Australian Academy of Science

SUBMISSION TO THE 2015 DEFENCE WHITE PAPER

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Australian Academy of Science submission to the 2015 Defence White Paper

The Australian Academy of Science welcomes the opportunity to provide a submission to the 2015 Defence White Paper. 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 470 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.

Summary of main points in the Academy's submission

- **Short-term budget pressures should not be allowed to impact on Australia's long-term defence science requirements.**
- **The Defence Science and Technology Organisation (DSTO) should continue to make use of the broader science and innovation system through the successful partnerships and mechanisms it has established. Adequate funding should be made available for any such collaboration opportunities so that their full benefits can be realised without coming at a cost to core activities.**
- **Maintaining defence science capability and access to US defence science is of greater significance than any short-term economic benefit that outsourcing DSTO might deliver.**
- **DSTO should continue to engage with the broader science sector to improve gender equity in science workforce.**
- **The Government should continue its efforts to enhance the quality and attractiveness of science, such as through its continued support for the Academy's science education programs *Primary Connections* and *Science by Doing*, and through implementing the recommendations relating to science education and the workforce outlined in the Office of the Chief Scientist's STEM Strategy[1].**
- **The White Paper should have due regard to the consultation recently undertaken by DSTO regarding the development of a new policy and program for invigorating science and technology for national security, including developing national security science and technology priorities.**
- **The White Paper should reflect the importance of continuing to monitor and respond to the disruptive potential of science and technology and its potential impact on defence and security.**
- **Appropriate attention should be given in the White Paper to the strategic threats that climate change will bring. This includes the implications of these threats in terms of risk-based planning by the Australian Defence Force, particularly with regards to how this might transform the types of roles which are undertaken by the Australian Defence Force in our region.**

Defence science investment

Australia faces complex national security problems over the coming years that will need significant and sustained investment in defence science. The Defence Science and Technology Organisation

[1] Office of the Chief Scientist (2013) *Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach*. Available at: http://www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf

(DSTO) states that such threats include "harmful cyber activity; proliferation of weapons of mass destruction; ready availability of new technology to malicious actors such as 3D printing, bioengineering and advances in material sciences; terrorism; espionage; serious and organised crime"[2]. For over a hundred years, defence science and technology, through DSTO, has played an essential role in ensuring Australia's defence and national security capabilities. There have been outstanding successful high-profile examples of DSTO's important role including the Jindalee Operational Radar Network and the Nulka Active Missile Decoy, and recently through the counter improvised explosive devices work[3]. The nature of the threats facing Australia and the rapid development of science and technology are making defence science all the more integral to 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."[4]

Despite the elevation and diversification of the identified threats facing Australia, investment in defence science relative to the overall investment in defence expenditure has declined over the last ten years. The relative proportion of Australian Government expenditure in DSTO has declined from 2.01% of defence expenditure in 2005-06 to a forecast 1.39% of defence expenditure in 2014-15[5]. Every year for the last four years, Australian Government expenditure through DSTO has reduced (in nominal terms), and at just $408.2 million is now at its lowest level since 2010-11, similar to 2006-07 when it stood at $408.1 million[6]. There is no evidence to support proportionally less expenditure for defence science and technology this century than Australia invested in previous years.

Given the lag time between investment in science and its translation into useful outcomes and products, and the unpredictability of the nature of threats facing Australia, it is difficult to know how this reduction in defence science expenditure will affect Australia's future defence capability. There have been some reports that recent budget reductions have resulted in about 100 scientists and engineers leaving the Department of Defence, DSTO, and the Defence Material Organisation[7]. It is notable that in recent years DSTO expenditure has been curtailed at times of overall budget pressure, and DSTO has itself stated that it is operating within a "…tightening resource environment for Defence and DSTO"[8].

Whilst all areas of the Federal Budget have been under pressure in recent years, the Academy recommends that short-term budget pressures should do not be allowed to impact on Australia's long-term defence science requirements.

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[2] DSTO (2014) *A national security science and technology policy and program*, p.11. Available at: http://www.dsto.defence.gov.au/publication/policy-and-program-invigorating-science-and-technology-national-security

[3] DSTO (2013) *Strategic Plan 2013-2018*, p.27. Available at: http://www.dsto.defence.gov.au/sites/default/files/publications/documents/DSTO-Strategic-Plan.pdf

[4] Department of Defence (2009) *A Defence Force for the 21st Century: Your guide to the 2009 Defence White Paper*, p.16. Available at:

[5] As calculated using the Science, Research and Innovation Budget Tables, and the Department of Defence Portfolio Budget Statement.

[6] Department of Industry (2014) *2014-15 Science, Research and Innovation Budget Tables*. Available at: http://www.industry.gov.au/AboutUs/Budget/Documents/SRIBudgetTables2014-15.pdf

[7] Towell, N. (2014) 'Military scientists and engineers appeal to Tony Abbott to stop the spending cuts'. *Sydney Morning Herald*, 1/7/14. Available at: http://www.smh.com.au/national/military-scientists-and-engineers-appeal-to-tony-abbott-to-stop-the-spending-cuts-20140701-zssey.html

[8] DSTO (2013) *Strategic Plan 2013-2018*, p.6. Available at: http://www.dsto.defence.gov.au/sites/default/files/publications/documents/DSTO-Strategic-Plan.pdf

The role of defence science within the broader Australian science and innovation system

The Issues Paper asks "*How can innovation more effectively be promoted and how should Defence draw on the private sector and Australia's university and research sectors to help sustain and improve critical military capabilities"*[9]. Defence science does not exist in isolation from the rest of the science system, and access to broader scientific knowledge is required to both develop defence science and for defence to stay aware of potential emerging issues and threats. DSTO has undertaken many successful collaborations with universities and external researchers; it recently announced the establishment of formal partnerships with 15 Australian universities through the Defence Science Partnerships framework, and MOUs facilitating engagements with CSIRO, ANSTO and AIMS are in place[10]. In addition, DSTO has also commissioned the Australian Academy of Science to undertake a series of foresight studies outlining the possible development pathways for different scientific fields[11]. Flowing the other way, defence science in Australia has also brought significant economic benefits to the broader economy[12].

Establishment of such relationships show DSTO is already aware of the benefits of collaboration and is able to seek out expertise within the broader science and innovation system, and there is no indication that DSTO is has been unable to obtain and integrate the science it needs from elsewhere within the work it undertakes. Where possible and practical, Defence should continue to make use of the extensive relationships that DSTO has established with universities, learned academies, public research agencies and the broader public and private research sector to sustain and improve critical military capability. There are areas of non-classified research where non-DSTO researchers can make an important contribution. For example, this might include identifying potential future opportunities and threats in the coming years through emerging areas of science and the application of new technology.

Whilst there are a number of effective ways in which defence can make best use of the broader innovation system, clearly open collaboration across all areas of defence science is not possible because of the sensitive nature of much of the work being undertaken. It is unrealistic and a potential security risk to expect all such non-government organisations, agencies or companies to be able to undertake sensitive and classified research. To continue to grow Australian capability through successful partnerships, it is essential that appropriate resourcing is made available for DSTO. In other areas of government where budget constraints and efficiency dividends are being applied, the ability of government agencies and public servants to engage with non-government organisations and the private sector is being inhibited, as budgets for staff travel, collaboration opportunities and external engagement are often the first to be hit. Whilst it is not known if this issue has had an impact on DSTO in recent times, care must be taken to ensure that the organisation has the right level of resources to collaborate and gain access to the broader science it needs.

DSTO collaborations with universities and other science agencies will continue to be important, and, over time, the mechanisms for collaboration will develop and change. As many researchers in Australia are familiar with the US Defense Advanced Research Projects Agency (DARPA) there are occasionally calls for Australia to try and emulate such a model. However it must be noted that in

[9] Department of Defence (2014) Defence Issues Paper, p.20. Available at: http://www.defence.gov.au/Whitepaper/docs/DefenceIssuesPaper2014.pdf

[10] See DSTO (2014) 'New Program to Strengthen Defence Research'. *Media release,* 26/7/14. Available at: http://www.dsto.defence.gov.au/news/2014/07/26/new-program-strengthen-defence-research

[11] The first in this series is Australian Academy of Science (2013) *Future Science: Computer Science – Meeting the scale challenge*. Available at: https://1-science.cdn.aspedia.net/sites/default/files/user-content/resources/file/fs-computerscience.pdf

[12] Trenberth, R.J. (2004) *Review of DSTO External Engagement and Contribution to Australia's Wealth*. Department of Defence, DSTO.

the US, DARPA is just one element of a considerably larger defence science enterprise. The US Department of Defense has a number of laboratories of its own which conduct the type of work which must be done in a Department of Defense owned entity, for reasons of classification, national sovereignty and independence. In addition, there are separate research laboratories for *each* of the US Armed Services—Army, Navy and Air Force—and each one is very much larger than DSTO. For example the Air Force Research Laboratory alone employs over 10,000 people.

The funding which is administered by DARPA is *separate* from the funding used to run the US Department of Defense laboratories. The DARPA funding supports high risk and potentially high payoff activities, but it does *not* support the central core science and technology support for the Army, Navy and Air Force, or the type of studies required by other elements of the US Department of Defense, that underpins their everyday operations. Given the completely contrasting scale of defence science investment between the United States and Australia it would not be feasible, and could be damaging, to divert precious defence science funding to try and replicate a DARPA model within Australia.

The Academy recommends that:

- **DSTO should continue to make use of the broader science and innovation system through the successful partnerships and mechanisms it has established**
- **adequate funding should be made available for any such collaboration opportunities so that their full benefits can be realised without coming at a cost to core activities.**

Outsourcing potential of Defence Science and Technology Organisation

As the Issues Paper states, DSTO is the Australian Government's lead agency charged with applying science and technology to protect and defend Australia's national interests[13]. Whilst the Issues Paper itself does not discuss or call for comment on how this function should be managed in the future, the way in which Australia undertakes and manages defence science has the potential to raise a range of defence capability, national security and national sovereignty issues which cannot be ignored and assessed in isolation of the development of the White Paper. These questions have been posed (albeit very briefly and without analysis) by the National Commission of Audit[14], and are now subject to assessment by the *First Principles Review* being undertaken alongside the development of the White Paper[15].

The National Commission of Audit recommended that "DSTO should be assessed for its outsourcing potential'[16], claiming that '[DSTO] was not tested as part of Defence's earlier outsourcing efforts". However DSTO has previously been reviewed for potential outsourcing on at least three occasions in the last 17 years (in 1997[17], 2004[18], and 2009[19]), and each time the conclusion has been that the outsourcing of DSTO is *not* in Australia's best interest. According to the National Commission of Audit, the Department of Defence "should compare a fully costed in-house bid to that offered by

[13] Department of Defence (2014) Defence Issues Paper. Available at: http://www.defence.gov.au/Whitepaper/docs/DefenceIssuesPaper2014.pdf
[14] National Commission of Audit (2014) *Towards Responsible Government: The Report of the National Commission of Audit – Phase two*, p.90. Available at: http://www.ncoa.gov.au/report/index.html
[15] Department of Defence (2014) *First Principles Review: Terms of Reference*. Available at: http://www.defence.gov.au/publications/reviews/firstprinciples/terms.asp
[16] National Commission of Audit (2014) *Towards Responsible Government: The Report of the National Commission of Audit – Phase two*, p.90. Available at: http://www.ncoa.gov.au/report/index.html
[17] Department of Defence (1997) *Future Directions for the Management of Australia's Defence: Report of the Defence Efficiency Review.* Available at: http://www.defence.gov.au/minister/der/report.pdf
[18] Trenberth, R.J. (2004) *Review of DSTO External Engagement and Contribution to Australia's Wealth*. Department of Defence, DSTO.
[19] Department of Defence (2009) *Defence White Paper 2009*. Available at: http://www.defence.gov.au/whitepaper/2009/

industry to provide confidence that the chosen option represents best value for money". It makes this assertion on the basis that the "default position should remain that, apart from combat and combat-related functions, all Defence activities are contestable"[20].

The National Commission of Audit does not appear to have considered important relationships and related issues. For much of its activity, defence science should be seen as absolutely integral to combat-related functions, and outsourcing defence science functions cannot just be seen as an accountancy exercise, given the broader impacts outsourcing could have on Australia's future defence science capability. The work that DSTO undertakes is not comparable to laboratory science undertaken in universities or in the private sector; its activities are highly integrated within the Australian Defence Force and it works to implement science and technology for strategic advantage. For example, embedding DSTO personnel in Iraq made for a very successful implementation with on-the-spot adaptation of new technologies. This close interaction between the Australian Defence Force and an outsourced defence science agency would be much harder, if not impossible, to achieve with a non-government science agency. Outsourcing defence-related activities out of a dedicated government agency increases risks as oversight of highly sensitive information is reduced, and the security of the environment in which such science is undertaken cannot be assured. There is a risk that by operating outside of government protocols, highly sensitive classified science could fall into the wrong hands and compromise Australia's ability to participate in defence science collaborations with alliance partners and allies.

It is clear from the Issues Paper that importance is placed upon the Alliance relationship that Australia has with the United States, and the benefits that this brings in terms of access to science, technology and intelligence. Specifically the Issues Paper states that *"Without the US Alliance relationship it would not be possible for Australia to maintain intelligence capabilities or the access to high technology defence equipment, which give such combat power to the ADF"*[21] and brings about *"[consideration for] enhanced cooperation on defence technology areas, including cyber security, space, ballistic missile defence, anti-submarine warfare, special forces and aerospace"*[22]. When assessing whether Australia's defence science requirements can be outsourced to a non-government entity, careful consideration needs to be given as to how this will impact on Australia's relationship with the United States, and how this might affect Australia's access to the latest science and technology being undertaken and developed by the US.

The experience from the United Kingdom with regard to outsourcing defence science has shown that international partners, particularly the United States, will *not* deal directly with outsourced agencies. This has meant that along with concerns about sovereign capability issues, in sensitive areas such as chemical and biological warfare and nuclear technologies, the UK has had to retain its Defence Science and Technology Laboratory as a government facility even when some functions were outsourced to QinetiQ. In Australia, gaining access to US government science and technology is probably more critical than it is for the UK, as Australia has a less capable industrial base and does not have ready access to industrial capability in Europe. As a result, Australia derives proportionately greater benefit from collaboration with the US and does not have mitigation measures available should this collaboration be diminished.

[20] National Commission of Audit (2014) *Towards Responsible Government: Appendix to the Report of the National Commission of Audit – Volume 1*, p.288. Available at: http://www.ncoa.gov.au/report/index.html
[21] Department of Defence (2014) Defence Issues Paper, p.16. Available at: http://www.defence.gov.au/Whitepaper/docs/DefenceIssuesPaper2014.pdf
[22] Department of Defence (2014) Defence Issues Paper, p.17. Available at: http://www.defence.gov.au/Whitepaper/docs/DefenceIssuesPaper2014.pdf

Any assessment of outsourcing DSTO's activities will therefore need to account for how Australia might manage any potential diminished relationship with international partners unwilling to work directly with outsourced defence science agencies, with such an assessment looking at both the additional final cost and the capability loss that this might bring about.

The Academy suggests that maintaining defence science capability and access to US defence science is of greater significance than any short-term economic benefit that outsourcing DSTO might deliver.

Defence science workforce

Gender equality within the science workforce

One of the six key questions put forward by the Issues Paper relates to Defence workforce and is *"How should Defence invest in its people, and how should it continue to enhance its culture"*[23].

The science sector as a whole has significant problems regarding gender equity, and defence science in particular is believed to have exceptionally low levels of employment of women scientists, perhaps as low as five per cent[24]. It is a considerable waste of talent and past investment to not make full use of the whole potential workforce. If the gender imbalance that exists in the science workforce is addressed, employers such as DSTO would have access to a larger pool of high-quality scientists from which to recruit.

The landmark *Women in Science in Australia* report[25] identified two separate but often compounding issues: firstly fewer women hold senior leadership roles than men and, secondly, women leave technical and scientific positions at a greater rate than men (either for other sectors, or to leave the workplace entirely). DSTO has acknowledged the need to take action in this area[26]. 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[27]. The Academy is helping to establish a Science in Australia Gender Equity Forum[28] to try and make real advances in this area, and government research agencies including DSTO have been invited to participate in this initiative.

The Academy recommends that DSTO should continue to engage with the broader science sector to improve gender equity in science workforce.

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[23] Department of Defence (2014) *Defence Issues Paper*, p.2. Available at: http://www.defence.gov.au/Whitepaper/docs/DefenceIssuesPaper2014.pdf

[24] Arabia, A-M. (2011) 'It costs more to lose women in science than keep them'. *Sydney Morning Herald*, 15/4/14. Available at: http://www.smh.com.au/federal-politics/society-and-culture/it-costs-more-to-lose-women-in-science-than-keep-them-20110414-1df9e.html

[25] Bell, S. (2009) *Women in Science in Australia: Maximizing Productivity, Diversity and Innovation.* Federation of Australian Scientific and Technological Societies. Available at: https://minerva-access.unimelb.edu.au/bitstream/handle/11343/28877/264253_2009_bell_women_report.pdf?sequence=1

[26] See DSTO (2013) *Strategic Plan 2013-2018*, p.27. Available at: http://www.dsto.defence.gov.au/sites/default/files/publications/documents/DSTO-Strategic-Plan.pdf

[27] See 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. Available at: https://www.science.org.au/sites/default/files/user-content/postdoc_training_best_practice_emcr_forum_letterhead_final.pdf

[28] See Australian Academy of Science (2014) *SAGE Forum*. Available at: https://www.science.org.au/sage-forum

Future workforce planning

In 2012 the Office of the Chief Scientist undertook a systematic review of the health of Australian science[29]. 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 have 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. In addition to this it found that there are some areas of science, particularly at the higher degree level, where 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 gaps in some areas of research. Whilst most employers have the option of recruiting overseas scientists to fill gaps within the science workforce, for security reasons this will not usually be an option available to DSTO.

There is a high 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 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 career opportunities, there might be difficulties for them in the future pursuing careers in defence science for security reasons.

The Academy recommends the Government should continue its efforts to enhance the quality and attractiveness of science, such as through its continued support for the Academy's science education programs *Primary Connections* and *Science by Doing*, and through implementing the recommendations relating to science education and the workforce outlined in the Office of the Chief Scientist's STEM Strategy[30].

Science and technology areas critical to underpinning broader defence capabilities

Earlier this year, the Government released a discussion paper and sought stakeholder input regarding the development of a new policy and program for invigorating science and technology for national security[31]. The stated purpose of the exercise was to develop a national security science and technology policy and program that improves the coordination, delivery and application of science and technology to address Australia's national security challenges now and in the future[32]. According to the discussion paper, this exercise will result in the Government developing national security science and technology priorities over the 0 to 5 year period, and then out to 10 years and

[29] Office of the Chief Scientist (2012) *Health of Australian Science*. Available at: http://www.chiefscientist.gov.au/wp-content/uploads/HASReport_Web-Update_200912.pdf
[30] Office of the Chief Scientist (2013) *Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach*. Available at: http://www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf
[31] See DSTO (2014) *A national security science and technology policy and program*. Available at: http://www.dsto.defence.gov.au/publication/policy-and-program-invigorating-science-and-technology-national-security
[32] See DSTO (2014) Corporate document | A policy and program for invigorating science and technology for national security. Available at: http://www.dsto.defence.gov.au/publication/policy-and-program-invigorating-science-and-technology-national-security.

longer[33]. Therefore the White Paper should have due regard to the key areas of science and technology identified by stakeholders in the submissions received during this consultation exercise, and take the priorities that are identified into account.

The Academy recommends that the White Paper should have due regard to the consultation recently undertaken by DSTO regarding the development of a new policy and program for invigorating science and technology for national security, including developing national security science and technology priorities.

Given that the above process to identify specific science and technology priorities is underway, the Academy does not seek to repeat or restate this important work within this submission. However it must be noted that discoveries in science and the development of technologies will impact on both defence force capability and how threats to Australia's security can be managed, as well as changing the nature of such threats that Australia faces. The following two examples of quantum science and technology, and climate change, are given to show the importance of recognising the disruptive potential of science and technology within the White Paper.

Quantum science and technology

Quantum science and technology, particularly the sub-disciplines of information processing and transmission, are developing at a more advanced rate than was anticipated even a decade ago. Quantum technology has the potential to be a disruptive technology over the next decade, with quantum computing one area which could impact on national security and the economy in a number of areas, including:

- optimization problems such as software design, machine learning, scheduling and logistical planning
- pattern recognition and anomaly detection for defence systems
- financial analysis and stock market modelling
- software/hardware verification and validation
- bioinformatics, including early disease detection and prevention.

Quantum information processing could potentially transform information technologies in the 21st century, as the properties of quantum physics are exploited to develop powerful new technologies for protecting, transmitting and processing information. Australia is well placed to enjoy significant competitive advantage in this area because of its past investment, particularly in the areas of cyber-security, cryptography and information processing[34].

Classical cryptography relies on the practical difficulty of factoring the product of two large prime numbers to create RSA encryption codes. The potential for quantum computers to break RSA codes in minutes, rather than 1000s of years using a powerful conventional computer, makes virtually every cryptographic system vulnerable. In addition to making existing cryptographic systems insecure, quantum computing offers the possibility of new secure quantum communication technologies.

Quantum communication uses the laws of quantum physics to encrypt information so that unconditionally secure communication is achieved whereby any attempt to intercept the

[33] DSTO (2014) *A national security science and technology policy and program*. Available at: http://www.dsto.defence.gov.au/publication/policy-and-program-invigorating-science-and-technology-national-security

[34] Further discussion on quantum computing and cryptography can be found in Australian Academy of Science (2013) *Future Science: Computer Science – Meeting the scale challenge*, p. 19. Available at: https://1-science.cdn.aspedia.net/sites/default/files/user-content/resources/file/fs-computerscience.pdf

information collapses the quantum state. This technology is currently limited to distances of less than 200 km due to noise and losses in transmission. Quantum repeaters are needed and these will require novel techniques to capture, store and process transmitted quantum information. The development of a quantum repeater and enhanced quantum communication systems will dramatically alter our capacity to transmit critical information securely over long distances. This will allow secure communications between governments, military, defence, finance, business and health systems, and these will be communications that cannot be intercepted even by other users of quantum technology. Whilst allowing secure communications, this technology will also potentially impact on intelligence gathering as it will be very difficult, if not impossible, to intercept the communications of those with access to this technology.

The Academy recommends that the White Paper should reflect the importance of continuing to monitor and respond to the disruptive potential of science and technology and its potential impact on defence and security.

Climate change science

There is strong evidence that changing occurrences of extreme events are related to climate change[35]. A shift in the climate baseline will change the frequency and intensity of extreme weather events. For example, an increase in mean temperature will increase the frequency and intensity of heat waves, while higher mean sea level will increase the frequency and intensity of coastal flooding associated with storm surges[36]. These changes might transform the nature and types of roles, particularly humanitarian roles, which are undertaken by the Australian Defence Force in Australia and in our region.

The lack of discussion on the potential impacts of climate change in the Issues Paper is inconsistent with the scale of the challenge that climate change presents, the science of climate change, and the recognition of this by Australia's strategic allies. Climate change, and the implications for defence forces, is acknowledged by our allies at the highest level. For example, the US Department of Defense has considered how to mitigate the risks that climate change presents to infrastructure[37]. The UK's Ministry of Defence has produced a Global Strategic Trends report that highlights climate change, including catastrophic climate change, as a risk, noting the implications of mass migration and widespread social unrest. The report notes that climate change is likely to lead to pressure on armed and security forces linked with humanitarian assistance[38]. In Australia the Australian Strategic Policy Institute conducted an extensive analysis of the impact of climate change on the Australian Defence Force[39], and the issue is under active discussion within the Australian Defence Force[40].

The Academy recommends appropriate attention be given in the White Paper to the strategic threats that climate change will bring. This includes implications of these threats in terms of risk-based planning by the Australian Defence Force, particularly with regards to how this might transform the types of roles which are undertaken by the Australian Defence Force in our region.

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[35] For further details Australian Academy of Science (2013) *Submission to the Senate Standing Committee on Environment and Communications: Inquiry into recent trends in and preparedness for extreme weather events*. Available at: https://www.science.org.au/sites/default/files/user-content/senateinquiryextremeweatherevents.pdf

[36] *Ibid*

[37] United States Government Accountability Office (2014) *Climate Change Adaptation: DOD Can Improve Infrastructure Planning and Processes to Better Account for potential Impacts.* Available at: http://www.gao.gov/assets/670/663734.pdf

[38] Ministry of Defence (2014) *Global Strategic Trends – Out to 2045*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/324188/8667_GST_textpages_v1_2w.pdf

[39] Australian Strategic Policy Institute (2013) *Special Report Issue 49 - Heavy weather: climate and the Australian Defence Force.* Available at: https://www.aspi.org.au/publications/special-report-issue-49-heavy-weather-climate-and-the-australian-defence-force

[40] Thomas, M.T. (2011) Climate Change and the ADF. Australian Defence Force Journal, 185:34-44