem than an IT professional to understand the science. There were also strong assertions that ICT graduates generally do not have sufficient mathematics, but graduate scientists do.

1.4Brisbane

21 August 2017

General views

Participants noted the need to be clear about Australia's intentions in participating in ICSET research considering our population is far too small to support some of the large industry that ICSET is associated with, and that availability of research investment in Australia is an order of magnitude smaller than other countries. We therefore need to be clear about to fact that we cannot hope to lead, and perhaps may not even be able to keep pace. What is more achievable for Australia is to target some specific niches in which we can lead, and to maintain sufficient capability to access international research and make the most of it for Australia. This realistic view was noted as being much harder to sell than unrealistic visions.

A general view was stated that the research sector was not balanced, and that CSIRO / Data61 encouraged substantial funding inequalities.

Research quality and relevance

Participants noted that ICSET is an international endeavour, and that focusing narrowly on Australian performance using the ERAs would only provide part of the picture. Questions of research quality and relevance need to be addressed in their international context, and comparisons between Australia and other countries will be essential. However, care should also be taken to place comparisons in context, as different countries also have different populations, natural resources, market dynamics, trade profiles, etc.

Research quality—both in Australia and the rest of the world—was seen as being higher and more prestigious in the core disciplines, and that a portion of the research community is fiercely protective of the core disciplines. A litany of well-known problems with inter-and trans-disciplinary research was aired, including that such research tends to be less applicable/transferable/generalizable outside of the immediate scope of the problem of interest at the time and its impact and longevity of impact is therefore lower.

Research impact

Research in the core disciplines was seen as having long-term or far-reaching impact, whereas inter-disciplinary research was seen as being focussed on problems-of-the-day and having more immediate but problem-specific impact. Inter- and cross-disciplinary problems are often quite exciting and inspiring, but there needs to be a spectrum of research that yields impact along the whole pipeline rather than at one end of it. (Not noted during the meeting: this has some strong parallels with the descriptions of 'pure' versus 'applied' research, and may even be emerging as a proxy in some circles).

Participants noted that in some cases, collaborative (or even interdisciplinary) research may be misclassified, and that simply sharing or re-using data should be solved by adequate data management and custodianship. A national, accessible research data custodian may by-pass what is currently seen as collaboration, and may reduce the scope of what we consider as interdisciplinarity. The implication of this is that some of what we currently consider collaboration should in fact 'just happen' without the need for formal collaboration (and the transaction costs it entails) if only we had our act together on data availability and reuse.

Research directions and impact in Australia was seen by some participants as being dominated by Data61, which directs Australian research impact to narrow areas and may take research activity out of universities. Participants also noted that universities could engage more directly and more fully with the Defence sector for funded, high-impact research of national significance.

Research infrastructure

The SKA project and related infrastructure is a significant ICS and ICT challenge for Australia, but the fact that it is seen as an astronomy project was considered to show something about Australian culture. In short—Australians relate to astrophysics (a field removed from our daily life experience, by definition) more easily than they do with ICS and ICT.

Innovation and translation

Participants floated the idea of setting a (non-binding) target for academic institutions to encourage every second sabbatical to be spent in industry. Once progress is made towards such a target over several years, there is a genuine expectation that the initiative would gain momentum and greatly assist with academic access to industry infrastructure, and with industry visibility into academia. In the longer term, this would assist (together with other policy measures) with research translation, and perhaps with other supporting conditions such as the ability to place PhD students in industry via networks that academics and companies build.

Regarding intellectual property and its role in technology translation and commercialisation: participants noted that open IP policies are sensible to maximise uptake/impact as long as research as seen as a public good. However, if research is considered as a 'for-profit' enterprise then IP logically has to be protected. (Not noted during the workshop: This appears to be a philosophical point as there does not appear to be an evidence base on the costs/benefits of the two approaches—perhaps because Australia has historically sought a middle-ground between the two options without conscious consideration, or a national debate that was not political). There was a general consensus among participants that defaulting to open IP would lead to faster technological progress and overall economic gain, yet the location of those gains could not be predicted.

Regarding general IP agreements and standardising IP management across universities: ARC and NHMRC would be in a position to impose standard terms on IP developed using ARC or NHMRC funds. Participants noted that this approach has been used with success by some programs in the US and Europe.

Participants noted the conventional wisdom that start-ups drive translation, but also noted that the majority of high-tech start-ups have been underpinned or initiated by publicly funded research. What the nature of the return on investment should be is also a matter of political opinion: return to society as a whole (as investors in publicly-funded research), or return to the researchers and entrepreneurs who carry out the research, innovation, translation and commercialisation. However, the need to maintain publicly funded research to start the process is clear, and it can be justified only in some interpretations of the nature of return on investment.

Regarding national priorities to direct research, innovation and translation towards areas of Australian need: participants noted the need to gain broad agreement to, and buy-in for, any priorities, and also the difficulty of gaining agreement. They are difficult to agree even at the university level. For example, the only current national priority, cybersecurity, was seen by some participants as not being broad enough to be useful for the whole nation. AI was proposed, and other participants noted that AI is a relatively narrow methodological descriptor that has application to many things, including cybersecurity, but that it isn't the only approach. It is even difficult to establish the means of arriving at priorities and form they should take (by topic, by application, by method, etc).

Education

For the university sector (and upper school to some extent), physics, chemistry and biology have a monopoly on practical field and laboratory work, but programming and computer science has online courses that are more rapidly brought to market, more relevant to current trends, and can produce more employable people with work-ready skills (at a point in time). Second and later-year students are sometimes financially better off to drop out and get a job, especially roles that require life-long-learning anyway. (Not noted during the workshop: the monopoly on laboratory work is not guaranteed either—iPhone spectrometers are a few dollars, benchtop/handheld DNA sequencers are coming down in price, Arduino-based environmental sensors are a few dollars each and can replace expensive analytical equipment, consumer 3D printers allow production of specialised lab equipment or physical models for a few dollars[4], etc. The cost barrier to entry for physical and biological science practical exercises is rapidly decreasing, and online tutorials are increasingly accessible. It may simply be the case that ICS and ICT is the first undergraduate domain to be truly disrupted by online learning, and that (as with most areas of human endeavour) accessible technology will sweep through the rest of the sector in due course, bringing similar changes).

Having lost a portion of the 'ICS and ICT educational curriculum space' to online courses, the remaining value proposition for bricks-and-mortar universities is (currently) in cluster computing and

[4] See, for example, https://www.thingiverse.com/explore/popular/learning/page:1

robotics (with respect to topical content), and the soft skills that make graduates good team members and valuable employees. This has implications for the role of universities—are they developing the personal attributes of graduates, or are they developing technical knowledge and skills (NB: not mutually exclusive). The implication of this for how and what universities teach is yet to be seen, but the change in value proposition will have to be effectively communicated (to both industry and students) to stem the trend of industry poaching second and subsequent year undergraduates.

A range of views regarding PhD training were discussed, including joint industry/academic PhDs, short placements in industry, and balancing the need to instil a sense of academic exploration.

Long-term geopolitical changes are set to affect the dynamics of the international education market and the flow of students around the world. These are likely to affect the business model of Australian universities, and tertiary education sector more generally, and participants noted that the UK, US, Europe and Australia all share a degree of dependence on educational exports. A foresighting exercise to evaluate the opportunities and challenges that this may present would be worthwhile.

Regarding university funding, philanthropy works well for some universities, but not all. Established and prestigious institutions tend to attract philanthropic funding more successfully than others, and that increasing reliance on philanthropy could have the unintended effect of reinforcing advantage (and disadvantage).

The workforce

Participants discussed mobility between industry, government and academia and criticised the efficacy of the ARC’s way of addressing the issue—output relative to opportunity weightings in grant applications. Participants also notes that this issue is not unique to ICS and ICT, and deeper examination of this issue in a wider context would be warranted. Similar considerations apply to consideration of industry experience in academic career development and promotion decisions rather than maintaining a narrow focus on publications and H-index.

Participants suggested that a contributing (but not only) factor to the workforce divide between industry and academia is that IP agreements with universities can be exceedingly difficult in Australia. There were anecdotal reports of companies deciding to conduct work in-house rather than deal with universities for this reason.

1.5Adelaide

25 August 2017

General views

Participants agreed that ‘ICSET’ as a new initialism could be confusing. Technical acronyms/initialisms were not considered to be helpful for generating impact on wider society. The relevant ATSE Working Group now uses the Plain English term ‘digital futures’.

Some state governments, and even local councils, have plans of varying depth and sophistication for IT and big data, yet the Commonwealth does not (beyond specific agencies such as Data61 and Defence). Participants noted a lack of high-level leadership in ICS and ICT in Australia.

Participants noted that the scope of ICSET is broader than could possibly be achieved. For example, the number of dependencies in the education sector alone is difficult to even map, and that it may be worthwhile limiting this project to expressing support for existing STEM initiatives and public engagement initiatives at large (in lieu of advocating for wholesale cultural change).

Research quality and relevance

Regarding current metrics for research quality: ERAs were seen as too broad to be useful (i.e. insufficient topical resolution that lumps broad areas together). Research topics at the project level are too specific to be captured accurately by ERAs.

Participants noted the current proposals and pilot programs to include industry engagement with universities as part of the ERAs, yet results are not yet available. This would be worth monitoring closely and perhaps re-analysing / supplementing to see if there is an impact from the industry side (as opposed to the research side).

Notwithstanding future improvements to ERAs, that type of approach is, by definition, looking backwards, and it will always be difficult (or perhaps even unfair) to make assumptions about current research using ERAs. Regardless of how 'good' ERAs get, we will still require a range of metrics (including ERAs) for some decisions.

Difficulty in establishing research strengths makes it hard to connect industry with academics, and even harder to demonstrate relevance (on a national scale).

When considering collaboration as a measure of relevance: research to business is often the default measure, but collaboration between research institutions may also be useful, and can sometimes be just as hard to establish. The number of research groups in Australia makes it hard to see what is going on and where, and what good even looks like. Breaking down the 'visibility barrier' between researchers could be a useful first-step in breaking down the barriers between researchers and businesses. An international perspective was provided that, for example, South Korea knows much more about other countries' research facilities and universities than they know about ours. Obtaining information about relevant research capability in Australia is difficult for them too, which means that tackling the problem of visibility would have multiple positive effects (not least innovation uptake and research impact, see section below). (Not noted during the workshop: if research is high quality and addressing an area of need, but no one knows about it, it is not 'relevant').

Regarding research-research collaboration: participants noted the ability of the Defence CRC program to encourage universities to partner up and develop coherent programs (and the supporting capabilities) around specific areas of need (e.g. trusted autonomous systems).

While the small size of our research community is not a weakness in and of itself, Australia's current research funding systems do not appear to fully account for size. For example, academic participants noted that they often know their grants are assessed by people who know very little about their field "because everyone skilled in my field is conflicted".

Participants noted research gaps (and business/workforce gaps) as:

- Big data use and management
- Cloud storage and data custodianship

- Cyber security
- Quantum telecomunications

Of these gaps, only one has been identified as a national priority.

Research impact

Research impact—different types of research have different impacts that need to be measured in different ways. For ICS and ICT, impact can also be defined in terms of impact on the other sciences and end-users. That is, people who are not IT professionals but who are literate and able to use ICT products and services once they are developed beyond the research phase. The majority of the ‘data-revolution’ sweeping the sciences can be considered in this way—big data and other resources are available yet their impact is sometimes (perhaps often) diminished by the lack of additional effort required to make them accessible (as distinct from merely available) to others. This may be a reflection on the incentives in place for those in academia, business and government who create such resources.

Australian governments have cut back (to zero for some countries) on travel allowances for international collaborative research. The effect of reduced international collaboration in an international research endeavour (as ICS and ICT is) should be obvious.

Participants suggested that other countries could provide models to boost Australia’s research impact. For example:

- Sweden runs annual research prioritisation processes that includes both academia and industry, and calls four funding rounds each year targeting those priorities. Regardless of the size of the total research investment, such an approach would be expected to marshal research towards areas of national impact. Comparison was made with Australia’s expensive R&D tax incentive which does not direct research strategically.
- Research councils in the UK are populated by experts who can set priorities within themselves. Comparison was made with the ARC and NHMRC, both of which make use of experts to assess applications but not set priorities. There was a strong perception that the highly skilled people employed in the Australian research councils (and indeed in governments more broadly—especially the Australian Government) are not used appropriately.

Participants noted with interest DSTG’s approach for the Next Generation Technology Fund (NGTF), which allocates funds for research into defined challenges. Solutions to the defined challenges are considered to be the priority, which changes the basis of the investment (from investing in projects, to investing in solutions). The timeframe for the defined challenges under the NGTF is also expected to allow (at least some of) the research to span the ‘valley of death’ between research and application—an approach which also contrasts with the short-term nature of Linkage grants, and even the often-too-short-lived nature of CoEs and CRCs.

Participants noted the merits of university and industry co-location to provide supportive conditions that could increase research impact. Examples in the US include whole divisions of companies (e.g. Intel) located on campuses. While Australia lacks Australian companies of the scale of Intel, Google, Apple, Facebook, etc, the nature of multinationals means there is technically no barrier to them setting up divisions in Australian universities. There may also be opportunities to attract whole sectors to university precincts rather than single, large companies. The result would be multiple, related companies interacting with universities, which could create a more dynamic knowledge exchange and help any given piece of research find its niche.

There may be a role for governments (state and Commonwealth) to attract this type of investment into Australian universities under the same type of initiatives as other inward investment attraction (e.g. major conferences, significant new developments, major sporting events, etc). (Not noted during the workshop: There have been smaller-scale attempts at co-location in Australia, such as the Motorola Building at UWA which was renamed the Ken and Julie Michael Building after Motorola chose not to continue its sponsorship arrangements).

Research infrastructure

Participants considered that under the current Australian system, proposals for big-bits-of-kit (BBoK) appear more successful than proposals for distributed infrastructure, which are in-turn more successful than proposals to fund access for researchers to information or data. This sends a message about relative values that may not be in line with impact (or scientific return on investment).

The infrastructure that is (and will be) needed for the IoT, or the 'industrial internet', does not appear to be included in considerations of research infrastructure: there appears to be an assumption that researchers will simply use commercially available services when they need them. However, this means we may be unconsciously placing a limitation on Australian research in an area of expected strong future growth. Considering the distributed nature of IoT and the relative success of BBoK rather than distributed infrastructure, it is not clear that NCRIS is the most appropriate mechanism for this type of research infrastructure. Australia needs to investigate the most appropriate way to plan for expected IoT explosion, especially considering that the rate of change is also increasing, and that being ahead of the curve early will likely favour those ahead of the curve (or the converse: catching up will likely get harder and harder if we fall behind).

Participants noted that the politicisation of the NBN was a huge opportunity lost for Australia.

Innovation and translation

Participants discussed the idea of an 'innovation research push' versus a 'pull on innovation from business', and that, if seen in the context of supply and demand, it is imbalanced heavily on the supply side (not noted during the workshop: to take the analogy further and extend it slightly beyond its literal limits, this could lead to a business perceiving academia as lower value). Addressing the supply/demand balance could be helped by:

- Addressing the lack of awareness on both sides
- Improving understanding of the different needs and limitation of both industry and business: the time to delivery research is often different from the time available for commercial (or government) decisions; the drivers for research are generally different.
- Addressing what is currently perceived to be a lack of mutual respect between academia, government and business (noting that awareness would come from mutual respect, and mutual respect from awareness).

Participants discussed the need for government and industry to work together in pursuing innovation and translation. For example, a participant who previously researched in Sweden noted: "I didn't know for 6 months if someone was from the industry side or the government side because they worked as a team". This situation was contrasted with Australia, where all three levels of government lack that alignment to various degrees.

Fewer skilled people occupying fewer technical roles in governments in Australia was identified as a major reason for the lack of alignment between government and industry (and indeed, between government and academia). There was a general consensus that central governments (especially Commonwealth agencies) no longer engage in technical arenas: where they do, engagement is via short-term consultants or by non-technical bureaucrats, and is therefore less effective than it used to be. To illustrate the point, participants noted that DARPA grand challenges are presented very professionally and are obviously developed in-house by people who deeply understood the subject matter, who could analyse the literature and prioritise the challenges. Similarly, for example, the calls for proposals undertaken by the EPSRC in the UK[5] are targeted and assessed by in-house deep-expertise. The same cannot be said of the Australian Government.

A particularly long-term view was proposed that if IP is not protected at all, it will eventually return as philanthropy.

Participants noted that, despite the industrial and consumer applications of some types of ICS and ICT, there is little difference between ICS and ICT research commercialisation and the commercialisation of other sciences. Suggested actions to improve the success rate include:

- Co-location (see 'research relevance' above).
- Re-shaping Australia's current research culture from highly competitive to more collaborative (with other research groups as well as with industry).
- Collaborative marketing (e.g. recent presentations of relevant capability by all three SA universities to energy industries and suppliers in the Upper Spencer Gulf).
- A formal brokerage role between research and business to match business needs with research capabilities.
- Longer funding horizons (not necessarily more money) for research, possibly accompanied with the approach employed for the NGTF and Defence Innovation Hub (both with 10 year funding horizons).

Participants noted Australia's lack of ICS and ICT-heavy large companies, and that our SMEs, while prolific and economically important, do not appear to have an entity or a locus around which to cluster. Providing such a locus could present a huge opportunity for Australian universities—particularly the 'technical universities'. This would be a new type of leadership that is possible because of the nature of our economy.

Regarding translation: participants noted that while all industries will experience digital transformations, we should focus on those of greatest importance to Australia's future competitiveness that, without help, would lag the rest of the world. This is ICS and ICT's greatest opportunity to lead, and in doing so help other sciences and industries become leaders. The first candidate should be Australia's minerals industry (already engaged and beginning to understand its digital transformation[6]), then agriculture and health. (Not noted during the workshop: the economic importance of FinTech to Australia is as great, but may not require such active help – its transformation is well underway).

[5] https://www.epsrc.ac.uk/ At the time of writing, the current call for proposals was ICSET-relevant: feasibility studies under an 'Industrial systems in the digital age' theme.

[6] For example, www.uncoveraustralia.org.au will require ICS and ICT-based breakthroughs in Earth Science.

Education

Participants consciously limited discussion to higher education to make the scope of discussion more tractable, and expressed support for the many initiatives already underway to boost Australia's performance in STEM in schools and the general population. For example, the primary school curriculum already has a digital technology component, yet out-of-field teaching has been identified as among the most significant problems, especially if teachers are going to keep the curriculum inspiring to children and make the most of it. Similarly, teaching needs to become more culturally valued, prestigious and well remunerated (*cf*. Finland).

The difficulty of attracting PhD students was noted (workforce implications are discussed in the next section). Participants discussed what appears to be a narrow view of education in Australian culture:

- Few people travel away from home for university studies (more for post-grad than undergrad, but the numbers are still small by international standards).
- A lack of curiosity now pervades (perhaps even characterises) Australians. Comparison was made with India where people are intensely curious about technology such as mobile phones.

The workforce

Australia's education system is able to attract top PhD students, yet participants noted that they often ask what they would do after they graduate or complete their first post-doc and decide against Australia. For the cohort of very high achieving, forward-thinking students (i.e. the people Australia needs to attract and retain), the lack of clear career paths in Australia presents a barrier to the development of our highly skilled workforce.

Despite the difficulties of attracting international students and retaining them in our workforce, there is a pressing problem of attracting Australian students to PhDs in ICS and ICT-related fields. This also presents hiring challenges for governments, and especially Defence, where Australian citizens are required.

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