



SUBMISSION TO THE

**INQUIRY INTO THE CAPABILITY OF
THE DEFENCE PHYSICAL SCIENCE
AND ENGINEERING WORKFORCE**

**SENATE FOREIGN AFFAIRS, DEFENCE AND TRADE
REFERENCES COMMITTEE**

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Australian Academy of Science submission— Senate inquiry into Defence's physical science and engineering workforce

Australian Academy of Science submission to the Senate Foreign Affairs, Defence and Trade References Committee

Summary

Defence science in Australia has been supporting the work of Australia's defence forces for over a century. The work performed by Australia's defence science and engineering establishment is vital to the operational success of the Australian Defence Force, and the Australian Academy of Science strongly supports the retention of domestic defence science capability. The defence science sector, in common with organisations in the broader economy, is likely to encounter difficulties in recruiting suitably qualified workers in the foreseeable future. The Academy is therefore of the view that efforts must be made to expand the supply of high-quality science, technology, engineering and mathematics graduates by initiatives on a number of fronts, including improving science education and retention of women in the science workforce.

Recommendations

Recommendation 1: The Academy recommends that the Department of Defence and the Defence Science and Technology Group (DSTG) re-commit to a program of basic and applied scientific research as a core activity, to develop future expertise and technology. The Academy strongly recommends that the Australian Government commits to a stable funding base, with an appropriate workforce level, for defence science and research to ensure this core capability is retained.

Recommendation 2: The Academy recommends that Defence and DSTG expand opportunities for communication and engagement between DSTG, Defence and the academic research sector, to assist DSTG's in-house expertise to take advantage of the latest innovations and research.

Recommendation 3: The Academy recommends that Defence and DSTG re-establish a graduate development program for defence science, technology, engineering and mathematics as a matter of priority.

Recommendation 4: The Academy recommends that DSTG continues to engage with the broader science sector to improve gender equity in its science workforce.

Overview

The Australian Academy of Science (the Academy) welcomes the opportunity to make a submission to the Senate Foreign Affairs, Defence and Trade References Committee's inquiry into the capability of the physical science and engineering workforce in the Department of Defence. The Academy promotes scientific excellence, disseminates scientific knowledge and provides independent scientific advice for the benefit of Australia and the world. The Academy is made up of over 500 of Australia's leading scientists, each elected for their outstanding contribution to science. The Academy would be pleased to provide further information or explanation on any of the points made in this submission.

Science and technology are a critical part of the capabilities of Australia's defence forces, which rely on advances in science and technology, and the advice of local experts, to carry out their important mission. Australian defence science expertise has supported Australian defence forces for over a century and has been responsible for a long list of innovations that have been of significant benefit both in military and civil application.

The 2013–2018 strategic plan of the Defence Science and Technology Group (DSTG) makes it clear that Defence's science capability directly supports the work of the Australian Defence Force (ADF), by being a 'valued adviser', a 'collaborative partner' and an 'innovation integrator'.¹

The recent *First principles review* of Defence clearly expressed the importance of DSTG:

*The Defence Science and Technology Organisation is valued by Defence and national security agencies for its contribution to saving lives, reducing risk, saving money and enhancing capabilities. It provides a range of specialised and technical services across both Defence and the national security community and has developed state-of-the-art technology that is being used across the world today.*²

The nature of the regional security issues and threats facing Australia, along with the rapid development of science and technology, are making defence science all the more important in meeting Australia's defence and national security objectives. As the 2009 Defence White Paper states:

*The wars of the future will require the Australian Defence Force to have access to and use of advanced military technology. This will include electronic and cyber warfare, precision targeting, stealth and information management.*³

Every significant review of Defence points to the increasing role of science and technology; this makes Defence's scientific and engineering expertise a key national asset. Science, technology, engineering and mathematics (STEM) expertise and capability requires long-term investment, and the Academy is supportive of strategic efforts to ensure that this capability is maintained into the future. It is critical that a long-term view is taken of defence science capability; DSTG's 'foresighting' report argues that 'R&D expenditure is strongly correlated to the quality of military capability 10 to

¹ Defence Science and Technology Organisation (2014), *Strategic plan 2013–2018*, Australian Government, Canberra, p. 20, <http://www.dsto.defence.gov.au/sites/default/files/publications/documents/dsto-strategic-plan.pdf>

² Peever, D (2015), *First principles review: creating one defence*, Australian Government, Canberra, p. 41, <http://www.defence.gov.au/publications/reviews/firstprinciples/Docs/FirstPrinciplesReviewB.pdf>

³ Department of Defence (2009), *A defence force for the 21st century: your guide to the 2009 Defence White Paper*, Australian Government, Canberra, p. 16, <http://www.defence.gov.au/publications/White%20Paper%20Booklet.pdf>

25 years later'.⁴ This illustrates the long-term nature of defence science and technology, and reinforces the need for a strategic view of defence science capability development.

It should be noted that R&D is only one part of DSTG's mission. DSTG also provides operational support to forces in the field, provides science and engineering support to the current defence force, and looks to help shape the forces of the future, as well as conducting research and development. These are all activities which are critical to the current and future capabilities of the ADF. The Academy is strongly supportive of the high-quality work done by the defence science and engineering workforce, and notes that DSTG is the only part of the Defence workforce directly engaging in innovation activities.

The Academy is concerned that research and development activities under the current operational structure and funding arrangements may be a lower priority for the defence science establishment than they have been previously. The science, research and innovation budget tables show that the vast majority (89.4 per cent in 2015–16) of financial support for defence-related research activities flows to DSTG.⁵ However, it seems that DSTG's functions are increasingly geared towards providing assessments and advice to government on technical aspects of defence acquisitions, and 'troubleshooting' problematic defence materiel. In combination with declining funding for the organisation, the increased workload in acquisition advice has inevitably meant a reduction in the research and development capability of the organisation.⁶ This reduction in internal capability has not been offset by a corresponding increase in defence-related R&D in other sectors, which puts Australian defence R&D at serious risk. The Academy is concerned that once expertise is lost, it is not easily replaced, and believes that it is vital to retain a strong defence R&D capability in Australia. The Academy would therefore welcome any measures designed to retain defence science expertise in Australia.

Recommendation 1: The Academy recommends that the Department of Defence and DSTG re-commit to a program of basic and applied scientific research as a core activity, to develop future expertise and technology. The Academy strongly recommends that the Australian Government commits to a stable funding base, with an appropriate workforce level, for defence science and research to ensure this core capability is retained.

Various parties have examined the organisational arrangements for defence science and explored what might be the optimal models for conducting defence science, and a number of conflicting opinions have been expressed concerning these arrangements. The Academy does not recommend any particular model for the specific organisational arrangements for Defence's science functions. However, the Academy would encourage Defence to take every possible advantage of the high-quality research capabilities available in Australia, both within and outside of the defence sector. The Academy is strongly committed to the principle of excellence in research and encourages Defence to

⁴ Boey, S, Dortmans, P and Nicholson, J (2014), *Forward 2035: DSTO foresight study*, Defence Science and Technology Organisation, Canberra, p. 18, <http://www.dsto.defence.gov.au/sites/default/files/publications/documents/Forward-2035.pdf>

⁵ Department of Industry and Science (2015), *The Australian Government's 2015–16 science, research and innovation budget tables*, Australian Government, Canberra, <http://www.industry.gov.au/innovation/reportsandstudies/Documents/2015-16ScienceResearchAndInnovationBudgetTables.pdf>

⁶ Callinan, M and Gray, A (2015), *Defence science and innovation: an affordable advantage*, Australian Strategic Policy Institute, Canberra, p. 4, https://www.aspi.org.au/publications/defence-science-and-innovation-an-affordable-strategic-advantage/SR79_Defence_Science_Innovation.pdf

examine global practices in defence science to determine where Australia's practice in this area may be improved.

The Academy is strongly of the view that regular and meaningful engagement between the defence science sector and the wider research sector is critically important to the success of defence science and engineering in Australia. The Academy understands that security concerns can, at times, limit some avenues of communication, but is of the view that, where possible, engagement between the defence science establishment and the academic research community can be mutually beneficial.

Recommendation 2: The Academy recommends that Defence and DSTG expand opportunities for communication and engagement between DSTG, Defence and the academic research sector, to assist DSTG's in-house expertise to take advantage of the latest innovations and research.

Although the Academy does not wish to make recommendations regarding the specific arrangements for the conduct of defence science in Australia, it is of the view that there are broader issues that will have an impact on the ability of Defence to maintain an effective physical science and engineering capability. These issues relate to the effective maintenance of a STEM-capable workforce more generally, from which Australia's defence science workforce will be drawn.

STEM workforce supply

Australia is facing serious challenges in maintaining a STEM-capable workforce for the future. The number of secondary students studying science subjects has been in decline over several decades.⁷ The number of STEM-qualified graduates has declined from 22 per cent of total graduates in 2002 to 16 per cent in 2012.⁸

In 2012, the Office of the Chief Scientist undertook a systematic review of the health of Australian science.⁹ The findings in its report are relevant to future science workforce planning, potentially impacting on Australia's ability to recruit and retain outstanding defence scientists. The report found that student participation at secondary schools in the enabling science subjects of mathematics, chemistry and physics has been declining. Furthermore, student participation in the enabling sciences at tertiary level has been in long-term decline, with continuing science undergraduate participation in mathematics, physics and chemistry all declining during the 1990s and not recovering during the 2000s.

Engaging students of all levels with science remains a challenge. The Academy acknowledges the government's continued support for the Academy's science education programs *Primary Connections* and *Science by Doing* and will continue to work with government where possible to improve the retention of students in science at all levels. The Academy would also encourage the

⁷ Goodrum, D, Druhan, A and Abbs, J (2011), *The status and quality of year 11 and 12 science in Australian schools*, Australian Academy of Science/Office of the Chief Scientist, Canberra, <https://www.science.org.au/sites/default/files/user-content/year-1112-report-final.pdf>

⁸ Australian Industry Group (Aigroup) (2015), *Progressing STEM skills in Australia*, http://www.aigroup.com.au/portal/binary/com.epicentric.contentmanagement.servlet.ContentDeliveryServlet/LIVE_CONTENT/Publications/Reports/2015/14571_STEM%20Skills%20Report%20Final%20-.pdf

⁹ Office of the Chief Scientist (2012), *Health of Australian science*, http://www.chiefscientist.gov.au/wp-content/uploads/HASReport_Web-Update_200912.pdf

government to implement the recommendations relating to science education and the STEM workforce outlined in the Office of the Chief Scientist's STEM strategy.¹⁰

Additionally, the Chief Scientist's review found that there are some areas of science, particularly at the higher degree level, in which international students outnumber domestic students. Given that international students would not usually be eligible for careers in defence science, this leaves the science system heavily dependent on Australian domestic students and, with a smaller pool of scientists, there are potentially deficiencies in some areas of research. While most employers are able to recruit overseas scientists to fill gaps within the science workforce, for security reasons this will not usually be an option available to DSTG.

There is currently a shortage of STEM-trained workers with appropriate skill sets to fill Australia's industry employment requirements. The Office of the Chief Scientist recently commissioned Deloitte Access Economics to conduct a survey of the STEM skills needs of employers. The survey found that 31.5 per cent of employers had difficulty recruiting STEM-qualified workers, and that recruiting experienced STEM workers was particularly hard for some sectors.

The following excerpt highlights some issues which are likely to arise, particularly in the defence science workforce:

Many [respondents] had significant concerns about the skills of those applying [for STEM jobs] ... mention [was] made [of] the relatively small number of local candidates applying for many positions—particularly those advertised as senior/experienced positions ...

One participant noted that the shortage of more experienced applicants in STEM industries was related to talented STEM graduates moving quickly into management and consultative roles ... there [is] a significant proportion of Chief Executive Officers (CEOs) of Australian Stock Exchange (ASX) companies with an engineering degree. This is echoed by research from LeadingCompany, which in 2012 found that 35 of the CEOs heading ASX100 companies had studied either science or engineering at the undergraduate level (Robin, 2012). Other participants observed that talented employees working in STEM fields were often attracted to other non-STEM industries, as well as overseas roles.¹¹

There are particular challenges for defence science. Currently, workers in Australian defence science are predominantly employed by DSTG. Not only do employees of DSTG need to be capable scientists and engineers, but they must also be Australian citizens and able to obtain a relatively high-level security clearance—usually top-secret negative vetting or higher. These requirements considerably restrict the available talent pool.

Several recent reports have highlighted the need to ensure a 'pipeline' supply of graduates with STEM skills.¹² The Academy is of the view that this is of paramount importance in research, especially

¹⁰ Office of the Chief Scientist (2014), *Science, technology, engineering and mathematics: Australia's future*, Office of the Chief Scientist, Canberra, http://www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf

¹¹ Deloitte Access Economics (2014), *Australia's STEM workforce: a survey of employers*, Office of the Chief Scientist, pp. 36–37, http://www.chiefscientist.gov.au/wp-content/uploads/DAE_OCS-Australias-STEM-Workforce_FINAL-REPORT.pdf

¹² Office of the Chief Scientist (2014), *Science, technology, engineering and mathematics: Australia's future*, Office of the Chief Scientist, Canberra, <http://www.chiefscientist.gov.au/wp->

that which is defence related. In defence science, in particular, it is not always possible to buy in skills and expertise from outside the organisation. Given that a significant amount of DSTG's work involves adapting off-the-shelf defence materiel to Australian conditions, it is clear that a domestic capability must be maintained. For this to happen, a relatively continuous supply of properly trained domestic graduates is needed.

There is a strong demand for highly skilled scientists in both developed nations and newly emerging science superpowers such as China and India. When this is combined with decreased science funding, extremely high competitive pressure for research grants, and a lack of opportunities for early- and mid-career researchers, many scientists choose to leave Australia to pursue opportunities overseas. This may impact on defence science recruitment in two ways. Firstly, the recruitment pool of talent is diminished, and once scientists move overseas it can be difficult to attract them back into the Australian science system. Secondly, depending on where Australian scientists pursue overseas opportunities, there might be difficulties for them in the future in taking up careers in defence science for security reasons.

Given these barriers to obtaining suitably qualified graduates, it is clear that, to maintain a domestic defence science and research capability, DSTG will be increasingly required to train new employees. The graduate program is an important pathway for recruiting newly qualified STEM graduates and training them to effectively conduct and support defence science operations. The suspension of this program in 2013 was very concerning.¹³ It should be noted that DSTG employs and develops early-career scientists through its postdoctoral pathways scheme, but that this is aimed at employees who already have a considerable amount of skill and expertise. Such employees will always be required, although they may not always be available. On the other hand, graduate programs are an important way of equipping new, less-specialised graduates with the skills required to be an effective member of the organisation. A practice of continually recruiting new cohorts into graduate program is an effective way of maintaining a pipeline of skills in the workplace.

Recommendation 3: The Academy recommends that Defence and DSTG re-establish a graduate development program for defence science, technology, engineering and mathematics as a matter of priority.

There may be significant opportunities for other research institutions to augment the capability of the defence science establishment—for example, by pursuing some less security-sensitive research programs through partner organisations. The DSTG–Universities Partnerships Program provides such opportunities, and the Academy strongly supports this initiative. There is significant research and development expertise available in Australia's university sector; utilising it to complement in-house activities could allow Defence to maintain a strong and diverse research program, while working within the constraints of the labour market.

[content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf](#); Australian Industry Group (Aigroup) (2015), *Progressing STEM skills in Australia*, http://www.aigroup.com.au/portal/binary/com.epicentric.contentmanagement.servlet.ContentDeliveryServlet/LIVE_CONTENT/Publications/Reports/2015/14571_STEM%20Skills%20Report%20Final%20-.pdf

¹³ Defence Science and Technology Organisation, *Careers* (archived 18 August 2013), <https://web.archive.org/web/20130818134208/http://www.dsto.defence.gov.au/grads/>; Riordan, P (2013), 'Key suppliers cut IT graduate programs', *IT News*, 5 February 2013, <http://www.itnews.com.au/news/key-suppliers-cut-it-graduate-programs-330710>

Gender equity within the science workforce

The science sector as a whole has significant problems regarding gender equity, and defence science in particular appears to have exceptionally low levels of employment of women scientists; women make up only 20 per cent of the DSTG workforce.¹⁴ If the gender imbalance that exists in the science workforce is addressed, employers such as DSTG will have access to a larger pool of high-quality scientists from which to recruit.

The landmark *Women in science in Australia* report¹⁵ identified two separate, but often compounding, issues: firstly, fewer women hold senior science leadership roles than men and, secondly, women leave technical and scientific positions (either to work in other sectors, or leaving the workplace entirely) at a greater rate than men. DSTG has acknowledged the need to take action in this area.¹⁶ Indeed, the science sector as a whole needs to take this issue more seriously, and collective action will be required to make a substantive difference. The Academy's Early- and Mid-Career Researcher Forum has clearly articulated the issues that need to be addressed, along with best practice responses and a range of ideas to try and overcome these challenges.¹⁷ The Academy, in partnership with the Australian Academy of Technological Sciences and Engineering, is establishing a Science in Australia Gender Equity (SAGE) pilot program to try and make real advances in this area, and government research agencies, including DSTG, will have opportunities to participate in this initiative in the future.¹⁸ SAGE helps organisations implement the Athena SWAN Charter, a program which has had considerable success in the United Kingdom.

Recommendation 4: The Academy recommends that DSTG continues to engage with the broader science sector to improve gender equity in its science workforce.

Further information and contact

For further information which may assist the Committee, please contact
Australian Academy of Science, on

¹⁴ Defence Science and Technology Group, *Freedom of information* (Other relevant information section), <http://www.dsto.defence.gov.au/discover-dsto/about-dsto/freedom-information>

¹⁵ Bell, S (2009), *Women in science in Australia: maximizing productivity, diversity and innovation*, Federation of Australian Scientific and Technological Societies, https://minerva-access.unimelb.edu.au/bitstream/handle/11343/28877/264253_2009_bell_women_report.pdf?sequence=1

¹⁶ Defence Science and Technology Organisation (2014), *Strategic plan 2013–2018*, Australian Government, Canberra, p. 27, <http://www.dsto.defence.gov.au/sites/default/files/publications/documents/dsto-strategic-plan.pdf>

¹⁷ Dunstone, M & Williamson, B (2013), *Gender equity: current issues, best practice and new ideas*, Early- and Mid-Career Researcher Forum, A Forum of the Australian Academy of Science, https://www.science.org.au/sites/default/files/user-content/genderequityemcrforum_1.pdf

¹⁸ Australian Academy of Science (2015), *Science in Australia Gender Equity (SAGE) pilot*, <https://www.science.org.au/SAGE/Pilot>