

Senator David Fawcett
Chair
Foreign Affairs, Defence and Trade Committee
Department of the Senate
PO Box 6100
Parliament House
Canberra ACT 2600

Dear Senator Fawcett

Inquiry into the Capability of Defence's Physical Science and Engineering (PSE) Workforce

We welcome the Senate Committee's invitation to provide comments into the Inquiry into the Capability of Defence's PSE Workforce.

Our interest in this subject stems in part from a Special Report we wrote in June 2015 for the Australian Strategic Policy Institute (ASPI). The Report looked into Australia's *Defence science and innovation – An affordable strategic advantage* (Appendix A). The report highlighted a number of concerning trends that are having an adverse impact on Australia's defence. We believe that the erosion of Australia's PSE workforce poses an unacceptable risk to Australia defence capability.

In principle, Defence should treat R&D the same way we treat materiel acquisition - with an eye to harnessing competition and obtaining value for money. Unlike capital investments, defence innovation assets are primarily people, ie. the PSE workforce. Like materiel, the recruitment, management and retention of PSE personnel should be managed systematically according to medium to long-term strategic interests.

We strongly support the Committee's interest in the important but neglected role that PSE contributes to Australia's defence and provide the following additional comments in response to the terms of reference.

(a) The importance of the PSE workforce to Defence projects

The eminent British historian Max Hastings in his most recent book *The Secret War* (2015) succinctly sums up the dilemma confronting defence PSE workforces.

“In peacetime, few nations commit their finest brains to national security. Brilliant people seldom choose careers in intelligence – or for that matter, in the armed forces. A struggle for national survival alone makes it possible for government to mobilise genius, or people possessing something close to it for the interests of the war effort.” (-page 68).

The Committee in considering this threshold issue must first resolve two definitional questions.

- (i) What is meant by PSE workforce? and
- (ii) What is meant by the term Defence Projects?

We are conscious that the Committee will consider a broad definition of the PSE workforce for the purposes of this Inquiry, embracing technicians, technical trade workers as well as various classes of scientists and engineers. As our expertise is science, engineering and innovation policy, our commentary relates primarily to physical scientists and engineers.

We note that treating Physical Scientists and Engineers as a homogeneous unit or as a single entity workforce is an error. The convenience of doing so is far out-weighed by the importance of their distinction. The terms have very different roots. The terms “science/scientist” comes from the Latin term *scire* which means “to know”. “engineering/engineer” comes from the Latin term *generare* which means “to create”.

We concur with the comments made by Dr Andrew Davies from ASPI to the Committee that:

“...Defence needs engineers and scientists. It needs engineers to help it identify and manage risk in projects and to manage its fleet of complex platforms and complex data and communications architectures. It needs scientists to collect data and conduct research that help inform operations and force structuring decision making and to investigate novel and promising technologies.”

A challenge for the Committee will be to assess the impact the next stage of the Digital Revolution on defence PSE workers. If it would help the Committee we

would be happy to provide additional commentary on our take on the implications of the next stage of the Digital Revolution on the sector.

We envisage, for example, that with the maturity and adoption of 3D printing technology, additive manufacturing and advanced robotics, where an idea can go directly from a 3D design file to a finished part or product, that some of today's technical trade roles may become redundant.

Equally, technological advancement will continue to change the roles engineers and scientists, eg. compared to 20 years ago, fewer engineers (using new skills, materials, infrastructure and tools) are required to undertake the same task today.

The upside of technological advancement is that new types of jobs, requiring new skills, are created, with which to perform greater tasks. The important point here is that new jobs will invariably require more advanced training for all PSE workers.

In respect of the Committee's use of the term "Defence Projects" we are presuming the Committee is referring to Projects involving some facet or facets of the life-cycle of equipment, platforms and architectures used by the ADF (namely the selection, acquisition, maintenance and ultimately disposal of equipment, platforms, architectures and technologies). But it would be useful if the Committee could define what it understands Defence Projects to mean. Current defence R&D activities addresses many needs, not all of which neatly fit under the "Defence Project" heading.

Knowledge underpins the successful progression of all Defence Projects and all technological developments relevant to our national security. Scientific knowledge has grown rapidly throughout the 20th century and there is no sign of that growth rate abating any time soon. This rapid growth in scientific knowledge, coupled with innovation, is having a fundamental impact on all our lives and is a key factor in Australia's economic competitiveness.

Military technologies have followed a similar trajectory with development increasingly commercially driven, as opposed to state (defence) driven, as it was in the 20th century. Platforms and technological services are becoming more expensive, complex and invariably the result of research across a number of different and disparate disciplines.

Just as Australia's circumstances are unique, so too are our defence needs, dependent as they are on geography, population (talent), budget and access/limits to overseas sources of PSE. This creates a unique demand for an onshore defence PSE capacity.

Our allies, particularly the US, are keenly aware of technological trends and their implications for defence. Recent remarks by US Defense Secretary Ash Carter at Stanford, California provide useful context and input for this inquiry (Appendix B). In outlining the US Department of Defense's Force of the Future initiative to a science and engineering audience, he said:

These trends are contributing to a growing problem we think about every day in DoD: the fact that threats to our security and our military's technological superiority are proliferating and diversifying. This is happening in terms of conventional weaponry and technologies, and in the cyber domain.

But to stay competitive and to stay ahead of threats, DoD must do even more. And that starts with our people, who are our most important asset – both in Silicon Valley and in the military. Who they are, and where they are, matters tremendously in affecting our ability to innovate. And that's the rationale behind some initial steps I'm taking starting today.

...

These are revolutionary things, but we have to do them. We can't have industrial age institutional and human resources thinking in an age when people, they want choice, they want flexibility, they want movement, they want mobility, and we have to be part of that, or we're not going to be a part of the generation that will make us successful in the future.

The importance of PSE to Australia's defence projects goes beyond successful conception and delivery. An effective PSE workforce underpins all our defence efforts in an increasingly technologically driven world.

(b) The current PSE capability within Defence, CASG and DSTG

The current PSE capability within Defence (DMO was abolished following the

release of the Defence First Principles Review earlier this year, now replaced by Capability Acquisition and Sustainment Group and DSTO is now the Defence Science and Technology Group within Defence following the same review) is, in our view, fragile.

The Inquiry may find it difficult to establish the true state of PSE capability within Defence as the statistical collections within the portfolio are not collected or managed in a fashion that make it simple for Parliament to draw ready or accurate conclusions about even the numerical state of the PSE workforce.

Nevertheless, public records do provide a number of insights to the Inquiry that collectively suggest that the PSE workforce in Defence has recently diminished and current services are under significant stress.

According to Budget documentation, in 1979 DSTO (as distinct from all of Defence) had a staff of 4,900, of whom 1,100 were classed as professional scientists or engineers. In 2015, the Australian Public Service Commission (APSC) in its annual *State of the Service Report* advised that for all of Defence (including DMO and DSTO) the number of PhD qualified staff stood at 520.

From a Budget perspective, in areas where the PSE workforce is most likely to be found, namely defence R&D, data says that total expenditure on defence R&D has fallen steadily since 2011. Further, the government R&D share of the overall defence R&D budget has dropped from 2% in 2008-09 to a forecast 1.1% in 2017-18. Between 2012-13 and 2017-18, DSTO is budgeted to reduce expenditure by around \$169 million.

In short, Australian defence science and technology investment, as a proportion of defence spending, is less than that of the Netherlands, Canada, Sweden and Singapore. With respect to population growth, per person expenditure has more than halved since 1977.

Technology trends also influence the ability of research groups such as DSTG to recruit and retain high quality and appropriate talent. DSTG is in a difficult position as a significant cadre of scientists and engineers recruited in the 1980s and 1990s is reaching retirement age.

Anecdotal evidence suggests that the recent staff freeze and staff cuts that have occurred within DSTG has impacted more severely on the PSE community of

DSTG than other parts of the organisation. Indications are that PSE personnel with 20, 30 or 40 years experience have taken advantage of redundancy packages on offer to leave the DSTG workforce.

Adding to the difficulties has been the freeze on recruiting graduates that has been in place across Defence for the last several years. While it is understood that DSTG is planning to recruit 20-25 new graduates in 2015-16 this by no means covers the losses that have occurred within the PSE community over the last several years. It is also unrealistic to expect that new graduates will be able to operate at the same level of effectiveness as those with 20, 30, or 40 or more years of experience in a particular field.

The authors wish to stress that these insights relate to only one part of the overall Defence organization. But we have reason to believe that these cuts and reductions to the PSE workforce are more broadly based than simply what has occurred to DSTG and symptomatic of a more broadly based problem.

We recommend the committee inquire and report on the change over recent years in a) the number PhD qualified staff in Defence and b) the average years of experience of staff in PSE roles. We appreciate that security concerns may restrict some of this information and that while the Senate needs to be aware of these important trends it may not be appropriate to publish all the data.

(c) The potential risks of a skills shortage in the PSE workforce and a decline in Defence's PSE capability

In our paper *Defence Science and Innovation* we address the question whether Australia's defence research ecosystem is fit for purpose?

In the 20th century, national defence budgets were prime drivers of technological development. During the later half of that century the work undertaken by the Defence PSE community (primarily through DSTO) ensured Australia and the ADF were the recipients of a number of strategic tactical and budget advantages in projects such as Jindalee Operational Radar Network, the Nulka active missile decoy, the Laser Airborne Depth Sounder system and aircraft structural testing (leading to life extension) to name but a few.

Today, with the federal budget in deficit and with significant fiscal constraints

on public sector organisations, technology development is increasingly driven by the private sector in response to customer demands. Two notable examples of this may be found in: CEA Technologies' design, production and delivery of the world's first fourth generation Active Phased Array Radar (PAR) System for the Royal Australian Navy; and the Thales Australia's innovative design of the Hawkei a light 4 x 4 protected mobility vehicle. The Government earlier this month placed an order for 1100 of these vehicles.

PSE workforce erosion we suggest is also an inevitable result of the changes arising from the 2003 Kinnaird Defence Procurement review which saw the Defence in-house PSE workforce re-focused more on the provision of advice, such as capability and risk assessments, for the ADF and Defence as a whole rather than undertaking new research efforts.

Defence has been slow to adapt to this new paradigm and instead has followed the usual pattern of organisations when confronted by budget and staff cuts, namely, to protect at all costs existing programs and activities. This has created conditions that discourage risk and innovation and is exacerbated by government signals that no new policy or program initiatives will be considered without offsetting savings. At a time when Australia faces significant strategic and disruptive technological challenges, this is not a sound strategic response for sustaining the ADF's technological edge.

The existing siloed internalized nature of how Australia's dedicated defence PSE workforce is being utilized is starkly different to how PSE workforces are utilized by Australia's allies. In those countries, the PSE workforces within their universities are embraced and incentivized to work on Defence projects of strategic importance to their nations. Processes and infrastructure are put in place to enable them to divide their time between working on their day jobs and working in secure environments to the benefit of their nation's security and well-being.

A real risk posed by having neither adequate PSE skills within Defence nor being able to readily and quickly harness such skills from outside of Defence, is that our national security system will not be suitably agile in responding to surprise developments.

We suggest that the decline in a dedicated defence PSE workforce can be mitigated provided Defence is given the tools and the ability to incentivize the

broader PSE workforce that exists within Australia's academia, industry and amongst our allies.

Prudent and sustained investments now in the requisite infrastructure, secure communications links, security clearances and training and funding to allow targeted basic and applied research to be undertaken by Australia's PSE communities resident within Australia's academia will yield returns to Australia defence and well-being for many decades to come. More importantly, a change in mindset is required to allow such a paradigm to occur.

(d) The ability of Defence to access relevant PSE capabilities to meet future technological needs;

From the perspective of the ADF and the Defence portfolio, competitive institutional responsiveness is needed to deal with future defence challenges and adversaries. Rapid technological change is a world wide trend, and the adoption of new technologies can accelerate strategic surprise.

In the 1970s, worst case scenario threats to Australia were limited to land forces coming to Australia by sea and long-range air attack, potentially with nuclear weapons. Global development and progress in international order have reduced the likelihood of such attacks occurring but new threats and disruptive technologies have emerged.

We are seeing small groups and individuals harnessing emerging and relatively inexpensive technologies to do harm. In 2013, a series of NeXTech war games initiated by the US Department of Defense and led by Noetic, an Australian based organization, identified a number of technology areas with the potential to affect the future strategic environment. They included additive manufacturing, autonomous and semi-autonomous systems, directed energy and human performance modification.

The sheer scale and diversity of these non-traditional forms of disruption pose a significant challenge to Defence and the ADF. The current public sector model, the metamorphosis of DSTG into a technology management advisory body and the loss of experienced PSE personnel raises real question marks on the ability of Defence to mobilise in a timely fashion the relevant PSE capabilities to respond effectively to these new threats.

Defence needs to be able to employ relevant PSE capabilities as and when they are needed. To do this it needs both core capabilities and the ability to readily harness external capabilities. In recent years defence PSE preparedness has diminished. This lamentable fact will no doubt be made clearly to the Committee. We argue that while short-falls in internal Defence skills do need to be addressed, what also needs to be addressed is the current very limited ability to harness the rest of Australia's (and those of our allies) S&T community to utilise relevant PSE capabilities.

(e) The ability to incorporate new technologies discovered by the PSE workforce into Australia's defence capability planning

The Defence Capability Planning Process has received more than its fair share of criticism over the years. Much of this criticism has been based on specific partisan or commercial interests. The examples highlighted earlier of CEA Technologies and Thales Australia demonstrate that despite a push towards buying proven Off the Shelf (OTS) technology, an appetite based on need exists within the ADF and defence procurement to adopt innovative, fit for purpose Australian products that are demonstrated to work.

The process to achieve such successful outcomes, however, takes many years. It takes, on average, around 10 years for a project to enter the Defence Capability Plan and to be delivered. As such firms require lots of patience and deep pocket – often prohibitive for small to medium enterprises, often the source of the most innovative products and services.

Part of the problem is the lack of an effective mechanism to foster innovation between the ADF and defence and Australia's civilian PSE community. We need to develop programs and initiatives that encourage our civilian PSE community to become involved in solving and addressing defence and national security challenges. The failure of Defence and the ADF to meaningfully engage with this community is hindering Defence science productivity.

There have been glimpses of what might be achieved, most notably with the Defence Materials Technology Centre but the lack of funding has acted as a brake on such initiatives realizing their full potential.

We recommend the Committee review the funding model used by the US Defence Advanced Research Projects Agency (DARPA). DARPA was created to fill a gap between the work of the military service R&D organisations (the equivalent of DSTG) and fundamental research in which new science, new ideas and radical new concepts emerge. Through the management and direction of basic and applied R&D projects, DARPA advances research and technology where the risk and pay-off are high to very high. DARPA seeks to mine fundamental discoveries, accelerate their development and lower their risk until they prove their promise and can be adopted by the Armed Services.

There is no dividing line between basic and applied research. The goal is to produce usable technological advances. DARPA's mandate extends to helping firms get products to the stage of commercial viability. Projects are typically 3-5 years in duration and have a strong focus on end goals.

(f) The effect of project outsourcing on Defence's PSE capability

Our Special Report (Appendix A) includes a detailed section on outsourcing Defence science. In addition, we offer the following observations.

While there is no case for the wholesale outsourcing of DSTG we do argue that in all areas of research, the efficient and effective use of an institution's resources necessitates timely access to national and international science infrastructure, data, talent and services. While obvious security considerations and restrictions exist, making the best use of the vast majority of Australia's PSE community which sits outside of DSTG and defence is the key.

We strongly concur with the recommendation arising from the Government's recent First Principles Review that in part recommended that "...strong partnerships be established with key academic and research institutions to leverage the knowledge of scientists and create pathways into and out of academia and industry."

As discussed above and in our ASPI Special Report, harnessing available national S&T resources is needed. The DARPA model provides such a function, under the secure direction of Defence (including ADF). While it is a form of

outsourcing it has the necessary effect of complimenting internal R&D by tapping collaborators within the 95% of Australia's S&T community that is outside Defence.

The effective use of external advice and capability also goes to the question of the role of the Chief Defence Scientist (CDS).

After the 2003 Kinnaird Review of Defence Procurement, the government provided the office of the CDS with a (much needed) remit to provide independent advice. In practice, because DSTG's advice is on tap and the CDS is responsible for DSTG's bureaucratic well being there is a powerful incentive to discharge both functions in a mutually supportive fashion. However, because scientific and technical knowledge is found across many disciplines, institutions and countries, there is a growing tension between how to supply the best available advice and how to advance one's own agency. Practically, there's some degree of disincentive to go beyond DSTG or Defence to form judgments, solve problems and advance research. This is an unsatisfactory arrangement in an era of globalised technological advancement.

(g) The ability to attract and retain a highly skilled PSE workforce in Defence, CASG and DSTG;

We have no doubt that Defence requires ready access to a robust PSE workforce. For Australia's defence to remain effective, our PSE workforce, in house and in collaboration with colleagues inside and outside Australia, needs to be globally competitive.

While wage disparities between the private and public sectors has government scientists, engineers and technologists at a disadvantage, the opportunity to work at the cutting edge of Australia's defence has innate appeal. However, national interest must be combined with cutting edge. Science and Engineering professionals are motivated by discovery and design. These are non-monetary aspects that fit well with public service and national security instincts. The most powerful employment incentive is having a first rate PSE workforce and system.

Science and engineering today is an increasingly collaborative and globally competitive endeavor. Scientists and engineers now work across institutions, nations, agencies, universities and companies in multidisciplinary teams to

solve shared problems. This trend is driven by value for money efficiencies as resources, ideas and risks are shared and measured by the level of research and commercial success.

Flexibility will be the key to Defence and the ADF securing access to these resources in the future. As evidenced by the disruptive technologies on the horizon, Defence and the ADF need to establish a human resource model that encourages mobility among the research community.

As will other research employers, the modern career paths follow research usefulness where it exists, rather than institutional identity. The skilled scientists and engineers currently on the books of the ADF and Defence are not necessarily the scientists and engineers needed to address each and every technology challenge of the future.

Adapted recruitment and retention practices are needed to attract and retain high-quality staff and to redress chronic gender and age imbalances. The inefficiencies caused by retirements and the under-representation of women in researcher and scientist ranks can be addressed by ensuring that external collaboration mechanisms enrich potential career paths.

A primary challenge is with security clearances. Researchers need to be able to move between government, industry and academia, as directed by the most effective use of their talents. So the security clearance system needs to accommodate this, ie. maintain security while affording the most effective and flexible use of national science and engineering talent.

A security clearance and terms and conditions framework fit for purpose in the 21st century needed to support a PSE workforce that moves frequently (eg. 2 -3 years) between our academic sector, industry sector and defence department to allow them to work on defence and national security issues.

An additional constraint on attracting the best and the brightest within Australia's PSE community is the loss of brand recognition that came with DSTO. Following the First Principles Review, earlier this year a surprise decision was taken to downgrade from an Organisation (DSTO) to a Group (DSTG). While this decision might have helped clean up an organization chart and reporting lines it is unclear whether any consideration was given to what the cost of abolishing the DSTO brand meant for international recognition, future recruiting and retention needs and for excellence in Australian defence science.

Like CSIRO, DSTO has over the years put much effort into building up a brand identity that is recognized internationally as an organization dedicated to excellence. It was a brand instantly recognized by PSE communities both in Australia and amongst our allies and a powerful recruitment tool. We believe that Defence will find it much harder to recruit suitable PSE personnel in the future following this change.

(h) And other related matters.

The decline and degradation of Australia's defence PSE workforce is a matter of serious concern.

Years of budget and staffing cuts and rolling re-organisations in efforts to match diminishing resources with revised roles have taken their toll on capability.

Coupled with the pressures of commercialization, globalization and the digital revolution serious fault lines have emerged within the Defence PSE community that can no longer be papered over.

The potential to enhance the ADF's PSE workforce should also be noted. Recent US defense experience suggests the growing need for technology specialists within their civilian and military workforce is driving structural reform. Currently the US military variously facilitates direct commission entry for officers and specialist entry for other ranks with science, engineering, medicine, pharmacy, dentistry and nursing qualifications and experience.

In reference to generation Y workforce realities, military structures and growing technology workforce needs, US Defense Secretary Ash Carter (Appendix B) noted in his above cited Stanford address:

The only way to do that is to make us as open and flexible as their private sector counterparts are. So that's why I talked about those three initiatives in the personnel area. I'm trying out ways to change the way we bring people in. Give them a try. People don't like to be tied down. Kids don't want to get into something that they're going to be in for their entire lives. They want to move in and out. That's why I'm looking for the cyber force about being able to move people laterally into the military rather than having to come up through the ranks because of their level of

expertise.

At a Pennsylvania high school in March this year Secretary Carter said in explaining the Force of the Future initiative:

Today the military rank structure still dates back to when Napoleon was invading Europe two hundred years ago. Now there's some good reasons for that. But certainly specialty jobs, like cyber-security, we need to be looking at ways to bring in more qualified people, even if they're already in the middle of their career, rather than just starting out.

The US experience, existing and planned, highlights both the need and methods by which PSE talent is used to support national security.

In our Special Report, *Defence science and innovation*, we make the case that the defence science eco-system needs to be urgently revamped and updated to reflect 21st century realities.

The current model provides too few incentives for innovation to meet Australia's unique defence needs. It encourages the maintenance of the status quo, rather than promoting innovative approaches and risk taking in research and engineering.

There is no clearer example of the decline than in the metamorphosis of DSTO, which was once Australia's premier defence research establishment and which has been turned into a technology management advisory body. This metamorphosis is less a consequence of deliberate strategic policy and more a response to short term political, financial and acquisition expediencies.

While this decline weakens our defence, this Inquiry has the opportunity to inform a fundamental revamp of our defence science and innovation settings. In so doing our core PSE workforce can be fit for purpose in the 21st century, with necessary access to the knowledge capability and capacity that is resident in Australia's civilian PSE community.

We would be happy to further assist by clarifying our submission or addressing queries the Committee may have during the course of this important inquiry.

Yours sincerely

p.p. Martin Callinan

Martin Callinan

p.p. Alan Gray

Alan Gray

16 October 2015

Appendix A

Defence science and innovation: An affordable strategic advantage

Australian Strategic Policy Institute: Special Report

June 8, 2015 by Martin Callinan and Alan Gray

<https://www.aspi.org.au/publications/defence-science-and-innovation-an-affordable-strategic-advantage>

Appendix B

2015 PSE related remarks by US Defense Secretary Ash Carter

- **Sidney Drell Lecture**

Stanford Graduate School of Business, Stanford, California

April 23, 2015

<http://www.defense.gov/News/News-Transcripts/Transcript-View/Article/607043/remarks-by-secretary-carter-at-the-drell-lecture-cemex-auditorium-stanford-grad>

- **Remarks on the Force of the Future Initiative**

Abington Senior High School, Abington, Pennsylvania

March 30, 2015

<http://www.defense.gov/News/Speeches/Speech-View/Article/606658>