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The challenge of automated and autonomous technologies to Australian Defence Force compliance with workplace health and safety laws

Simon McKenzie

Introduction

Digital technologies are radically changing Australian workplaces. Factories, call centres, universities, hospitals – workplaces of all kinds – are using a range of techniques to work more efficiently, such as deploying automating and autonomous processes, employing robotics, or using machine learning to collect, filter and analyse large data sets. The Australian Defence Force (ADF) is also experiencing this technological revolution: in time, we can expect that it will be central to all aspects of defence work, including training, logistics, repair and maintenance, survey and surveillance, and armed conflict.

A key consideration for the ADF is how to manage the adoption of these technologies consistently with Australian workplace health and safety (WHS) laws. These laws require the ADF to protect the ongoing health and day-to-day safety of its members during their work. Along with mandating a general duty to take all 'reasonably practicable' steps to keep workers safe, the WHS legal regime includes inspections, investigations, prosecutions by WHS regulators, as well as fines to encourage employers to comply with the rules. The proliferation of digital technologies will make keeping workers healthy and safe more complicated, and some of the regulatory interventions more challenging to carry out.

This paper sketches the potential WHS risks – and benefits – of the ADF using digital technologies outside of an operational context (so, during peacetime) and reflects on how these automated and autonomous technologies might test the

legal regime.[1] Using recent scholarship from WHS literature, it suggests that the use of new digital technologies will require the ADF give greater attention to certain kinds of risks, particularly those relating to the interaction between humans and complex machines. It argues the nature of Defence work, combined with the exemptions the ADF has from some legislative requirements, increase some risks. Most significantly, the complexity of new technology has the potential to make it more difficult for ADF members to communicate health and safety risks to their managers. The paper considers how this might be offset by other activities: the same technologies will increase the range of 'reasonably practicable' WHS measures, allowing for the sophisticated monitoring of worker health and safety and hopefully providing effective and timely feedback mechanisms.

Part one of the paper sets out the legal regime. It explains how the ADF's WHS duties operate and how these obligations are reflected in the ADF's Safety Manual. It focuses particularly on the policies that are in place to identify and manage new risks. Part two of the paper turns to the impact of new technologies on workplaces and identifies three key risks of relevance to the ADF: the psychosocial impacts of new technologies; the physical risks of working closely with highly capable machines; and the challenge of testing the safety of complex systems. There are also some safety opportunities, with the deployment of digital technologies providing more ways to keep healthy and safe at work.

Part three returns to the legal regime, analysing what recent jurisprudence and scholarship on WHS regulation suggests about the impact of these technologies. First, they will change what safety measures are 'reasonably practicable' by allowing for more kinds of safety interventions. Second, the complexity of these technologies will make regulatory interventions more difficult, expensive, time consuming and increase the likelihood they will be inconclusive. Overall, the paper demonstrates the importance of ensuring that operators, managers, and regulators within the ADF understand the technologies being used and how these technologies interact with the people that work alongside them.

Australian WHS regulation and the ADF

Being part of the ADF is hazardous. The most obvious of these hazards occur during armed conflict: being tasked with using armed force for Australia means that ADF members will, at times, be exposed to grave physical risks.[2] Along

1 While there are safety issues with the use of new technologies during ADF operations – including in armed conflict – considering the implications of this is beyond the scope of this paper. Safety in an operational context gives rise to different questions and pressures and is governed by different legal regimes.

2 Neil Westphalen, 'Occupational and environmental health in the ADF', *Journal of Military and Veterans Health*, 2017 25(1):44–52. https://jmvh.org/article/occupational-and-environmental-health-in-the-adf/

with physical injuries, ADF members can also suffer severe psychological injuries associated with extreme stress and trauma. These injuries – both physical and psychological – not only occur on the battlefield but also during domestic disaster relief deployments; they can even occur during non-operational activities such as training, carrying out routine maintenance, or when travelling from one location to another. It is the health and safety risks in this latter context that are the focus of this paper.

The ADF clearly has an interest in ensuring its members can carry out their jobs as safely as possible. The Defence work health and safety policy and strategy explains that its aim is to 'ensure no person will suffer a serious preventable work related injury or illness while working for Defence' and that 'protection of our people is paramount'.[3] Even when exposing people to 'extreme risk and hazard' in military operations, the ADF commits to 'manage risk to ensure that all risks to the health and safety of our people are eliminated, or, where risks cannot be eliminated entirely, that they are managed and reduced as far as possible'.[4]

Policymakers have struggled with finding an appropriate WHS regime for the ADF

Much of the history of compensation for ADF members focuses on wartime injuries; less is written about injuries suffered in peacetime and the regulatory interventions that might prevent them.[5] Exactly how the health and safety of ADF personnel should be promoted and how they should be supported or compensated for injuries they receive during service has been contested.[6]

Three events in the 1990s led to an increased focus on how the ADF was, and should be, complying with its WHS obligations. In 1996, two Black Hawk helicopters carrying members of Australia's special forces collided during a training exercise, killing several people and significantly impacting the capability of the special forces.[7] The ADF Board of Inquiry (BOI) found that the accident

3 Defence, 'Defence Work Health and Safety Policy and Strategy', *Defence* [website], Defence: Australian Government, n.d., accessed 17 January 2022, https://www1.defence.gov.au/about/complaints-incident-reporting/work-health-safety/policy-strategy.

4 DOD, 'Defence Work Health and Safety Policy and Strategy'.

5 See, for example, Peter Sutherland, 'The history of military compensation law in Australia [paper presented to the Veteran's Law conference, Banora Point, 2004]', *AIAL Forum*, September 2006, 50, pp 39–59. Available via https://search.informit.org/toc/10.3316/aiafor.2006_n050

6 Sutherland, 'The history of military compensation law in Australia'.

7 Meredith Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army* [unpublished Master thesis], Griffith University, 2020, p 18, accessed 12 May 2022. https://doi.org/10.25904/1912/3947

was caused by several systemic factors,[8] including failures in servicing the helicopters, a lack of pilot experience,[9] and insufficient planning and risk assessment.[10] Another avoidable accident followed two years later, when a Navy Replenishment Ship, *HMAS Westralia*, caught fire after a fuel leak and four sailors were killed.[11] Once again, the investigating BOI identified 'systemic defects' in Navy safety management,[12] and made recommendations in relation to, inter alia, quality assurance and safety training.[13]

The third event was the revelation in 2000 that over a period of 20 years, hundreds of RAAF personnel had been exposed to toxic chemicals while maintaining the fuel tanks of F-111 aircraft and had suffered serious and long-term health effects.[14] The investigating BOI found that many of the contributing factors were systemic: for example, maintenance workers were relatively powerless due to a lack of union organisation or other forms of employee empowerment, such as independent health and safety representatives;[15] and the doctors who saw the symptoms of the maintenance workers did not recognise the seriousness of the problem as they did not appreciate the workers' occupational context.[16] More generally, there was an absence of a consideration in WHS in designing new processes or reviewing existing ones.[17]

These events appear to have been part of the reason that in September 2004 Crown Immunity was withdrawn from the *Workplace Health and Safety Act 2011* (Cth) (WHS Act),[18] making Defence liable for prosecution in the same way as any

8 A Board of Inquiry is a high level of inquiry constituted under Defence regulations to investigate service-related death or injury; Parliament of Australia, 'Chief of Army CA 102/97' in *Black Hawk Board of Inquiry: Documents for Public Release*, 22 February 1997, Publications - ID: publications/tabledpapers/HSTP06420_1996-98 - Source: Senate, paras 8–16. https://parlinfo.aph.gov.au/parlInfo/download/publications/tabledpapers/HSTP06420_1996-98/upload_pdf/6420_1996-98.pdf

9 Parliament of Australia, 'Chief of Army CA 102/97', para 14.

10 Parliament of Australia, 'Chief of Army CA 102/97', para 13.

11 National Archive of Australia (NAA), Royal Australian Navy 'Report of the Board of Inquiry into the fire in HMAS WESTRALIA on 5 May 1998 [electronic resource]', RAN, 28 August 1998, Bib ID 2482080, http://nla.gov.au/nla.arc-33100 https://webarchive.nla.gov.au/awa/20030706091700/http://navy.gov.au/fleet/O195westralia/boi/report.htm, pp 15–42; and p 71.

12 RAN, 'Report of the Board of Inquiry into the fire in HMAS WESTRALIA on 5 May 1998', p 210.

13 RAN, 'Report of the Board of Inquiry into the fire in HMAS WESTRALIA on 5 May 1998', ss. 12 and 13.

14 Royal Australian Air Force (RAAF), 'Chemical exposure of Air Force maintenance workers: Report of the Board of Inquiry into F-111 (Fuel Tank) deseal/reseal and spray seal operations, Vol 1: Entrenching safety in the RAAF, a review of systemic issues, and the recommendations with a view to preventing recurrence', RAAF, 29 June 2001, p 8. https://www.airforce.gov.au/sites/default/files/report_of_the_board_-_volume_1.pdf

15 RAAF, 'Chemical exposure of Air Force maintenance workers', p 87.

16 RAAF, 'Chemical exposure of Air Force maintenance workers', p 87.

17 RAAF, 'Chemical exposure of Air Force maintenance workers', p 89.

18 *Work Health and Safety Act 2011* (Cth).

employer, including exposure to civil penalties, and enforceable undertakings and prosecutions.[19]

Regulatory assessment of the WHS processes and policies of the ADF is tough. Comcare – the relevant WHS regulator – must understand the specific Defence context and how it differs from civilian workplaces.[20] Effective regulator invention requires an appreciation of the unique nature of the work of the organisation and the difference in the relationship between ADF members and the risks that they take as part of their work.[21] A failure to appreciate this context may result in unhelpful (and unsuccessful) prosecutions of 'unintended consequences in a complex and high-risk work environment'.[22] In addition, the ADF must ensure that its members understand their health and safety obligations and how to operationalise them.

The WHS regime imposes broad duties on the ADF to promote health and safety

The hallmark of Australian WHS regulation is its 'performance-based approach', where employers have broad, general duties to achieve safety, security, health and environmental outcomes.[23] Ensuring compliance with these general duties is the focus of regulator interventions.[24] While they operate in a broadly similar manner, each Australian jurisdiction (the States, Territories and Commonwealth) has its own WHS regime, supported by primary and delegated legislation and independent regulators.[25]

The health and safety of ADF members and efficient task completion are sometimes in conflict; and where this arises, a balancing process must occur.[26] For the ADF, this balancing is structured by the legal obligations of the WHS Act.[27] This Act sets out the obligations of the ADF to its members and provides for certain kinds of safety processes, inspections, and deterrence via prosecutions for breaches.

19 Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army*, p 22.

20 Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army*, p 6.

21 Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army*, p 6.

22 Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army*, p 6.

23 Michael Tooma, *Safety, Security, Health and Environment Law,* 3rd edn, The Federation Press, Alexandria NSW, 2019, p 53.

24 Tooma, *Safety, Security, Health and Environment Law*, p 53.

25 *Occupational Health and Safety Act 2004* (Vic); *Work Health and Safety Act 2011* (Qld); *Work Health and Safety Act 2011* (NSW); *Work Health and Safety (National Uniform Legislation) Act 2011* (NT); *Work Health and Safety Act 2011* (ACT); *Work Health and Safety Act 2012 (*SA); *Work Health and Safety Act 2020* (WA).

26 Of course, preventable workplace accidents are hardly conducive to efficient task completion and in many circumstances compliance with WHS requirements can be an operational enabler.

27 *Work Health and Safety Act 2011* (Cth).

Section 19(1) of the WHS Act sets out the primary duty providing a 'person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety' of workers while they are at work.[28] Section 19(3) provides a non-exhaustive list of the kinds of activities that are required, including providing and maintaining safe work environments, safe systems of work, and providing information, training, instruction or supervision.[29]

Of course, this begs the question of what exactly is meant by 'reasonably practicable' measures to ensure health and safety. Section 18 of the WHS Act provides a definition of the term which is worth setting out in full:

> In this Act, ***reasonably practicable***, in relation to a duty to ensure health and safety, means that which is, or was at a particular time, reasonably able to be done in relation to ensuring health and safety, taking into account and weighing up all relevant matters, including:
>
> a. the likelihood of the hazard or the risk concerned occurring; and
>
> b. the degree of harm that might result from the hazard or the risk; and
>
> c. what the person concerned knows, or ought reasonably to know, about:
>
> i. the hazard or the risk; and
>
> ii. ways of eliminating or minimising the risk; and
>
> d. the availability and suitability of ways to eliminate or minimise the risk; and
>
> e. after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, the including whether the cost is grossly disproportionate to the risk.[30]

The investigator, prosecutor or judicial officer charged with figuring out whether something is 'reasonably practicable' considers the matter objectively.[31] They assess the employer's actions according to the knowledge 'possessed by persons generally who are engaged in the relevant field of activity and not by reference to the actual knowledge of a specific defendant in particular circumstances'.[32] The difficulty that a non-Defence investigator or prosecutor, not to mention judicial officer, might have in assessing what health and safety measure are objectively 'reasonably practicable' is easy to see: much of the work and supporting technology is very complicated and is sometimes protected by secrecy provisions. There are no other Australian organisations that offer an easy comparison.

28 *Work Health and Safety Act 2011* (Cth), section 19.

29 *Work Health and Safety Act 2011* (Cth), section 19.

30 *Work Health and Safety Act 2011* (Cth), section 18.

31 *Safework NSW v Tamex Transport Services Pty Ltd t/as Tamext* (2016) NSWDC 295, para 19.

32 Tooma, *Safety, Security, Health and Environment Law*, pp 57–8.

The regime does make some allowances for the unique nature of ADF work. Section 12D(2) of the Act provides that the Chief of the Defence Force can declare that certain provisions of the Act do not apply, or apply only in a modified form.[33] Currently, uniformed ADF members are excluded from certain rights under the WHS Act, including participation in industrial actions, forming a union, or being appointed as health and safety representatives.[34] While this declaration constrains those rights in the WHS regime seen to be incompatible with military command,[35] they mean that ADF members 'do not have the right to cease work, where they are concerned about risks to their health or safety, or disobey orders, without fear of consequences'.[36]

There are risks to these exclusions. They 'undermined one of the objects of the […] Act, to foster a co-operative consultative relationship between employers and the employees on the health, safety and welfare of such employees at work.'[37] Closing some of the conduits for information, particularly contested information, may make the ADF more vulnerable to breakdowns in communication between workers and their managers. As will be seen, this might increase the challenge of safely deploying automated and autonomous technologies.

Current ADF WHS policy provides solid ground for coping with technological change

The ADF sets out how it complies with its duties under the WHS Act in the Defence Safety Manual (known as 'SafetyMan'). The manual is the central WHS policy document for the ADF and covers a variety of topics, including working with hazardous chemicals, asbestos, noise and the general work environment.[38] The manual is written in broad terms and, on its face, can deal with the health and safety issues arising from the use of digital technologies.

There is not a specific section of the manual dealing with digital technologies (unsurprisingly, given their ubiquity). The part that deals with governance and due diligence (Section 2) is the most relevant aspect of SafetyMan for the purposes of this paper. Reflecting the requirements of the WHS Act, it provides

33 *Work Health and Safety Act 2011* (Cth), section 12D.

34 *Work Health and Safety Act 2011 (application to Defence activities and Defence members) Declaration 2012*.

35 Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army*, p 16.

36 Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army*, p 6.

37 Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army*, p 15.

38 Defence, 'Defence Work Health and Safety Policy and Strategy' [website].

that leaders must take steps to 'support' and 'contribute to' a culture of safety.[39] It explains how the ADF collects information for the assessment of the WHS management systems and to 'identify work health and safety issues, guide improvement initiatives and provide assurance that initiatives are effective in achieving a reduction in work related injury, illness and disease'.[40] Ideally, these metrics should enable Defence leaders to meet their due diligence obligations and make 'informed decisions' about how best to promote a culture of safety.[41]

The risks of statutory exclusions mentioned above are somewhat offset by the explicit recognition in Section 2 that 'consultation, communication and issue resolution' are key to effective WHS management.[42] The policy emphasises the need to collect and disseminate WHS information to allow for informed decisions and due diligence. This includes collecting data and making sure it is in a form that can be used for evaluating health and safety practices.[43] Further, it provides for the education of employees on a continuing basis about how to effectively manage hazards.[44]

Hazard identification and risk management are key to health and safety,[45] and must be a routine process.[46] Along with a 'rigorous assessment of work health and safety threats' and the 'proactive elimination or control of these threats',[47] this includes:

- 'policies, processes, tools and systems used to identify, risk assess and record … safety risks and hazards'[48]
- 'systems used to record and communicate the high risk/major hazard areas and processes'[49]

39 Defence People Group (Defence), '17 Element Work Health and Safety Management System' [PDF], Defence People Policy, SafetyMan: Department of Defence, https://www.defence.gov.au/sites/default/files/2021-03/section-2-governance-and-due-diligence.pdf, para 6. Access via: Defence, 'Defence Work Health and Safety Policy and Strategy', *Defence* [website], Australian Government, n.d., 'SafetyMan – Section 2 – Governance and Due Diligence' (PDF, 9MB). https://www1.defence.gov.au/about/complaints-incident-reporting/work-health-safety/policy-strategy

40 Defence, '17 Element Work Health and Safety Management System', para 7.

41 Defence, '17 Element Work Health and Safety Management System', para 8.

42 Defence, '17 Element Work Health and Safety Management System', para 9.

43 Defence, '17 Element Work Health and Safety Management System', para 21.

44 Defence, '17 Element Work Health and Safety Management System', paras 24–28.

45 Defence, '17 Element Work Health and Safety Management System', paras 36–42.

46 Defence, '17 Element Work Health and Safety Management System', para 39.

47 Defence, '17 Element Work Health and Safety Management System', para 38.

48 Defence, '17 Element Work Health and Safety Management System', para 38.1.

49 Defence, '17 Element Work Health and Safety Management System', para 38.2.

- 'policies, processes and systems used to develop, document, communicate, supervise, audit, review and amend the control mechanisms required to mitigate … hazards'[50]
- 'methods by which highly specialised external knowledge is accessed for hazard identification, inspection and mitigation activities.'[51]

While the policies are broad enough to cope with technological change, it must be acknowledged that appropriate processes do not, by themselves, ensure appropriate outcomes. The broad framework set out in the SafetyMan policies will be tested by the deployment of automated and autonomous digital technologies,[52] particularly as hazard identification and risk management is even more important when dealing with highly complex systems that can operate in unexpected ways. Safety engineering literature has begun to address the implications of these new digital technologies as well as the potential benefits; and it is to this body of work that we now turn.

Safety implications for the ADF of new digital technologies

The convergence of several forms of technology – autonomous robots, the internet of things and additive manufacturing – has led some safety engineers to declare that we are experiencing a fourth industrial revolution.[53] It is evident that these technologies are transforming how work happens, including in the ADF.[54] By working in combination to enhance and augment one another, these technologies are displacing some roles, such as in manufacturing and creating new kinds of jobs, such as in computer engineering.[55] The boundary between home and work is becoming more blurred as remote working becomes more viable and peer-to-peer platforms making 'freelancing' possible on a global scale.[56]

The relationship between humans and the technology they work with is continuing to change. While computer systems are reliable at carrying out repetitive tasks, they cannot match the flexibility, intelligence and context-based

50 Defence, '17 Element Work Health and Safety Management System', para 38.3.

51 Defence, '17 Element Work Health and Safety Management System' para 38.6.

52 This point was made in Eve Massingham, 'Navigating to autonomy: legal questions in the use of autonomous aerial vehicles by the Australian military', *Australian Journal of Defence and Strategic Studies*, 1 July 2021, 3(1): 3–25, 22–23.

53 Gabriel Chia MPH, See Ming Lim MPH, Gek Khim Judy Sng FAMS, Yi-Fu Jeff Hwang MPH, Kee Seng Chia MD, 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', *American Journal of Industrial Medicine*, April 2019, 62(4):275.

54 Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 275.

55 Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 275.

56 Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 275.

thinking of human operators, all of which are needed to respond to unexpected events.[57] Guznov et al. explain that, instead of being manually controlled by a human or human team, 'future robotic systems will be self-directing and receive high-level commands from a single human partner as part of human–machine team'.[58] They give the example of a search and rescue being carried out by an uncrewed ground vehicle:

> [The vehicle] would navigate autonomously through debris using a multitude of on-board sensors. It would communicate to the human partner about the environment and its states via a live video feed and other forms of communication (e.g. text messages). The human is responsible for monitoring navigation performance as well as high-level decision making (route selection, task prioritization, etc.). Both the robot and human partner need to work together to achieve mission objectives.[59]

The effective use of digital technologies has real benefits for civilian industry. For example, it is hoped that the use of artificial intelligence and the internet of things will 'allow manufacturers to meet ever-changing demand more efficiently using adaptable, and responsive machinery.'[60]

Many aspects of the future of work are relevant to the ADF. The most prominent example is the 'remote work' enabled by drone technology: the pilots of uncrewed aerial vehicles can be based far away from where the device is flying. Given the need for the specialised design and manufacture of military equipment, the ADF is also likely to benefit from advanced manufacturing. The efficiencies of other tasks essential to military work like maintenance, logistics and keeping track of equipment and personnel will be improved if well-designed computer programs are used to assist with gathering and filtering information. For those tasks that can be automated, personnel will be freed to do other work. While some concerns – such as those to do with increased employment precarity and the 'gig economy' – are unlikely to directly affect the ADF, they could impact on defence indirectly through contractors or suppliers.

57 European Agency for Safety and Health at Work (EASHW), P Pappachan, A Hauke and E Flaspöler, 'The human machine Interface as an emerging risk', EASHW Publication Office, 2010, p 17. https://data.europa.eu/doi/10.2802/21813

58 Svyatoslav Guznov, J Lyons, M Pfahler, A Heironimus, M Woolley, J Friedman and A Neimeier, 'Robot transparency and team orientation effects on human–robot teaming', *International Journal of Human–Computer Interaction*, 2020, 36(7):650.

59 Guznov et al., 'Robot transparency and team orientation effects on human–robot teaming', p 650.

60 Adel Badri, Bryan Boudreau-Trudel and Ahmed Saâdeddine Souissi, 'Occupational health and safety in the industry 4.0 era: A cause for concern?', *Safety Science*, November 2018, 109:403.

New digital technologies will exacerbate some risks

Despite many engineers and scientists working and publishing on the potential of new digital technologies, relatively few papers address the health and safety implications of the changes,[61] some of which are potentially very serious.[62] Responding to these risks might require changing work practices.[63] Three risks are particularly relevant to the ADF: psychosocial risks, physical risks, and the challenge of testing new technologies to better understand the health and safety implications.

Psychosocial risks

Many of the potential WHS issues relate to how people will cope psychologically with the changes to their work. People are likely to find these changes stressful, particularly the pace of working with robots that they do not fully understand and might even mistrust or fear.[64] These risks are often overlooked by the engineers and designers of new systems.[65]

One directly relevant risk for the ADF is the potential for human–machine interfaces (HMIs) to increase mental or emotional strain on workers.[66] The capacity of technology to present copious amounts of information and combine tasks carries the risk of compounding small operator errors and leading to serious consequences.[67] Even when health and safety systems are included in the HMI, a user overloaded with information will not necessarily be able to use all the available functions to prevent harm.[68]

The central role of human–machine collaboration makes effective communication between the computer system and the human operator essential. Effective communication requires trust and transparency.[69] This is complicated by the 'natural perturbations of robot reliability' but ensuring human operators

61 Badri, Boudreau-Trudel and Souissi, 'Occupational health and safety in the industry 4.0 era', p 405.

62 Badri, Boudreau-Trudel and Souissi, 'Occupational health and safety in the industry 4.0 era', p 404.

63 Sara L Tamers, Jessica Streit, Rene Pana-Cryan, Tapas Ray, Laura Syron, Michael A. Flynn, Dawn Castillo, Gary Roth, Charles Geraci, Rebecca Guerin, Paul Schulte, Scott Henn, Chia-Chia Chang, Sarah Felknor, and John Howard, 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce: a perspective from the CDC's National Institute for Occupational Safety and Health', *American Journal of Industrial Medicine*, 2020, 63(12):1066.

64 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 1072.

65 Badri, Boudreau-Trudel and Souissi, 'Occupational health and safety in the industry 4.0 era', p 407.

66 EASHW, 'The human machine interface as an emerging risk'.

67 EASHW, 'The human machine interface as an emerging risk', p 17.

68 EASHW, 'The human machine interface as an emerging risk', p 17; Gabriel Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 277.

69 Svyatoslav Guznov et al., 'Robot transparency and team orientation effects on human–robot teaming', p 656–7.

appreciate these 'perturbations' is not straightforward.[70] Designers must find a way to balance the need to provide clear and relevant information about how the system is arriving at recommendations, decisions or actions with the risk of overloading the human operator.[71]

Some concerns are more to do barriers between work and non-work breaking down.[72] The increased fluidity of the physical boundaries of work makes it challenging for employers to ensure they are providing a safe work environment.[73] Furthermore, research suggests that there could be negative psychological effects from blurring work and non-work, leading workers to:

> experience emotional and mental stress more frequently and more intensely […], greater demands for work availability and flexibility, and decreased human connections due to remote working and the use of robots in the workplace.[74]

The increasing use of 'on-call' systems and duty officers mean that at least some ADF members, as well as some of the contractors and businesses that provide goods and services to the ADF, will be exposed to these hazards.

Physical risks

ADF members will also face physical risks from working alongside automated machinery and robots.[75] In the past, such risks were more limited as robots were confined to certain spaces or only moved according to predictable, tested and validated sequences.[76] Less predictable movement will be more dangerous and will require a response.[77] Beetz et al. use the example of a

70 Svyatoslav Guznov et al., 'Robot transparency and team orientation effects on human–robot teaming', p 657.

71 Svyatoslav Guznov et al., 'Robot transparency and team orientation effects on human–robot teaming', p 658.

72 Gabriel Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 277.

73 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 5.

74 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 6.

75 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 14.

76 Badri, Boudreau-Trudel and Souissi, 'Occupational health and safety in the industry 4.0 era', p 408.

77 Badri, Boudreau-Trudel and Souissi, 'Occupational health and safety in the industry 4.0 Era', p 405; Michael Beetz, Georg Bartels, Alin Albu-Schaffer, Ferenc Bálint-Benczédi, Rico Belder, Daniel Beßler, Sami Haddadin, Alexis Maldonado, Nico Mansfeld, Thiemo Wiedemeyer, Roman Weitschat, Jan-Hendrik Worch, 'Robotic agents capable of natural and safe physical interaction with human co-workers', in *2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (IEEE, Hamburg, 2015):6528–6535. https://doi.org/10.1109/IROS.2015.7354310

robot in a hospital assisting with tidying up and arranging surgical instruments to demonstrate the risk:

> While the robot holds a scalpel to put it onto the tray, a human co-worker suddenly steps into its reach […] As robot system designers, we would like the robot control program to identify this as a potentially dangerous situation, and react by a) pointing the sharp blade of the scalpel away from the human, and b) stopping or drastically reducing speed and stiffness of its motion.[78]

Robot control programs – including those used by the ADF – will ideally be equipped with 'basic knowledge about tasks, humans and motions to act competently and safely in open human environments'.[79]

Challenge of testing for risks

Testing is a crucial opportunity to assess the health and safety consequences of using a system and identify any risks and hazards. This is true of assessments by militaries of autonomous systems. Testing allows for the risks and hazards of new systems to be identified and documented and for mitigation strategies to be recommended. Risk mitigation might involve providing warnings, requiring certain equipment be worn, or mandating training.[80]

Testing defence systems is already time consuming, complicated and very expensive.[81] For example, the verification of software supporting aircraft 'has become the single most costly development activity' and 'testing alone cannot establish strict bounds on all behaviours that may occur during the operation of these software-intensive systems.'[82] Figuring out how to carry out these tests efficiently while also ensuring safety is particularly important as militaries attempt to speed up development timelines to enable technology to be deployed more quickly.[83]

78 Beetz et al., 'Robotic agents capable of natural and safe physical interaction with human co-workers', p 6528.

79 Beetz et al., 'Robotic agents capable of natural and safe physical interaction with human co-workers', p 6529.

80 Amar Marathe, Ralph Brewer, Bret Kellihan and Kristin E Schaefer, 'Leveraging wearable technologies to improve test & evaluation of human-agent teams', *Theoretical Issues in Ergonomics Science*, 2020, 21(4):400. https://doi.org/10.1080/1463922X.2019.1697389

81 Keith F Joiner and Malcolm G Tutty, 'A tale of two allied defence departments: new assurance initiatives for managing increasing system complexity, interconnectedness and vulnerability', *Australian Journal of Multi-Disciplinary Engineering*, 2018, 14(1):8. https://doi-org.ezproxy-b.deakin.edu.au/10.1080/14488388.2018.1426407

82 Darren Cofer, 'Taming the complexity beast', *The ITEA Journal of Test and Evaluation*, 2015.

83 Marathe et al., 'Leveraging wearable technologies to improve test and evaluation of human-agent teams', p 398.

The increasing number of systems that provide for, or depend on, human–machine teams, and the algorithmic complexity of the software supporting these systems, means these difficulties are certain to increase. Current testing and evaluation approaches are based on factors that are 'either defined or directly observed by the engineer or system evaluator'.[84] It involves 'testing edge cases of specific requirements' and developing a testing script where 'the sequence of inputs and events a system will encounter, as well as the expected result, are known prior to the execution of the test'.[85] This sort of testing will not be sufficient for autonomous, learning systems. Instead, evaluation will have to be more of a collaboration with the end users, allowing designers to understand how they will want to use the technology and how the technology will respond to this use. It might even involve users using the systems in an 'unconstrained and unscripted setting to enable evaluation of their utility'.[86]

The challenge of testing and verifying the reliability of machine-learning systems is well known. Algorithms can lack transparency, be biased to certain outcomes, and be very hard to understand and trust, even after testing.[87] The 'as yet unquantified or even unquantifiable risks' mean that 'these emerging hazards will require a robust surveillance system, adaptive risk-management tools as well as innovative control measures.'[88]

Joiner and Tutty point to a few key issues with the assurance of complex defence systems. First, they are becoming so 'synthesised or fused, complex and independent' that they can have 'emergent properties or exhibited behaviours' that are tough to predict.[89] Second, the range of permutations in modern software-enabled systems makes standard testing impractical and that instead, modelling and 'continuous through-life monitoring' is required.[90] Where systems are capable of higher-order decision-making – that is developing and executing strategies – it becomes harder to define the tasks the system must do. This makes it crucial to develop the systems with an intimate and iterative

84 Marathe et al., 'Leveraging wearable technologies to improve test and evaluation of human-agent teams', p 398.

85 Marathe et al., 'Leveraging wearable technologies to improve test and evaluation of human-agent teams', p 398.

86 Marathe et al., 'Leveraging wearable technologies to improve test and evaluation of human-agent teams', p 398.

87 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 13.

88 Gabriel Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 277.

89 Joiner and Tutty, 'A tale of two allied defence departments', p 4.

90 Joiner and Tutty, 'A tale of two allied defence departments', pp 4–5.

understanding of operator agency and decision-making and evaluating the safe operation of the system of systems (rather than just a single system in isolation).[91]

In addition, appropriately skilled human-factors engineers should be included in the development of strategies to ensure that there is iterative testing of the consequences of people being replaced or augmented.[92] Evaluating the performance of human–machine teams is difficult as the relationship between the operator and the device is complex with the behaviour of each effecting the other. This sometimes results in counterintuitive results. For example, the use of AI-enabled technology to assist with maintaining health and safety could 'lead people to take more risks to maintain the pre-intervention risk level, and for that reason, the new interventions have a limited effect'.[93]

The environment the system operates in will also have a significant impact on how technology behaves. Exploring ways to test and evaluate uncrewed underwater vehicles, Keane and Joiner explain that the phasing of the testing will have to be adjusted to deal with the 'complexities of testing a complex system in open, non-deterministic environments'.[94]

New technologies can be used to help keep ADF members safe

The rapid development and deployment of digital technologies does not only present risks; it presents opportunities to improve the health and safety of ADF members. Most obviously, the use of robots improve work for humans by reducing the need for human workers to do dangerous or repetitive work.[95] This includes tasks that risk exposure to dangerous chemicals or explosives, or tasks that are repetitive and time consuming, like surveillance. Instead of these possibilities –

91 Joiner and Tutty, 'A tale of two allied defence departments', p 5; MG Tutty and T White, 'Unlocking the future: decision making in complex military and safety critical systems', in *Systems Evaluation Test and Evaluation Conference 2018: Unlocking the Future Through Systems Engineering: SETE 2018*, (Engineers Australia, 2018) p 557, p 563; Marathe et al., 'Leveraging wearable technologies to improve test and evaluation of human-agent teams', p 399.

92 Joiner and Tutty, 'A tale of two allied defence departments', p 9.

93 Doron Cohen and Ido Erev, 'On safety, protection, and underweighting of rare events', *Safety Science*, November 2018, 109:377.

94 James Keane and Keith Joiner, 'Experimental test and evaluation of autonomous underwater Vehicles', *Australian Journal of Multi-Disciplinary Engineering*, 2020, 16(1):67. https://doi-org/10.1080/14488388.2020.1788228

95 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 14.

which have been well canvassed elsewhere[96] – this section identifies some less obvious ways that the ADF can leverage new technology to improve the safety of its members and ensure compliance with its WHS obligations.

Responsive and real-time safety monitoring

The increasing availability of wearable technology, particularly when combined with software able to analyse large sets of data, will revolutionise health and safety monitoring.[97] For example, the use of intelligent sensors might allow for a 'more dynamic [WHS] conceptual framework based on new, more personalized and dynamic risk management system'.[98] Increased automation may help cut out human-process errors and enable and automated appropriate responses when WHS issues occur.[99]

Advanced sensors can be used to monitor health and safety, including by being worn on the body, surgically placed in the body, or embedded in safety clothing or a workplace object.[100] For example, when working with dangerous substances, sensors could allow for 'continuous sampling' instead of 'a reliance on slower, episodic sampling, enabling early intervention to prevent toxic exposures'.[101] Some studies have suggested that some personal protective equipment could be equipped with thermoregulation properties to help workers maintain a safe temperature,[102] or include sensors to track the location of workers in relation to high-risk zones, to keep tabs on environmental conditions, or the physiology

96 See, for example, Australian Defence Force, *Concept for Robotic and Autonomous Systems*, vol 1.0, Reference DPN: BN9939583, Australian Defence Force: Australian Government, 2020, https://defence.gov.au/vcdf/forceexploration/_Master/docs/ADF-Concept-Robotics.pdf; Royal Australian Navy (RAN), 'RAS-AI Strategy 2040', Warfare Innovation Navy, RAN, 2020, https://navalinstitute.com.au/wp-content/uploads/RAN_WIN_RASAI_Strategy_2040f.pdf; Massingham, 'Navigating to autonomy: legal questions in the use of autonomous aerial vehicles by the Australian military', pp 8-9; Simon McKenzie, 'Autonomous technology and dynamic obligations: uncrewed maritime vehicles and the regulation of maritime military surveillance in the exclusive economic zone', *Asian Journal of International Law*, January 2021, 11(1):146-75, pp 149–153. http://doi.org/10.1017/S2044251321000011

97 Daniel Podgórski, Katarzyna Majchrzycka, Anna Dąbrowska, Grzegorz Gralewicz and Malgorzata Okrasa, et al., 'Towards a conceptual framework of OSH risk management in smart working environments based on smart PPE, ambient intelligence and the internet of things technologies', *International Journal of Occupational Safety and Ergonomics*, 2017, 23(1):1–20, https://doi-org/10.1080/10803548.2016.1214431; Sara L Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 12.

98 Badri, Boudreau-Trudel and Souissi, 'Occupational health and safety in the industry 4.0 era', p 405.

99 Badri, Boudreau-Trudel and Souissi, 'Occupational health and safety in the industry 4.0 era', p 408.

100 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 15.

101 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 15.

102 Podgórski et al., 'Towards a conceptual framework of OSH risk management in smart working environments based on smart PPE, ambient intelligence and the internet of things technologies', p 4.

of workers.[103] Examples include the integration of wearable electronics in the gloves of firefighters for 'temperature measurements, haptic feedback and gesture recognition'[104] or the use of smart watches to track movement and physical activity, detecting falls or evaluating risks associated with vibrations.[105]

Virtual training

New technologies are also transforming training.[106] AI-enabled virtual reality can be used to create 'dynamic, high-fidelity immersive environments to stimulate hazardous situations and enhance a worker's hazard recognition capabilities'.[107] The ADF is already using forms of this technology. For example, along with the currently existing RAAF aircraft simulators and RAN ship bridge simulators,[108] the North Queensland Simulation Park (NQ Spark) facility will allow the ADF to conduct immersive live and simulation training using cutting-edge technology.[109] Some analysts have argued that the ADF should go further and build the capacity to conduct live, virtual and constructive training (LVC), which is where there is a mix of 'real people, simulated capabilities and environments, and computer-generated elements'.[110]

Research suggests that this form of training can be particularly effective. A 2013 study found that using immersive virtual reality to train construction workers in identifying and assessing risks was more effective than training in a traditional classroom.[111] Trainees were able to concentrate and stay engaged for longer

103 Podgórski et al., 'Towards a conceptual framework of OSH risk management in smart working environments based on smart PPE, ambient intelligence and the internet of things technologies', p 5.

104 Podgórski et al., 'Towards a conceptual framework of OSH risk management in smart working environments based on smart PPE, ambient intelligence and the internet of things technologies', p 5.

105 Luis Sigcha, Ignacio Pavon, Pedro Arezes, Nelson Costa, Guillermo De Arcas and Juan Manuel Lopez, 'Occupational risk prevention through smartwatches: precision and uncertainty effects of the built-in accelerometer', *Sensors*, 2018, 18(11):3805. https://doi.org/10.3390/s18113805

106 Gabriel Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 277.

107 Tamers et al., 'Envisioning the future of work to safeguard the safety, health, and well-being of the workforce', p 12.

108 Julian Kerr, 'Training for the 21st century', *Australian Defence Magazine*, 17 December 2021, https://www.australiandefence.com.au/defence/simulation/training-for-the-21st-century; Louis Dillon, 'RAN awards bridge simulator contract', *Defence Connect*, 9 May 2019. https://www.defenceconnect.com.au/maritime-antisub/4009-ran-awards-bridge-simulator-contract

109 David Burke, 'Cutting-edge simulation facility planned for Townsville', *The Strategist*, 15 December 2020, https://www.aspistrategist.org.au/cutting-edge-simulation-facility-planned-for-townsville/

110 Tony McCormack, 'Covid-19 means live, virtual and constructive training's time has come', *The Strategist*, 9 February 2021. https://www.aspistrategist.org.au/covid-19-means-live-virtual-and-constructive-trainings-time-has-come/

111 Rafael Sacks, Amotz Perlman and Ronen Barak, 'Construction safety training using immersive virtual reality', *Construction Management and Economics*, 2013, 31(9):1005–1017. https://doi-org/10.1080/01446193.2013.828844

periods during the training and it allowed them to be exposed to hazards 'directly and realistically without compromising their safety'.[112]

The possibilities of virtual reality go beyond training. Sun et al. note that smart factories, data processing capacity combined with the internet of things will 'enable a close connection between the physical and digital worlds', allowing digital twins to be a 'comprehensive physical and functional description of a component, product or system'.[113] Ideally, the digital twin will 'virtually replicate the behaviour of the physical counterpart', enhancing the value of testing.[114]

Regulatory responses to new technologies

While Australian WHS laws are flexible and sufficiently broad to cope with them without legislative change, these technological changes will have an impact on the operation of the regulatory scheme. This section of the paper considers two key implications: first, the increase of 'reasonably practicable' WHS measures available to the ADF; and second, the difficulties regulators will face carrying out inspections and investigating safety incidents related to new digital technologies.

The range of 'reasonably practicable' safety measures will increase

As noted, the WHS Act requires the ADF to take 'reasonably practicable' steps to keep its workers safe. New technology will increase the range of interventions that might be 'reasonably practicable.' For example, it may be reasonable in some ADF settings to use advanced technology to undertake personalised occupational risk assessment for individual workers.[115] Depending on the risks, it might even be reasonable for this to be continuous and real time.[116]

Australian Courts have considered when adopting a new WHS measure is reasonably practicable. While a comprehensive review of this jurisprudence is beyond the scope of this paper, considering some of the cases helps understand how the law will apply to ADF use of new health and safety technology. It shows just how fact-dependent the operation of this test is: Courts consider the safety

112 Sacks, Perlman and Barak, 'Construction safety training using immersive virtual reality', p 1016.

113 Shengjing Sun, Xiaochen Zheng, Bing Gong, Jorge Garcia Paredes and Joaquin Ordieres-Meré, 'Healthy operator 4.0: A human cyber–physical system architecture for smart workplaces' 2011, *Sensors*, 2020, 20(7):1–21. https://doi.org/10.3390/s20072011

114 Sun et al., 'Healthy operator 4.0', p 2.

115 Podgórski et al., 'Towards a conceptual framework of OSH risk management in smart working environments based on smart PPE, ambient intelligence and the internet of things technologies', p 8.

116 Podgórski et al., 'Towards a conceptual framework of OSH risk management in smart working environments based on smart PPE, Ambient Intelligence and the Internet of Things Technologies', p 8.

measure in the context of the worksite and the constraints that are on the employer.

Even where a WHS measure may help in some circumstances it still may not be reasonably practicable. The benefits of the measure must be more than speculative and people with the necessary expertise to carry out the intervention should be reasonably available. For example, *May v Helicopter Resources* concerned the death of a pilot in Antarctica after he fell into a crevasse when returning to his helicopter.[117] One of the safety measures that the prosecution alleged was reasonably practicable was using satellite imagery to check if there was crevassing at the operation site and to only proceed if there was evidence of 'minimal crevassing'.[118] The ACT Supreme Court found that such a measure was not reasonably practicable: the prosecution had failed to provide enough evidence of what 'minimal crevassing' meant, and it was unclear whether the imagery (which could be many years out of date) would have actually assisted in preventing the incident.[119] Furthermore, there were not people available to the employer who had the necessary expertise to interpret satellite imagery before each flight for signs of crevassing.[120]

Similarly, the deployment of new technology may not always be reasonably practicable even if it would improve safety. The case of *Greenham Tasmania Pty Ltd v Director and Public Prosecutions* demonstrates this point:[121] the case concerned an abattoir cleaner who was crushed underneath a moving platform used in meat processing.[122] The Magistrate found installing a pressure mat under the platform to prevent its operation when someone was underneath was not reasonably practicable 'given such mats were not commercially available and were not known to have been installed in any other abattoir'.[123]

Proper training connected to the tasks being undertaken and ongoing safety briefings are key measures that are regularly found to be reasonably practicable for employers. In *Guilfoyle v Culverthorpe Pty Ltd*,[124] the Court found that holding documented 'toolbox' meetings and training workers specifically to work in

117 *May v Helicopter Resources; Commonwealth of Australia v May* [2021] ACTSC 116.

118 *May v Helicopter Resources; Commonwealth of Australia v May* [2021] ACTSC 116, para 19.

119 *May v Helicopter Resources; Commonwealth of Australia v May* [2021] ACTSC 116, para 34.

120 May v Helicopter Resources; *Commonwealth of Australia v May* [2021] ACTSC 116, para 36.

121 *Greenham Tasmania Pty Ltd v Director and Public Prosecutions* [2021] TASSC 51.

122 *Greenham Tasmania Pty Ltd v Director and Public Prosecutions* [2021] TASSC 51, paras 2–5.

123 *Greenham Tasmania Pty Ltd v Director and Public Prosecutions* [2021] TASSC 51, para 14.

124 *Guilfoyle v Culverthorpe Pty Ltd* [2019] QMC 17.

deep trenches were reasonably practicable and would have addressed the risk of injury if the trench collapsed (as happened in that case).[125]

As can be seen, whether the adoption of a new technology or new form of training is reasonably practicable depends on several factors. ADF managers will have to maintain awareness of what types of new WHS monitoring are available and continue to consider how computer systems might aid in keeping their workers safe. They should ensure that where monitoring programs are adopted, there are systems and processes in in place to properly respond to these risk assessments. It does not mean that every possible WHS measure is required but rather only those that are reasonable considering the nature of the risk or hazard and the cost of addressing it.

New digital technology makes investigating some safety incidents more complicated

The complexity of new digital technologies makes carrying out workplace inspections and investigations of any WHS incidents more difficult. Where a system is governed by code, a visual inspection will not reveal some of the most important aspects of its operation. If a workplace accident happens, it might not be possible to conclusively assign responsibility for incidents involving multiple complex systems interacting in unexpected ways. More people and organisations are likely to be involved in the development, deployment and use of these systems – which might be made up of smaller, separately programmed technologies – that result in an accident when they are combined together. At a minimum, investigators will need highly specialised skills,[126] and even then, there might be some parts of the system that cannot be understood.

Furthermore, where a system operates through complex 'black box' algorithms, it might not be possible for anyone to know exactly what went awry; all that will be observed is the unexpected outcome that put someone's health and safety at risk. While an incident like this may not be able to be anticipated, once it has occurred, the operators and managers of the system will be on notice and be required to take 'reasonably practicable' steps to avoid it happening again.

Investigating and prosecuting breaches of WHS law will require specialised knowledge of how the systems operate and technical evidence demonstrating how any breach happened. This is likely to become more time consuming and

125 *Guilfoyle v Culverthorpe Pty Ltd* [2019] QMC 17, para 90; para 93.

126 This has been acknowledged by the regulator: see Comcare, *Comcare Corporate Plan 2019–2023*, Comcare: Australian Government, 2019, p 5. https://www.comcare.gov.au/about/forms-publications/documents/publications/corporate-publications/corporate-plan-2019-23.pdf

costly as the systems become more complex. Adding to the difficulty is the reliance of the ADF, at least in part, on systems that do not have a direct corollary in civilian life and that only ADF insiders properly understand. It might be hard to find independent investigators that have sufficient knowledge and expertise to unpack what has occurred. If a WHS incident ends up in some sort of judicial investigation – whether in a contested hearing or some other form of inquiry – evidence about the operation of the system will have to be presented to the decision-makers in a way they can understand. Where this involves pulling apart programming language, assessing the approach taken to testing, or considering the operation of many algorithms working in concert, they will be almost completely reliant on expert evidence. Again, this will make any proceedings take longer and cost more and may ultimately lead to an inconclusive outcome.

These difficulties have the potential to undermine a key component of the regulatory regime. One of the few things that can be said with a degree of confidence about WHS regulation is that, generally speaking, health and safety outcomes are improved by regular inspections backed up by sanctions for failures to comply.[127] These inspections are not necessarily in response to a WHS incident but are conducted to ensure the employer is meeting their WHS obligations. Inspections by regulators – both with and without penalties – are associated with reducing injury rates and compliance;[128] some even argue inspections are more important to deterrence than the level of penalties.[129] The effectiveness of inspections is improved when managers are made aware of any safety issues and given information to allow them to comply with their obligations.[130]

While this evidence on the effectiveness of WHS regulation is useful, it should be treated with caution. Assessing the general impact of any regulatory measure, let alone the extent to which they will be challenged by new technology, is complicated. It is hard to unpick what workplace cultures, policies or regulatory

127 Kevin Purse and Jillian Dorrian, 'Deterrence and enforcement of occupational health and safety law', *International Journal of Comparative Labour Law and Industrial Relations*, 2011, 27(1):35–6; Emile Tompa, Christina Kalcevich, Michael Foley, Chris McLeod, Sheilah Hogg-Johnson, Kim Cullen, Ellen MacEachen, Quenby Mahood, Emma Irvin, 'A systematic literature review of the effectiveness of occupational health and safety regulatory enforcement', *American Journal of Industrial Medicine*, November 2016, 59(11):929. https://doi.org/10.1002/ajim.22605

128 Johan Hviid Andersen, Per Malmros, Niels Erik Ebbehoej, Esben Meulengracht Flachs, Elizabeth Bengtsen and Jens Peter Bonde, 'Systematic literature review on the effects of occupational safety and health (OSH) Interventions at the Workplace', *Scandinavian Journal of Work, Environment & Health*, 2019, 45(2):103. https://doi.org/10.5271/sjweh.3775

129 Nestor, *The effect of occupational health and safety regulator intervention on the Australian Army*, pp 25–6.

130 Safe Work Australia, *Effectiveness of Work Health and Safety Interventions by Regulators: A Literature Review*, Safe Work Australia, April 2013, p 7. https://www.safeworkaustralia.gov.au/system/files/documents/1702/effectiveness-whs-interventions-by-regulators-literature-review.pdf

interventions are most important; and furthermore, compliance with WHS rules does not always result in a corresponding improvement in actual workplace health and safety.[131] Studies have shown that the 'nexus between compliance and injury rates is very much a mediated relationship' and that this 'important dynamic' should be considered when assessing the effect of WHS regulation.[132] A 2013 Australian study found that the key mechanisms within businesses to improve safety include awareness of safety requirements, an understanding of how to comply, concern with reputation and the perception of their level of risk.[133] Duty holders should have access to adequate information and training for them to meet their legal obligations.[134]

The ADF should reassess its WHS policies and processes in light of emerging technologies

The WHS arrangements that Defence currently have in place are hard to assess from outside the organisation. The Defence Work and Safety Management Committee is responsible for monitoring, reviewing and reporting on the *Defence Work Health and Safety Strategy 2017–2022* ('the ADF WHS Strategy'), including ensuring that WHS is 'managed as an enterprise priority' and that 'significant work health and safety risks are identified and addressed'.[135] The committee was designed to address a gap in 'joint and service policy specifying how health surveillance information collection at a tactical level informs operational and strategic health intelligence products and the follow-on feedback loop',[136] and it reports directly to the Defence Enterprise Business Committee and the Defence Audit Risk Committee.[137]

The ADF WHS Strategy does acknowledge the 'fundamental' importance of WHS in the 'design, acquisition, sustainment and disposal of Defence materiel' and that risk-management approaches must be 'integrated into the capability life cycle'.[138] It also commits to ensuring that 'safe systems of work are improved

131 Purse and Dorrian, 'Deterrence and enforcement of occupational health and safety law', pp 26–7.

132 Purse and Dorrian, 'Deterrence and enforcement of occupational health and safety law', pp 26–7.

133 Safe Work Australia, *Effectiveness of Work Health and Safety Interventions by Regulators*, p 7.

134 Purse and Dorrian, 'Deterrence and enforcement of occupational health and safety law', p 37.

135 Department of Defence (Defence), *Defence Work Health and Safety Strategy 2017–2022*, Department of Defence: Australian Government, 2017, p 3. https://www.defence.gov.au/about/complaints-incident-reporting/work-health-safety/policy-strategy

136 Derek Licina, A Brittain, A Tout, T Strickland, D Taplin, 'Aligning Defence environmental and occupational health (EOH) capability with future requirements: The 4th Australian Defence Force EOH Conference', *Journal of Military and Veterans' Health*, April 2016, 24(2):22.

137 Defence*, Defence Work Health and Safety Strategy 2017–2022*, p 4.

138 Defence, *Defence Work Health and Safety Strategy 2017–2022*, p 4.

through collaboration, innovation and integration'.[139] Beyond this, it is unclear whether there are plans to review policies in light of the rapid acquisition and deployment of emerging technologies.

The lack of certainty about the effectiveness of any intervention means we should be cautious before recommending particular policies. In its 2013 report Safe Work Australia noted that there is a 'paucity of available research on intervention effectiveness' in the WHS context, and that there was 'no currently published work available' specifically addressing the Australian context.[140] This is true more generally: outside of aviation, there is a lack of studies addressing the use of autonomous devices and human–machine teaming looking at interventions to prevent and/or reduce psychosocial risk factors and the effects of these interventions on psychological health.[141] Despite these difficulties, some general points can be made.

ADF safety managers and commanders must ensure that they continue to manage the emerging risks of new technology appropriately. As has been shown, communication between human team members and the machines they operate alongside will be key. Collaborating with a wide range of specialists will help the ADF reduce risk,[142] such as working with ergonomists to design forms of human–machine integration that minimise the risk of information overload.[143] It might also require new governance mechanisms that are more 'collaborative and anticipatory'.

> Anticipatory governance is a proactive, iterative, trial and error approach with rapid feedback loops to allow for calibration of policy tools. This differs from traditional governance structure where regulations take years to draft and implement and are rarely considered once in effect.[144]

The ADF should ensure that its command structures facilitate working together to keep safe when operating with technologies.

139 Defence, *Defence Work Health and Safety Strategy 2017–2022*, p 11.

140 Safe Work Australia, *Effectiveness of Work Health and Safety Interventions by Regulators*, p 45.

141 Andersen et al., 'Systematic literature review on the effects of occupational safety and health (OSH) interventions at the workplace', p 109.

142 Gabriel Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 277.

143 Gabriel Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 277.

144 Gabriel Chia et al., 'Need for a new workplace safety and health (WSH) strategy for the fourth industrial revolution', p 278.

Conclusion

The ADF is no stranger to dealing with new and potentially dangerous technologies. WHS law provides a key framework for how this technology will be designed and deployed by the ADF, requiring the responsible commanders and managers to maintain awareness of risks and hazards and plan for new ones. The benefits of using new technology must be weighed against the requirement to take reasonably practicable steps to keep ADF members healthy and safe at work.

This paper has set out some of the WHS risks posed by automated and autonomous computer technologies, identifying three key concerns: psychosocial risks, physical risks, and the difficulty of testing for potential hazards. It noted some of the potential benefits to the use of new technology, including responsive and real-time WHS monitoring and virtual training. The ADF should take advantage of opportunities presented by these new technologies.

The paper also considered some of the regulatory issues the technology presents. First, as the duties imposed by WHS law are so context-dependent, the increase in the range of technologies will increase the range of health and safety measures that are reasonably practicable. Second, the complexity and opaqueness of at least some computer systems will make investigating and prosecuting health and safety incidents more costly and time consuming. Inspectors, investigators and prosecutors should be equipped with the knowledge and understanding of systems to ensure the regulatory regime continues to be effective. It is in the interests of all ADF members if the organisation ensures that its personnel are properly trained, equipped and empowered to respond to these emerging health and safety risks.

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