Island Australia: improving resilience in a rapidly-changing region

The contribution of universities and research in improving resilience

A paper based on a presentation to the Institute in Sydney on 23 November 2021 by

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The Australian university system, and organisations like the Commonwealth Scientific and Industrial Research Organisation, working with the Defence Science and Technology Group and defence industry, can contribute to Australia's competitive edge in defence in an age of high technology platforms, weapons systems and equipment. Developing an appropriately educated workforce and collaborative innovation networks across disciplines and organisations, via arrangements such as co-operative research centres, are bases for success. Several examples of successful defence innovations are cited.

Key words: Defence Science and Technology (DST); autonomous systems; co-operative research centres; CSIRO; defence and industrial ecosystems; high-technology; hypersonics; innovation networks; research; underwater glider; universities; wi-fi.

Earlier speakers in this seminar touched on high-technology (high-tech) platforms. That is what defence capability relies upon today – access to high tech, and innovation and integration of high-tech. In some instances, you can buy it off-the-shelf. In others, products require customisation or need to be developed from scratch as a bespoke solution. Partnerships with other nations and organisations also provide the opportunity to exchange capabilities. In the proposed AUKUS nuclear submarine deal, Australia will contribute technologies in exchange for gaining access to partners' technologies. To build capability, we need to be adept at buying, tailoring and sharing high tech, but we also need to develop sovereign innovation capability where we can design and implement our own technology solutions.

Previous speakers have mentioned the defence ecosystems. During my time as Australia's Chief Defence Scientist, I was involved in developing the 2016 Defence White Paper (Defence 2016), which I consider as one of the best White Papers since the 2000 White Paper (Defence 2000). 2016 was a real game-changer in its embracing of innovation. I anticipate that the next strategy paper, which is due in 2023, will continue that same focus on innovation. It will not be a U-turn; it will head in the same direction and will maintain the emphasis on partnerships with industry and with universities.

When I was leading Defence Science and Technology (DST), we knew that academia had a lot to contribute. Academics were listened to and were granted a seat at the table to influence policies and settings. Now that I have returned to higher education, I see that Defence has continued to recognise the value of engaging with the academic community and industry to support its innovation needs.

Science and Technology within the Department of Defence

Traditionally, DST had a narrow way of thinking about its capabilities. We had 2,000 defence scientists – a lot of people – yet we could not span all technology developments and domains of interest. For many reasons, budget included, we could not recruit the people that we wanted. To build capability, we needed to leverage the scientific expertise within industry and other research organisations. In the last 30-40 years, Australia's education and research system has changed. Universities in particular have increased their capabilities and the quality of their research. There are more researchers out there doing more innovation, including in fields of interest to Defence. For DST, we needed to understand the expertise within the broader community, and determine where we could grow and leverage capabilities.

The key idea was to see how we could get 'Team Australia' to come together and find solutions and develop new technologies. We sought to create an innovation ecosystem in defence science, bringing together industry, research and the Defence community. We wanted to build on what industry and researchers were already doing, and then determine how to integrate these capabilities. Underpinning these capabilities required developing an educated workforce that could support our future innovation needs.

Developing an Educated Workforce

Earlier in this seminar, we discussed how nuclear-submarine commanders will require a master's degree to support both technical mastery and leadership skills. This is quite an advanced form of study. Most, if not all crew members will also need nuclear training. Hence, we need universities to be preparing to meet this workforce need. Should all universities start running nuclear science courses? No. Institutions with established expertise should lead the charge. For example, the University of New South Wales has worked with the Australian Nuclear Science and Technology Organisation (ANSTO) for many years. Their primary focus is nuclear medicine. There are other universities, too, that have elements of nuclear capability. We should be supporting these institutions to establish programs for the future, rather than creating new expertise in organisations. As another example, there are universities across Australia wanting to build new research programs in hypersonics. We did not pursue this idea since the best hypersonic capabilities are already established in Queens-

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land. Rather, we strengthened our capabilities in Queensland. It is important to get the concentrations correct. We do not necessarily want a monopoly of expertise, which can stifle innovation. But we also want to avoid diluting talent and missing out on the benefits of clustering and collaboration.

Through a combination of research, innovation and education, working with industry and the community, we can develop technologies and a workforce for the future that can increase capability and builds resilience across Defence. In my current role at the University of Newcastle, I am bridging what I learned in the Defence portfolio and aligning it with the higher education environment. I see that universities have real potential to support the next phase of innovation and workforce development for defence science and defence industries. I am also thinking about how we can help to scale and grow new industries that support Defence and create new jobs. This is particularly relevant for our community in the Hunter, which is home to major Defence assets like RAAF Williamtown and Lone Pine Barracks in Singleton.

Innovation and Collaboration for Defence

In his recent memoir (Pyne 2021), the Former Defence Minister, The Hon. Christopher Pyne, observed that in the 2016 Defence White Paper (Defence 2016), the government, for the first time, was willing to risk $1.6 billion on innovation without necessarily getting any return on the investment. Program leads would have to spend the money allocated, and if possible, make sure that they acquired the capability desired. Teams had to spend money on projects they believed would produce successful innovation. Some parts of the program might succeed and others not.

I recall Dr John Stocker, CSIRO's Chief Executive (1991-1995), suggesting that CSIRO needed to do some forward thinking and fund ten stretch projects. One of the projects we supported was Wi-Fi. At the time, everyone said, 'Why wireless computers, who would ever want that?' Yet it went on to be one of the greatest innovations ever produced out of Australia. In the information technology industry, all wireless that runs today is underpinned by CSIRO technology. At the time, it was a gamble. We did not know that it was going to succeed and become a billion-dollar program. But that is how innovation works. There is risk, and in some cases, reward. You have to 'back' a portfolio of projects understanding that some will deliver, and some will fail. That was one of the great things about the 2016 Defence White Paper. It allowed us to fund a variety of emerging research and technologies, and to accept a level of risk in doing so.

There is no one correct way to make innovation work. It is not a single nail for which you only need a hammer. In DST, we pursued multiple pathways to encourage innovation. We modelled programs from those that had achieved success in other countries; small business programs, Grand Challenges, industry-driven research, as well as co-operative research centres (CRCs) in which Australian industry was working with end users, universities and government organisations like CSIRO and DST.

A major challenge was looking forward to 2030 and trying to forecast what technologies we will need. There are many emerging technologies showing promise- areas like space, quantum technologies, trusted autonomous systems, cyber and others. Without knowing which area of innovation will be most successful, we decided we would concentrate on the mechanisms available to drive collaborative work with industry and universities. In some areas, we have done reasonably well; I was very pleased to hear that we are now setting up the Space Division within Defence.

During my time in DST we launched a satellite – a small one for developing new capabilities for over-the-horizon radar. It was the first satellite Australia had launched in 20 years. Such small experiments have contributed to the broader space capability we continue to build today. For example, we are now seeing emerging industry groups, such as Gilmour Space Technologies make strides in this area. This is the value of the research, development and innovation program. Getting the key players working together – Defence partnering with industry and universities, and leveraging shared expertise to develop and test new ideas. Success is made possible through working together. Precincts, networks and industrial clusters are another effective mechanism to encourage collaboration and innovation, and to attract talent and researchers, and new industries.

Victoria's Defence Science Institute (DSI) brought together the universities in Victoria to collaborate on focused defence problems. DSI helped to build an understanding of defence needs and developed capabilities within universities, allowing them to bid for projects and funding. The Defence Innovation Network in New South Wales followed a similar formula – all New South Wales universities came together sharing defence expertise, aligning them with White Paper priorities and proposing projects in areas of mutual strength. Comparable networks are emerging in other states too. We've seen that these clusters and networks often derive greater success for proposals where all parties share the risks and have skin in the game. Funding is contributed by state governments, universities, industry and Defence. One challenge with these state-based networks, funded through state governments, is that they are not able to fully respond to large-scale Defence challenges, noting some Defence activities can span all states and territories.

From my time in DST, I found that there was no single university that could bring the full suite of capabilities needed solve all defence science problems. However, universities often bid to Defence individually, proposing to deliver on a part of a project. To navigate this challenge, we would consider, 'Who are the best people in Australia working in this particular technology space?' and 'How can we bring them together to collaborate?' Providing incentives for universities to collaborate by forming networks was a useful approach, particularly to addressing futuristic problem sets.

We established the Defence Co-operative Research Centre for Trusted Autonomous Systems. This was for robotic systems that need to work on their own with minimal human supervision. The challenge becomes, how do you know that an autonomous system will do what it is supposed to do? How do we ensure that it is not hacked or turns against you, or fails to achieve its mission? How can you guarantee that, and, at the same time, how can it be properly integrated into the chain of command? These are the systems we need, and in many cases they are not currently mature enough to be used in the field. (*see Figure 1 next page*)

One of the innovations that the CRC team were working on was an underwater glider. It came out of a startup enterprise in Sydney. You might be familiar with the footage showing the *Titanic* on the ocean floor? The Deepsea Challenger was the submarine vehicle used to capture that footage. It was developed by Ron Allum, an Australian engineer from Sydney who understood how to make high-pressure vehicles, able to go to great ocean depths. He also created the Sun Ray Glider, an underwater glider that could

descend several thousand metres into the ocean and could keep generating enough energy to travel almost infinite distances. The underwater glider could have applications for defence, particularly in surveillance. This Australian technology is superior to any comparable overseas innovations. It could only be developed because we had niche capability. The Navy is sponsoring the underwater glider in the hope that it will be able to satisfy its operational requirements. Succeed and Australia will benefit from game-changing capability.

Figure 1: Sun Ray Glider [Source: Defence Media Australia]

Another program driving world leading research is the HIFIRE program, looking at hypersonic technology. It is based in Queensland, led by DST and the US Air Force, with the University of Queensland, Boeing, NASA and other key partners contributing, including from India. There is now a dedicated facility in Queensland accommodating this research in a secure space. It is pleasing to see that ten years after we first supported this program, it is on track to deliver important capabilities.

There is also great activity underway in my region in the Hunter, north of Sydney. I encourage the Royal United Services Institute to become involved – hold some meetings there, visit the area and have a look at what the region's industry is doing in defence. Similarly, in the Shoalhaven region south of Sydney, there is some great industrial capability, including activation zones and a capable workforce.

With the capabilities that are available in the Hunter, the University of Newcastle is partnering with industry and other institutions in areas of interest to Defence, including aviation fuels and technologies to support training of ADF personnel. We see opportunities in areas like autonomous systems, alternative and sustainable fuels. Green hydrogen production is a particularly promising area for the Hunter as a future fuel, energy source and export commodity.

Emerging Opportunities

When it comes to thinking ahead in defence innovation and science, we are not talking about the next 5-10 years. We are talking about a 20-30 year time horizon. Technology developments and threats emerge and evolve quickly. Our future capability will be shaped by the innovations we pursue now, understanding that we may not reap the benefits for several decades.

There are challenges and opportunities that will be important in the years ahead. Cyber warfare is not going away; if anything, it is more important now than it was even 5 years ago. Human factors will continue to be important. Earlier in this seminar, we heard how military commanders rely on people, how they need to make teams operate better and interact with technology more effectively, with fewer errors. There is more we can do to advance the ways we train and learn.

Advanced materials science represents a fascinating emerging field that could change the ways we arm and protect our personnel and assets. Consider, for example, a future where we could change the camouflage of a ship or aircraft by being able to alter the properties of its paint.

Climate adaptation is going to be another major challenge. There will be more frequent severe natural disasters - disasters correlated with climate change – which Defence will be called upon to assist. Australia is working toward a net zero economy by 2050. This policy setting will drive innovation and create fundamental change in the way we power our nation. So, how will defence and defence industries adopt and adapt to that while continuing to operate?

Conclusion

Australia has long worked alongside partner nations to develop and strengthen its defence capabilities. However, in recent decades, the nation has taken steps to better leverage and boost its sovereign capabilities to drive home-grown innovations. Australia boasts world-class scientific and technological expertise and has established a robust ecosystem that favours collaboration and leverages the talent of the research community within Defence, universities, industry and other organisations. Continued efforts to drive local innovation and develop a pipeline for the scientific workforce will allow our nation to meet the challenges in the future, secure our competitive advantage, and improve the resilience of our Defence forces.

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Professor Alex Zelinsky, AO, is the University of Newcastle's 8th Vice-Chancellor and President and commenced in the role on 19 November 2018. Prior to being the Vice Chancellor, the Professor's previous appointments were, Australia's Chief Defence Scientist and leader of Defence Science and Technology within the Department of Defence; Group Executive for Information Sciences at CSIRO; Chief Executive Officer and co-founder of Seeing Machines, a technology company focused on computer vision and listed on the London Stock Exchange. Professor Zelinsky has a Bachelor of Mathematical Sciences (Honours), Doctor of Philosophy, and Honorary Doctor of Science from the University of Wollongong, and is a graduate of the Australian Institute of Company Directors. He has completed the Advanced Management Program from Harvard University and the Senior Executive Program from London Business School.

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