Australian Government
Department of Defence
Science and Technology

EDTAS
EMERGING DISRUPTIVE TECHNOLOGY
ASSESSMENT SYMPOSIUM

AGILE COMMAND & CONTROL

INSIGHTS PAPER

Noetic GROUP

Acknowledgements

The author of this paper is Ash Colmer. Ash is a former Army officer and Principal Consultant for Noetic. Ash would like to acknowledge the insights that underpinned the development of this paper, that were gathered through a series of interviews with a wide range of subject matter experts from academia, industry, and Defence – in Australia and around the world. Ash would also like to acknowledge the support provided by Oscar Dowling and David Vallance from Noetic in drafting this paper and Defence Science and Technology Group for the review and feedback. This Insights Paper was designed by Noetic's creative design team.

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Contents

Aim

The aim of this Insights Paper is to present key themes relating to recent and projected developments in the technologies that enable Agile Command and Control (Agile C2) and their implications. In particular, this Paper seeks to draw out the many implications for the Australian Defence Force (ADF)'s future warfighters – the people – who these technologies will support. This will provide a base level of common knowledge to inform EDTAS participants and help engender debate during the symposia. To achieve this, the Insights Paper will describe the context and the current situation regarding C2 technologies. It will describe the emerging technologies and how they are intended to support C2, as well as the risks and challenges the technologies present.

Scope

This paper does not intend to be definitive as Agile C2 spans many academic and technological disciplines and is doctrinally embedded in the culture of Defence Force members, past and present. What is presented in this paper is an array of opinions that seek to promote discussion and potential Agile C2 research objectives for Defence Science and Technology (DST). Thought Leaders and Subject Matter Experts (SMEs) in academia, industry and Defence were identified at a scoping workshop and then approached to participate in an explorative, structured interview. The list of interviewees is appended to this paper. Some of the opinions presented may not necessarily be aligned with present doctrine, concepts or even policy. The conclusions reached are those of the author, noting the limitations of stakeholder availabilities and open-source research.

CONTEXT

The Future of War

As technology and the pace of information grows, there will be an increasing need to gather information, process it and inform decision making faster than an adversary. While one can argue that this has always been the case, what differentiates the next twenty years is the emergence of technologies such as artificial intelligence, machine learning, data analytics and high-performance computing with the potential to exponentially aid decision making. Coupled with advances in Intelligence, Surveillance and Reconnaissance (ISR), communications and automation; future ADF warfighters will operate across all domains, where every action and decision can be recorded and communicated immediately. They will require a command and control (C2) system that is flexible, modular, human-centric, all-informed and multi-domain, joint, interagency and multi-national and most importantly, capable of adapting to changing or unexpected circumstances.

While there is a necessary focus on technology and the need for agility at least for the foreseeable future, C2 will remain a human endeavour. This Insights Paper does not intend to predict the future, it seeks to remind readers that discussion about C2 is discussion about warfighters and war, for which some aspects will forever remain the same. Warfare will remain a pursuit of organised violence characterised by the use or threat of lethal force. It will seek to kill, maim, destroy, discredit, embarrass and ruin. Despite continued refinement and expansion into cyber and virtual spaces, it will operate across all domains, involve personal suffering and physical exertion, violence, friction and uncertainty.[1]

Finally, and not surprisingly, a future adversary will seek to destroy, disable or otherwise interfere with our C2 systems. In a world that is already characterised by disinformation, where for little investment, an adversary can seriously interfere with systems and perceptions, the cost of defence remains hugely expensive, slow and cumbersome. Future C2 systems need to be resilient and capable of operating when interdicted, degraded or electronically shut down.

1 Commonwealth of Australia, Future Joint Operating Concept 2030, March 2011, 2.

What is Agile Command and Control?

C2 is an activity that spans the conception of plans, their execution, and their monitoring with respect to a defined group or organisation. It comprises a philosophical and a functional aspect – functional in that groups must be effectively directed towards a given end, and philosophical in that the group must be properly organised and equipped to achieve that end.

'C2 is fundamentally a human endeavour – even if there are not many humans in it.'[2] The purpose of the organisation shapes the C2 model that is employed. The model needs to encompass a wide range of technological, structural, philosophical, ethical and legal considerations, and should be designed to enable the organisation to operate most effectively to achieve its aims.

Command and Control around the world

Australia: 'The process and means for the exercise of authority over, and lawful direction of, assigned forces'[3]

USA: 'The exercise of authority and direction by a properly designated commander over assigned and attached forces in accomplishment of the mission'[4]

UK: The UK employs the standard NATO definiton of C2, breaking it down into its components of;

- *Command* 'the authority vested in an individual for the direction, coordination, and control of military forces'
- *Control* 'the authority exercised by a commander over part of the activities of subordinate organisations, or other organisations not normally under his command, that encompasses the responsibility for implementing orders or directives'[5]

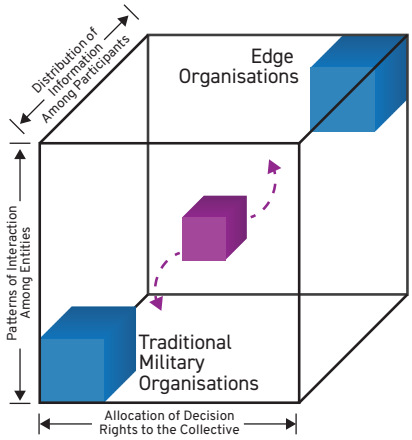
2 Noble, Roger, Major General, Interview with Ash Colmer, 24 September 2020, 1.
3 ADF Concept for Command and Control of the Future Force (Canberra, 2019), 9.
4 Office of the Chairman of the Joint Chiefs of Staff, DOD Dictionary of Military and Associated Terms (Washington DC: The Joint Staff, 2020), 40.
5 Ministry of Defence, "Joint Concept Note 2/17: Future of Command and Control" (September 2017), 9.

The most basic definition of agility is the ability to move, act, think or understand quickly.[6] An individual or organisation with this quality is able to modify its behaviour rapidly in line with changing circumstances. Underlying agility is the aim of being adaptive. In a world with a sometimes-dizzying pace of change, the ability to absorb and understand new information, and then make decisions based on it, is critical to success in areas ranging from IT to the battlefield.

Agility is a key attribute for any organisation in the 21st century. It is a state in which one becomes more capable of 'dealing with the combined effects of the presence of complexity and uncertainty.'[7] In simpler terms, if you are agile, you can successfully and rapidly cope with changes in your circumstances.

Importantly, agility is not just about being successful once, but 'it is about maintaining success in the light of changed or changing circumstances.'[8]

Agile C2 is not an end state. Rather, it is the ability for an organisation to rapidly adapt its C2 information, interaction and decision rights appropriately depending on the adversity and circumstances. As shown by the graphic below, C2 systems can be scaled on three axes.



Agile C2 involves the ability to move around the C2 Approach Space appropriately

Sourced from: https://www.infoq.com/news/2010/06/c2-military-gets-agile/

6 Oxford English Dictionary, accessed at https://www.lexico.com/definition/agile.
7 D. Alberts, The Agility Advantage: A Survival Guide for Complex Enterprises and Endeavors (Washington DC, 2011), 61.
8 Ibid, 68.

A highly distributed C2 system (sometimes known as an edge organisation) is not always appropriate for all circumstances. Nevertheless, an Agile C2 construct has the versatility to adapt as required.

The way that we approach agility will affect the outcome. Professor David Woods from the Ohio State University argues that the approach needs to be determined through an understanding of adaptive systems which are inherently biological and must consider the characteristics of human behaviour. He argues that the standard approach to building capability will not work for Agile C2.

The approach itself needs to be agile and be centred around a cadre of people spanning many disciplines.[9] The ADF Concept for Command and Control is based on 'hierarchical command' and 'agile control.' Agility in this sense '...allows the control relationships within the force to proactively adapt to the environment to take advantage of opportunities that emerge during operations.'[10]

9 Woods, Professor David, University of Ohio, Interview with Ash Colmer, 12 August 2020, 9.
10 Command and Control of the Future Force, 9.

C2 Throughout History

Throughout time, the most successful military forces employed functioning C2 systems. These systems allowed them to out-manoeuvre their foe, react successfully to a surprise or unexpected enemy activity, or to move force elements to exploit the enemy's circumstances.

Commanders who were unable to manoeuvre effectively or respond to changing circumstances due to inferior C2 systems rarely tasted victory unless they possessed an overwhelming numerical advantage. Compared to their adversaries, such forces were slow and unable to adapt their plans fast enough to respond to changing circumstances. Commanders simply 'culminated' when events overtook their ability to respond.

In addition to effective C2, successful commanders led well-trained forces whose structure was very much a part of the C2 system. Roman legions whose sub-units manoeuvred in well-drilled formations and responded to trumpet blasts and other battlefield signals, were able to be controlled in a manner that their Barbarian adversaries could not imagine. The Barbarians may well have devised cunning plans, however once these plans were in train, there were few ways of adapting if the Romans did not act as expected.

Leaders commanded their forces using various signals – trumpets, drumbeats, signal guns, flags or even gestures – and by conveying messages to subordinates either directly or via messengers on foot

or horseback. Over time, forces developed staff who assisted the commander with all the minutiae required to keep a force in the field or afloat, including most of the functions that you would see in a modern headquarters – planning, logistics, personnel, engineering, intelligence, etc. Such structures had their genesis with Napoleon. They were further refined and improved by the Prussians after the French defeated and humiliated them at the 'twin battles' of Jena and Auerstadt in 1806. These staff systems continued to evolve into NATO's modern day 'Continental Staff System' or the 'General Staff System' where, depending on the hierarchical level of the headquarters, each staff position is assigned a specific number, or numbers, that defines their role.

Military structures have evolved in a similar way; however, today's construct of army-corps-division-brigade-regiment-battalion-company-platoon is one that would be recognised by most soldiers who fought in Napoleon's time. Although modern armies tend to 'task organise' to fight, deploying all arms 'combat teams' and 'battle groups' rather than the day-to-day administrative companies and battalions.

There is discussion around the unsuitability of the prevailing military structures and the need for more 'agile' teams for future conflict. The argument focuses on the rigidity of formal military structures with their hierarchical ranks and, despite adaptive, task-oriented teaming, how agile decision making is constrained.

Is there a natural balance for organising military forces that have been manifested through tribal warbands; to the Greek phalanx; Roman centuries, cohorts and legions; through to Napoleonic corps and divisions and the present day? Have the lessons of the past, through both victory and defeat, shaped a natural development? Whilst one might draw a genealogical line through European and Western history, this is not necessarily the case for the Chinese, Indians or pre-Twentieth Century Japanese, where remarkably similar structures also emerged naturally. In southern Africa, the most efficient Zulu impi structure triumphed over less well-organised and adaptive structures.[11]

11 Ghose, Professor Aditya, University of Wollongong, interview with Ash Colmer, 2 September 2020, 3.

Current Environment

The ability to make decisions and enact them faster than the adversary remains the key to future battlespace success. There is currently a gulf between decision making and technology, particularly at the headquarters level where 'teaming' between humans and machines remains immature. Too great a proportion of planning is conducted using, what some describe as 'inappropriate tools' such as Microsoft Office and PowerPoint, and (more recently) web technologies like SharePoint. These are systems of bespoke programs and applications that at best could be described as 'federated', but not 'integrated.'[12]

Moreover, there are a variety of different tools that do not necessarily talk to each other.

> 'The system is in dire need of upgrading so as to maintain our competitiveness in the future.'[13]

There is also a view that decision support tools are not acquired in an 'agile' manner that may produce what the ADF describes as 'decision overmatch.' They are acquired subject to traditional procurement protocols and potentially have inadequate introduction into service processes.[14]

> 'Although some people will tell you that there are some tools out there, such as the Australian Army's Battle Management System, these are just glorified spreadsheets of the JMAP. What is needed are empowered analysis tools and wargaming tools at the tactical level to help those leaders make decisions.'[15]

12 Lennon, Richard, Air Commodore, Interview with Ash Colmer, 14 September 2020, 2.
13 Ibid, 2.
14 Fish, Dr Deborah, Interview with Ash Colmer, 29 August 2020, 2.
15 Noble, Roger, Major General, op. cit., 3.

The current Agile C2 technology environment is a platform-centric work-in-progress. We are still very much in an age of human-driven C2, and only just at the start of an era for human-machine teaming as a technology approach. Defence has been trying to augment voice with data for C2, but 'voice is still king.'[16]

The current state of technologies that enable C2 is characterised by the legacy of doctrine and is in an active state of transition to digitisation. The doctrine is a positive thing but has not all been digitised or automated. There appears to be too much focus on the technology, but not on the human. We may be over-promising what technology can do.[17]

The information required to produce this overmatch requires both the bandwidth to transport it to the headquarters and the computing power to identify, analyse and prioritise it.

In turn, these processes create additional electronic footprints that enable the adversary to locate and identify you and decide whether to observe, confuse or destroy you.

The operational use of technologies that enable C2 is generally basic. The opportunity for decision making support is relatively low in these systems. There is a question as to what technologies may be included in this space – everything from communications systems that support C2 through to aiding decision makers in a whole range of ways. In Defence, there are some systems that are state of the art, sophisticated and expensive, through to those that are quite primitive and basic – some of which remain so for good reason.

16 Fletcher, Duncan, DSTG, Interview with Oscar Dowling and David Vallance, 8 September 2020, 1.
17 Pearce, Professor Adrian & Aickelin, Professor Uwe, University of Melbourne, Interview with Ash Colmer, 4 August 2020, 1-2.

Defence achieves some decision integration, but generally systems exist in isolation (commonly referred to as 'stove pipes') due to various limitations such as proprietary integration and a lack of effective application of open standards. Some technologies are tools to get the job done, not to assist with C2 and decision making. There is an opportunity to make some significant advances in some of these areas, particularly in the cognitive functions of decision making, that will have important implications for control and potentially for command as well.

In order to formulate commands for and exercise control over a group, two main things are needed: information and communication. If facts on the ground change rapidly, that information must be sent to a commanding authority so that new orders can be produced at speed. During the 2019-20 Australian bushfires, decision makers experienced delays of up to four hours in this process, with spotter planes flying back to landing strips before their collected information could be analysed and new orders formulated. By the time these new orders were received on the fire front, the situation had changed dramatically.

In operations in the Middle East and Afghanistan since 2001, Coalition C2 has also had its challenges. Faced with decentralised and irregular enemy forces, the Coalition often relied on innovative but ad hoc battlefield relationships.[18]

In Iraq and Afghanistan, Coalition forces encountered insurgent groups who were organised in loose conglomerations that might come together at one time to train, conduct attacks, or share intelligence, and then 'disperse at times never to operate together again.'[19] Coalition forces sometimes found it difficult to use their existing communication capabilities to facilitate the 'rapid re-missioning, re-tasking and re-grouping of force elements'[20] required for successful counterinsurgency (COIN) operations.

Sourced from: Defence Images

18 W. Perry et al, (eds.), Operation IRAQI FREEDOM: Decisive War, Elusive Peace (RAND, 2015), 245.
19 B. Hoffman, "Insurgency and Counterinsurgency in Iraq, Occasional Paper 127 (RAND, 2004), 17.
20 Eikelboom, Dr Aletta, op. cit., 2.

The COVID-19 pandemic has placed stress on the ability of countries around the world to manage change while maintaining at least some level of social or economic stability. Many organisations in both the private and public sectors were able to shift their operating models to deal with new and largely unprecedented restrictions on indoor gatherings. However, these shifts do not necessarily indicate that an agile system is at work. COVID-19 has highlighted that there are key differences between 'brilliant improvisation' and a repeatable capability.'[21] An agile system provides for that repeatable capability, allowing an organisation to maintain a level of success despite rapid and major change. An adaptive system, on the other hand, is better described as systemic change for survival rather than success.[22] While agility and adaptability are complementary and necessary when responding to change, adaptability by itself represents 'a descriptive rather than a prescriptive concept.'[23]

An adaptive organisation may reward successful improvisation to change and punish failed efforts; an agile organisation rewards learning and encourages sustained and effective process changes in the knowledge that they may change again.[24]

Current organisational structure

The structure of modern military forces and the technologies that support and enable the function could reasonably be described as a legacy system.[25] As discussed above, modern staff structures can trace their genesis in the Napoleonic Wars. Moreover, it could be argued that the hard divisions we see between services today are 'accidents of history',[26] and that militaries around the world are 'still organised in an industrial-era confederation of stove piped agencies.'[27]

21 C. Worley, C. Jules, "COVID-19's Uncomfortable Revelations About Agile and Sustainable Organisations in a VUCA World", The Journal of Applied Behavioural Science, 56, 3 (2020), 281.
22 M. Janssen, H. van der Voort, "Agile and adaptive governance in crisis response: Lessons from the COVID-19 pandemic", International Journal of Information Management (2020) 3.
23 Ibid, 5.
24 "Agile and Sustainable Organisations in a VUCA world", 281.
25 Kalloniatis, Dr Alex, DSTG, Interview with Ash Colmer and David Vallance, 26 August 2020, 2.
26 Fletcher, Duncan, op. cit., 4.
27 "The Combat Cloud", 2.

The ADF's own Concept for Command and Control of the Future Force notes that certain aspects of its organisation are not suited to the kinds of multi-domain operations it will be called on to perform in the coming decades: 'the future ADF will need to operate in domains that are not characterised by geography' and will need 'to establish headquarters with the ability to simultaneously command all domains.'[28] Across operations, S&T and Defence enterprise areas, there are major opportunities for structural reforms that avoid siloed effort and move towards a more joint and agile Defence organisation.

Current technology acquisition methods

Current attitudes to and processes around the acquisition of technology, particularly software, also suffer from the same kind of outdated thinking. Due to the ethical and legal necessity in Western countries for accountability and civilian control of the military, Defence establishments are naturally risk averse, wanting to ensure that taxpayer money is spent on assured capabilities rather than those that may have unclear requirements, but potentially war-winning effects. This does not support the rapid acquisition of technologies that could support Agile C2.[29]

In Australia, 'we buy technology the way we buy ship hulls.'[30] Compounding this issue is the relatively low involvement of Australian technology companies in Defence,[31] coupled with slow implementation arrangements, meaning that the longer these issues remain unaddressed, the greater the opportunity cost for sovereign Australian industry.[32]

28 ADF Concept for Command and Control of the Future Force, 37.
29 Fish, Dr Deborah, op. cit., 2.
30 Fletcher, Duncan, op. cit., 2.
31 B. Clark, "Unnecessary challenges face Australian high-tech SMEs supplying Defence", Australia Defence Magazine (6 Aug 20), accessed at https://www.australiandefence.com.au/defence/general/unnecessary-challenges-face-australian-high-tech-smes-supplying-defence.
32 B. Thomas-Noone, "Ebbing Opportunity: Australia and the US National Technology and Industrial Base", United States Studies Centre (November 2019), 4.

Why Agile C2?

The pace of change in the 21st century continues to accelerate strategically, operationally, and critically, technologically. For the ADF to achieve its objectives to shape Australia's strategic environment, deter actions against our interests and, when required, respond with credible military force, it must have the skills, tools and structures necessary to ride this change, not be led by it.

> The world is scaling up in temporal, spatial and functional scales. This is often described as multi-scaling. One of the problems in the research of modelling and engineering is that people are still doing their 'old stuff', but with new labels. They are extending their 'old stuff', but they're not breaking new ground and doing the new things that are necessary to deal with the scaling up, such as the interconnectivity and interdependency that's going on in the world.[33]

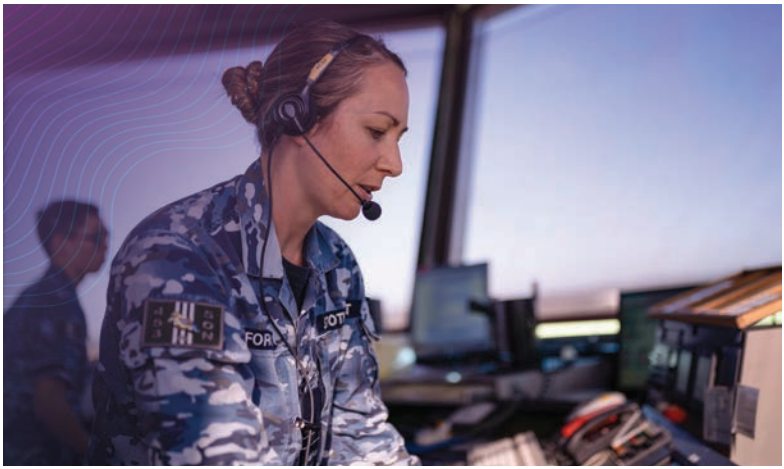
The 2020 Defence Strategic Update notes that great power competition will make 'the prospect of a high-intensity military conflict in the Indo-Pacific…less remote' than it has been in the recent past.[34] A command and control system that is able to deal with threats across the spectrum from sub-state actors, grey zone tactics and state-on-state competition cannot simply be technologically advanced. It must be appropriately structured so that it can adopt the most appropriate configurations to deal with a competing array of threats in quick succession, or potentially simultaneously.

33 Woods, Professor David, op. cit., 2.
34 Commonwealth of Australia, Department of Defence, 2020 Defence Strategic Update (2020), 14.

An array of technical and non-technical opportunities exist that the ADF can harness to achieve agility. These include:

- Artificial Intelligence and Machine Learning to support better and faster decision-making
- innovative organisational psychology to encourage greater levels of initiative
- new data visualisation systems to aid in the digestion of large amounts of information
- edge computer processing to support faster distributed data processing
- cloud computing to provide readily scalable ICT platforms
- adaptive communications networks to enable operations in low-connectivity environments
- improved information management systems to deal with collection and storage of large amounts of data.

Many of these technologies are not necessarily futuristic, as they are being used by the private sector today. Defence establishments around the world could have deep wells of civilian innovation to draw from if they were better able to leverage the private sector.



Sourced from: Defence Images

Chaos monkeys – adaptive networks in everyday life

As a service that needs to provide potentially millions of data connections at any one time, Netflix has produced an innovative way to ensure that their networks are up to the task. An army of bots, called 'chaos monkeys', are specifically tasked to randomly shut down servers or communications nodes while they are in operation. This self-sabotage allows Netflix to create networks that can survive, adapt and deliver data under extreme stress.

An Agile C2 system will enable commanders to more effectively deal with a rapidly changing strategic, operational or tactical environment by allowing them to delegate control responsibilities to subordinate force elements without delegating command.[35] This approach would allow the ADF to utilise the agile structures of some of our non-state adversaries while maintaining the ethical and accountable frameworks required by our political system.[36]

This approach of decentralised and distributed C2 systems also promotes resilience to more traditional state-based threats, for instance offering protection 'from spatio-temporally constrained strike capabilities like missiles.'[37] Technologies already exist to enable this decentralised control and centralised command. In 2007, the first edition of the International C2 Journal remarked that 'proximity is no longer a condition for real-time collaboration.'[38] This attribute will continue to intensify in the coming decades. For instance, the level of connectivity that has allowed many industries to continue working remotely during the COVID-19 pandemic would have been science fiction twenty years previously.

35 ADF Concept for Command and Control of the Future Force, 21.
36 Ibid, 22.
37 D. Lambert, J. Scholz, "Ubiquitous command and control" Intelligent Decision Technologies, 1 (2007), 166.
38 P. Essens, M. Spaans, W. Treurniet, "Agile Networking in Command and Control", The International C2 Journal, 1, 1 (2007), 185.

It is the pace of change of our modern world combined with the scope of threats and challenges with which we must cope that creates the requirement for an agile command and control system. Such a system should, at the most conceptual level, support human cognitive processes in both command and control so that they are not overwhelmed by the number or variety of challenges to which they must respond.

Unlike space capabilities, directed energy devices, or human biotechnologies, the innovation that will produce an Agile C2 system will not add tools to the kit to do brand new things. Instead, they will support processes that have existed since the dawn of organised conflict to be fully adapted into an information age context.

It is this adaptation that will form the fundamental basis for agility in command and control. The technology areas discussed in the following section will all contribute greatly in multifaceted ways to this critical adaptation.

Snapshot – Iraq 2016

Major General Roger Noble was embedded with the US 101st Airborne Division in Iraq in 2016. He has argued that all new wars must be approached and fought as counterinsurgencies in which everybody is a stakeholder. It is now possible for every action and decision to be recorded and communicated immediately. In his view, what is certain is '…that operating and gaining advantage in that environment, attaining and maintaining agility, will not be achieved by written briefs and PowerPoint presentations. What is required is an ability to embrace "…an all domain approach."'[39] This approach was successful in Iraq, not through the application of C2 technologies, but through leadership. Noble describes this as the ability of the chain of command to communicate and to adapt to changing circumstances. To enable this, the commanders spent most of their day – and he reminds us that a day on operations lasts 24 hours – speaking to people, their subordinates, their superiors and their lateral peers.

He warns against isolated experimentation where there is a danger of trying to understand war as a series of tactical activities, such as a missile being fired at a platform. War cannot be viewed as the sum of these activities.

In Iraq, he says, the Coalition had every means available to it in the Western World, '…100% non-blinking ISR, long range fires…every system and all domains. However, ISIS had shovels and dug really deep holes under the ground. The only way to get them was to go into those holes. We could have had 100 Joint Strike Fighters, but they wouldn't counter their "five buck shovels."'

39 Noble, Roger, Major General, op. cit., 5.

The nature of war does not necessarily change. 'The enemy doesn't just stop fighting because it might be emolliated by a hellfire missile.'[40] He argues that they fight hard because they believe in their leaders and they believe in their cause.

He warns that Australia should pause before spending billions on the most 'fantastic, all encumbering C2 system.' What he saw of ISIS in 2016 was that they used every commercial means available right down to runners. The group could not afford its own satellite communications network. Instead, its fighters used everything that was available, he said: the internet, chat rooms, mobile phones. The Coalition was able to observe, eventually learn their methods and finally out-manoeuvre ISIS in the C2 space. The Coalition would push enemy fighters into communications sequences from which they could be isolated and then destroyed.

So, he says, that is what our enemies will try to do to Australia in the future. We must therefore incorporate redundancy within our C2 systems. This redundancy, along with our unique requirements entail the need for our own C2 system. Copying somebody else's will not be adequate.

ADF Concept for Command and Control of the Future Force

In May 2019, the ADF published a new future concept for C2, ADF Concept for Command and Control of the Future Force. It seeks to answer the military problem of 'how does the ADF Command and Control the future force to provide a competitive advantage during operations in the future environment?' The VCDF, Vice Admiral Johnston advises in the Foreword that the concept is designed to be a guide for how the Future Joint Force might be employed and for the acquisition of capabilities. Importantly, 'concepts must be subject to continual improvement, as the nature of the operating environment evolves...'[41]

40 Ibid, 5.
41 ADF Concept for Command and Control of the Future Force (Canberra, 2019), 5.

The central theme of the concept is 'hierarchical command – agile control.' It posits that for operations in the future (beyond 2035), the ADF will maintain a hierarchical command model in accordance with present doctrine. Commanders will '…implement "mission layers" within which control relationships can be adjusted rapidly during an operation…' It states that this will provide the force with the agility needed to 'proactively adapt to the environment to take advantage of opportunities…'

Central to the future concept is the 'separation of control and command functions.' It allows for the commander to delegate authority to another officer to coordinate the actions of forces to achieve specified missions. It implies the use of 'collaboration' to '…improve the speed, efficiency and survivability of the decision-making process.'[42] It seeks to move away from C2 nodes which are easy for an adversary to detect and target, instead spreading the decision-making capability across the network.

The concept seeks to re-energise the principle of Mission Command. While stating that the present definition remains valid, 'a philosophy for command and a system for conducting operations in which subordinates are given clear direction by a superior of their intentions', it should be updated to state that 'under mission command, commanders direct what is to be achieved but leave controllers free to decide how to achieve assigned tasks.'[43]

ADF Concept for Command and Control of the Future Force – Hierarchical Command, Agile Control

'The defining feature of the central idea is that the functions of command and control can be separated. By separating the functions of command and control, the concept balances the need for unity of command and the need to coordinate forces so that the commander can bring integrated, multi-domain effects to bear against the adversary'[44]

42 ADF Concept for Command and Control of the Future Force (Canberra, 2019), 11.
43 Ibid, 10.
44 Ibid, 17.

KEY TECHNOLOGIES

This section seeks to outline the key technological areas that are emerging with the potential to increase agility within C2 systems. It does not claim to provide an in-depth analysis of each area, nor to provide a solution for its application or integration within such systems. Technologies do not provide a capability themselves, but do so only with all the fundamental inputs necessary for enduring effective service such as support, doctrine, personnel, training, supplies, command and management, etc.

Artificial Intelligence and Machine Learning

In the last decade there has been both a resurgence of interests and major advances made in the areas of artificial intelligence (AI) and machine learning (ML). There have been some high-profile examples such as self-driving cars, game-playing machines and virtual assistants.[45] These technological areas are highly complex, but a good definition of both terms is as follows:

Artificial Intelligence: the broad class of techniques in which seemingly intelligent behaviour is demonstrated by machines

Machine learning: a collection of techniques in which a machine learns to perform a specific task without explicit instructions provided by a human – instead relying on patterns, inference and statistical models applied to data[46]

These applications are generally immature. Technologies that were predicted to grow exponentially in sophistication have been much slower to develop. For example, self-driving cars are far from being ubiquitous forms of transport. Other areas have seen major and unexpected breakthroughs – Google AlphaGo beating the world's best player of the board game 'Go' being a prime example.

45 Moy et al., "Technical Report: Recent Advances in Artificial Intelligence and their Impact on Defence", DSTG TR-3716 (2020), 1.
46 Ibid, vii.

Given the nature of the field, we can expect there to be many ways in which AI and ML can support the operations of the ADF, particularly in relation to command and control. This section outlines five key areas in which applications of AI and ML can have a significant impact on Defence in the coming decades.

Image understanding

Image understanding using AI and ML builds upon a long-standing strand of research through which scientists have attempted to effectively task machines to extract meaning from visual data.[47] With the rise of 'deep learning' – a ML technique relying on multiple layers or 'neural nets' to extract increasingly nuanced meaning from raw data – machines are becoming more adept at classifying visual data without using features that have been pre-defined by a human.

Machines for image understanding have made significant recent advances. Both Facebook and Google launched facial recognition programs in 2014 and 2015 that were able to achieve 97%-100% accuracy in identifying whether two photographs represented the same individual. Building on this success, there have also been advances in image captioning and visual question answering.[48]

47 Ibid, 12.
48 Ibid, 13.

These techniques allow machines to produce descriptions of images, or to answer questions about an image, in language that is meaningful to humans. These techniques still have a way to go before reaching human performance levels.

Image understanding of military applications is significant. This technique will be able to quickly analyse large amounts of complex images, freeing up manpower to produce a more effective surveillance system. In the USA, the Maven Project is currently using such technologies to scan UAV imagery and identify potential targets – be they people, vehicles or buildings.

Target identification and targeted surveillance are also areas that will be positively impacted by image understanding. Moreover, AI techniques may be integrated into surveillance platforms themselves. This has important implications for the management of bandwidth for communications, as only processed data needs to be distributed across the network. These techniques may also be embedded within associated headquarters, giving greater processing power at the potential cost of lower image quality due to bandwidth restrictions.[49]

Intelligent decision making

This technique refers to the ability of machines to use available data to develop high-level strategies in complex environments.[50] Many of these advances have been made through research in game-playing machines, where machines have exhibited 'human-level or super-human performance' at highly complex real-time strategy games such as DOTA or StarCraft. There have also been recent advances in the ability of machines to formulate strategies in games that involve bluffing, chance or partial observability. For example, in 2019 Carnegie Mellon University developed Pluribus, the first AI system that was capable of beating humans at a game of Texas Hold-'em Poker.[51]

49 Ibid, 14.
50 Ibid, 15.
51 Ibid, 15-16.

Building on this research, there are currently significant developments happening with recommender systems that work to prioritise the most relevant information, as well as data analytic techniques to support enhanced situational awareness and sense making.[52]

Given the amount and complexity of information required for effective military decision making, this AI technique has significant applications in this area. AI for decision support will be initially most successful in application areas with large amounts of data available, due to the requirements of deep learning algorithms. While current efforts are focused on low-level decision making, there is an growing role for AI at a higher level.

While AI cannot currently provide high-level military decisions, there is large scope for it to be involved in supporting human decision makers. This sort of human-machine teaming can allow the human to make highly informed decisions based on large data sets without having to analyse that data manually. This technique also has significant applications for task management, plan monitoring, and course-of-action analysis – all things that are important for effective command and control.[53]

Artificial creativity

In recent years, advances in AI have challenged the pre-conception that only humans are capable of exhibiting creative behaviour – that is, behaviour that goes beyond a set of pre-programmed rules. The invention in 2014 of 'generative adversarial networks' (GAN) has 'enabled computers to automatically generate realistic-looking 'fake' data.'[54] This means that computers are capable of producing items that do not exist in the real world, much in the same way that humans can create new things. Programs like the Generative Pretrained Transformer 2 (GPT-2) are capable of generating 'plausible stories from a very short piece of input text.'[55]

52 Ibid, 16.
53 Ibid, 17-18.
54 Ibid, 18.
55 Ibid, 19.

Concerns around the ability of GPT-2 to produce text that is nearly indistinguishable from human-produced text led its creator, OpenAI, not to release full information regarding the program for some time, fearing the potential for its misuse.

In terms of military applications, the most relevant application of artificial creativity is providing the ADF an ability to detect disinformation circulated by adversaries.

Additionally, the creation of such disinformation produces potential ethical problems and there are potential benefits for militaries that are able to sow confusion or generate support for certain lines of effort.[56] Understanding how these techniques may be applied will be increasingly important for the ADF.

Natural language processing

Natural language processing spans a wide array of functions, from machine translation, text summarisation, topic modelling, question answering and more.[57] This field is not as developed as those discussed above. In translation, for instance, some machines are approaching human levels of accuracy, but there remains a significant gap between their capabilities and those of humans.

Despite this current state, there are many areas in which natural language processing can support the ADF into the future. Information retrieval systems could be automated, and question answering systems could be improved to ensure that decision makers can have easier access to the information they require. Automated text summarisation software will also be very useful given the large and increasing quantities of information present in the 21st century battlespace. Sentiment analysis could also prove useful in a military context. Large global databases such as the Global Database of Events, Language, and Tone (GDELT) could be mined for large scale analysis of major trends, around the world, regionally, and in certain countries. This could provide a wealth of strategic situational awareness for planners.

56 Ibid, 19.
57 Ibid, 20.

Physical automation

Finally, while unmanned systems have become increasingly prevalent in 21st century militaries, the difficulty of integrating AI on such platforms has been underestimated.[58] An observation that is famous in the field, called Moravec's paradox, states that 'it is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, but difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility.' Significant advances have been made, however, in the areas of self-driving cars and robotic manipulator arms. These systems use AI and ML techniques to improve their ability to achieve their desired functions.

While this paper does not explain the critical roles already played by autonomous systems in modern militaries, what should be noted is that time needs to be invested in considering the ethical and legal implications of increasing machine autonomy, particularly in the context of armed platforms. However, there are potentially areas that will not be impacted by ethics. Physical automation could significantly improve logistics. A capability for autonomous resupply using self-driving vehicles, for example, could help save the lives of soldiers when they might be called upon to deliver supplies into a contested zone, or free up behind-the-line personnel, allowing them to focus on other tasks.

Sourced from: https://www.telegraph.co.uk/technology/2020/09/06/britains-first-robot-ship-prepares-set-sail/?s=09

58 Ibid, 22.

Edge Processing and Cloud Computing

Edge processing refers to the ability to process data away from a central hub or headquarters, while cloud computing refers to a distributed computing architecture in which computing and analytical power is dispersed across a wide range of servers and locations. These technologies present a wide array of potential military applications, particularly in relation to command and control. Additionally, as cloud computing and edge processing become more sophisticated and integrated into military platforms, increasing amounts of information will become available to inform decision making during the planning and execution of operational activities.

Increasing transmission speed of time-sensitive information

Distributed networks and edge sensors are able to provide more dynamic management of bandwidth as the cloud is able to reconfigure itself in terms of storage and transmission. Micro-edge processors can be activated on demand, meaning that they are not consuming bandwidth when not in use. This in turn allows for time-sensitive information from the battlespace to be transmitted at speed to those who require it.

Leveraging/integrating civilian innovation

The private sector is leading the way in this space. If the ADF wishes to take full advantage of these advances, particularly in cloud computing, it needs to find more effective methods of leveraging these innovations.

While cloud-based technologies may provide great opportunities for information management and the integration of networks, further research is required to understand what 'gateways' and protocols are required for military integration.[59]

59 Eikelboom, Dr Aletta, op. cit., 2.

Technology Integration

Integrating new technologies into existing human and technical systems is a key factor when considering how the ADF might increase agility in C2. New technologies must be integrated across the entire C2 spectrum, from the tactical edge to the strategic view in order to create the effects Defence needs for planning and executing operations. There must also be reach-back into industry that produces, sells, and supports the installation of new technologies in a Defence context. Additionally, new technologies cannot compromise Australia's ability to operate with its partners.

Challenges to integration

The challenges to effective integration of new technologies are both technical and structural. The technical issue is the lack of open or common architecture shared between Australian and allied systems. The structural issue, on the other hand, is related to the process by which Defence goes about designing, acquiring, and integrating new technologies. As with all facets of Agile C2, however, the technical and structural issues intersect in important ways that must be considered.

Open architecture

Open architecture is a technique in computer or software engineering that helps to eliminate barriers to the integration of multiple systems across multiple platforms, allowing individual systems to change and adapt with greater ease. A basic example of an open architecture is a desktop computer that can have its graphics cards or central processing unit swapped out should it become outdated, or if the user desires to have a different sort of capability. A related example of a closed architecture would be laptops such as MacBooks, which do not have that level of hardware customisation.

Open architectures work well to promote better cooperation, coordination, interoperability, and modularity in systems only when a series of enabling hardware or software technologies are built to common or known standards.[60] Without this, compatibility issues make

60 Fletcher, Duncan, op. cit., 3.

openness very difficult if not impossible to achieve, stymying efforts to integrate new technologies and systems with existing ones to create agility and modularity.

As the ADF relies on many legacy systems for its day-to-day business, the integration of modern technology is critical across virtually all aspects of its ability to achieve its strategic objectives.[61] Open architecture is inherently agile, evolvable, and adaptable.[62] Some argue that the key risk with open architecture is its ability to provide the level of security required by the entire Defence enterprise and function propey, while others argue that this concern is unfounded.[63]

Before the technical issues of open architecture can be solved, a more prosaic issue must be addressed. This is that the acquisition of legacy, closed architecture systems have produced a 'vendor lock-in' situation not conducive to the kind of information sharing required for open architecture. Contractors selected to provide a certain service to Defence are not obligated to share information with each other.

There is no commercial, or structural incentive for them to do so, and indeed such sharing might harm their chance of procuring future Defence contracts.

Opportunities

In order to end this environment of unhealthy competition – unhealthy that is in terms of open architecture - Defence must change its relationship with both suppliers and prime systems integrators (PSI). Some opportunities for reform in this area might include ensuring that Defence always has separate contractual relationships with suppliers and PSIs, encouraging them to share information. Another, more far-reaching, opportunity would be the creation of a dedicated systems integrator for the Commonwealth as a government agency. This would support the development of a sovereign systems integration capability as an Australian Intellectual Property.

61 "Recent Advances in Artificial Intelligence", 27.
62 Ibid, 26.
63 Fletcher, Duncan, op. cit., 3.

Managing Data: Storage, Processing, and Analytics

Consistent storage processes

Vast quantities of data are required for effective machine learning to be achieved. It is just as important that the quantity is high quality. Data must be properly structured for it to be useful for machines. The ADF currently has little consistency in its data storage processes. Many force elements will use different electronic systems that feed into Defence databases, use their own on-base software, or even use paper recording. If the ADF wishes to take full advantage of the opportunities presented by the information age, these processes must evolve and standardised ones developed and applied. Data is the great resource of the 21st century, but if it is not collected and stored properly, it will simply be numbers rather than something to build meaningful capabilities from.

Just as the 21st century has seen an increase in the amount of information that is available, so too has it seen an increase in the diversity of that information.

Particularly in a military context where a planner must receive and collate information from multiple domains – land, air, sea, space and cyber – in order to formulate courses of action that take into account as full a range of variables as possible.

To adequately deal with the large amounts of highly diverse data that will confront Defence in the coming decades, it will need to invest in more sophisticated processing techniques. Data analytics techniques supported by high performance computing (HPC) are two opportunities for investment.

Data analytics may be defined as the process of 'cleaning' data, to transform it into modellable and generalisable information that can be used to guide decision-making. Different kinds of analysis can be undertaken, from textual, statistical or descriptive analysis, to diagnostic or prescriptive analysis. The process is broken down into the following stages:

- requirement gathering – why the analysis is being done
- collection – based upon requirements
- cleaning – remove duplications and errors
- analysis – manipulate and study collected data to produce results
- interpretation – interpret the results of analysis to guide decisions
- visualisation – display data in digestible ways to aid communication and comparison.

Given the large amounts of data across the various domains that Defence will need to analyse, current computing power may not be sufficient. HPC may be able to solve this issue. HPC solutions are orders of magnitude faster than normal laptops or desktops. For instance, where a computer with a 3 Gigahertz processor can perform around 3 billion calculations per second, a HPC solution such as a supercomputer can perform quadrillions of calculations a second.

This capability is incredibly useful when considering that not only will Defence need to process large amounts of data, but also that such data will often be time-sensitive and potentially able to save lives.

Australia already operates one supercomputer, Gadi, which is the most powerful in the southern hemisphere. Gadi supports a workload of over 9 petaflops (a petaflop being 10^{15} floating point calculations per second) at peak performance.[64] This means it can conduct in excess of $9x10^{15}$ floating-point calculations per second.[65]

64 Floating-point calculations use mathematical approximations of real integers to create fast processing times through a trade-off between range and precision.
65 National Computational Infrastructure Australia, "HPC Systems", accessed at https://nci.org.au/our-systems/hpc-systems.

This enables Gadi to do in one hour what it might take an average desktop computer 35 years to accomplish.[66] Gadi is already utilised by the Bureau of Meteorology and Geoscience Australia to perform complex predictive calculations based on vast datasets. This enables more rapid responses to national crises – such as the recent bushfires and ongoing COVID-19 pandemic – than would have been possible previously.[67] The applications of HPC and supercomputers like Gadi for Defence are obvious. The ability to quickly processes large quantities of data to support decision making both strategically and operationally could provide a key technology edge into the future.

Sourced from: https://nci.org.au/media/images/gadi-supercomputer-0

66 S. Smith, M, Stickells, "How Australia's supercomputers crunched the numbers to guide our bushfire and pandemic response", The Conversation, 30 Jun 20, accessed at https://theconversation.com/how-australias-supercomputers-crunched-the-numbers-to-guide-our-bushfire-and-pandemic-response-141047.

67 M. Johnston, "NCI's Gadi ranks among top 25 supercomputers", IT News, 24 Jun 20, accessed at https://www.itnews.com.au/news/ncis-gadi-ranks-among-top-25-supercomputers-549613.

NON-TECHNICAL FACTORS

As stated earlier, command and control and warfighting remain intensely human endeavours for the moment. Whilst emerging technologies may enhance the agility Defence is seeking for C2, there are many non-technical factors that require research effort in order for their benefits to be fully realised. These factors are discussed in this section.

Organisational Structures

While there are many great technologies that support hierarchical military structures, there are new technologies in development that may allow for flatter, more agile and flexible groupings that provide commanders with more alternatives to achieve mission success. Research continues into how information may be collected and shared between multiple domains; how to share cyber information with human domain information; sociological information with the traditional physical information; and how to combine those and make sense of it. AI can support these processes, especially when there is a lot of data, to see patterns and support the human decision maker.[68]

Examining organisational culture and the possibilities and applications of reconfigurable and flexible teaming may produce more agile C2. The focus should not only be on human actors, but also on autonomous and semi-autonomous agents as well. This involves looking at the cultural aspects in a military sense, seeking out the values that are brought and those that still might be required for successful teaming in different environments.

The pursuit of Agile C2 is not only about brilliant technologies, but it is ultimately about the people who will be using them.

68 Eikelboom, Dr Aletta, op. cit., 2.

'We need to consider not just the formal behaviour, but the informal behaviour as well.' It is not just all about the standalone culture or the organisational structures, it is about the organisational system and the technological system, both composing the enterprise as a whole. How do you position your organisation to be able to use these new technologies and yield the capabilities required?' [69]

Many believe that organisational change is necessary to realise the full benefit of Agile C2. Organisations evolve; you cannot bring together elements of capability like you would components in a technological system. It is not like a commercial-of-the-shelf (COTS) of teams, where you can simply bring together units and expect them to work together seamlessly. Systems thinking tells us that the sum is greater than its parts. There will be emergent behaviour (both good and bad). Yes, you can design organisations, but this takes time, and there is often resistance to change, which is not necessarily conducive to agility.

Authority

Some argue that perhaps the greatest barrier to achieving Agile C2 is if we do not change the way in which the military deals with authority. The military needs to understand how authority is culturally embedded within itself, and how authoritative styles of leadership may restrict the coming together of all the technologies that enable it to work as a networked organisation.

What are the best ways to structure military teams and delegate authority?

Consideration should be given to how decision making within hierarchical military structures impedes the benefits of Agile C2. This argument is not proposing that we do away with rank structures within the Services, but that these structures should be critically analysed. It is about the culture between the ranks and knowing where and how to delegate authority.

69 Kennedy, Grace, University of Wollongong, Interview with Ash Colmer, 1 September 2020, 3.

There are many who believe that the term 'mission command' is often flaunted to disguise what is a hierarchical structure and directive culture. Dr Aletta Eikelboom does not believe that the actual intent of mission command is ever realised by modern Western militaries when the organisation and culture do not change. She argues that the gap between different levels of command needs to be blurred all the way from sub-tactical to strategic levels. These levels need to come closer together to act as one. 'Maybe we need more "strategic decision makers at tactical levels to enable this transfer of authority." Maybe the rank structures at the lower tactical levels are too low.'[70]

While traditional military organisational and staff structures still serve their purpose to a point, they do not suit every situation. Agile C2 in its purest sense should aim to give the military the ability to modify existing structures in anticipation of events in their environment. The Common Joint Staff System (CJSS) does not necessarily lend itself to allowing integrated 'cradle-to-grave' agile teams. Such teams would perform planning, execution, lessons learned and replanning cycles. 'How do you design a whole headquarters with multiple areas of operation, with new structures that enable new modes of restructuring that can be manipulated and adapted rather than set in stone and left to run?'[71]

Challenges for the Future Commander

Traditionally, commanders have been respected because of their experience. In the future they cannot be expected to have such a great breadth of experience across all aspects of the C2 environment. It will be difficult for them to gain even simulated experience of all aspects of the future battlespace. Where they once drew from their training, their posting history and potentially their operational experiences, to give them their broad understanding of warfare, they will increasingly have a much greater reliance on their staff.

70 Eikelboom, Dr Aletta, op. cit., 4.
71 Kalloniatis, Dr Alex, op. cit., 3.

'As technologies become more "rarefied" commanders may not have the necessary levels of confidence to enable them to combine all these elements and "see the intersections" that they may have seen in the past. They will heavily rely on their staff to see the "showstoppers" and to make the connections and insights that the commander may have made in the past.'[72]

To reduce these risks, we need to identify how we might better train our commanders. They need to understand the constraints and opportunities provided by an Agile C2 system. They need to understand how to employ them and how to best articulate their commander's intent in a way that is consumable by human-machine teams.[73]

Commanders will not know their subordinates as well as they have in the past because they may be working on-line or in remote ways. This lack of familiarity may lead to a lower level of trust that restricts agility. We should look for ways in which we can build levels of trust, not just in automation, but between commanders and teams that are less familiar with each other than they were in the past.

Sourced from: Defence Images

72 Klein, Dr Gary, op. cit., 4.
73 Molan, Senator Jim, Interview with Ash Colmer, 10 August 2020, 2.

There is some argument regarding the need for command agility. The Future Concept maintains traditional 'Hierarchical Command', based upon the necessary legal accountability of a commander through responsible government. While the Future Concept seeks to re-energise the concept of Mission Command as discussed above, some argue that the military should examine its culture around leadership and its approach to authority. This is certainly an issue for future commanders to ponder. Which leadership style best enables Agile C2?

Agility in Acquisition

The current style of capability acquisition is not necessarily suited to Agile C2. Long lead times coupled with an inability to define project requirements and a generally risk averse attitude to failure hinders an agile approach.[74] The ability to deploy such systems will be restricted by the capacity of the capability lifecycle, in particular the limitations on access to SMEs who are willing to work in the field and the competition for their services in other sectors.[75]

Defence does not appear to have solved the capability acquisition process for software or ICT, which is markedly different from that of large-scale capital acquisitions. This results in software being treated differently to hard-end capability with detrimental effects. For instance, a major surface combatant for the RAN is expected to remain in service for decades and remain potent. Communications capabilities may be acquired and then become obsolete or be superseded in a matter of years rather than a few decades. The pace of technological advances should be acknowledged so that acquisition culture reflects reality more accurately. Technologies that exist today such as cloud computing or even mobile phones do not have proper strategies for their use. If this cannot be done properly with existing technologies, trying to do so with AI or ML may be a thankless task.[76]

74 Chim, Leung and van Antwerpen, Coen, Interview with Oscar Dowling and David Vallance, 31 August 2020, 2.
75 Pearce, Professor Adrian, op. cit., 3.
76 Kwok, Hing-Wah, Interview with Ash Colmer and David Vallance, 27 August 2020, 2.

There will be many technical challenges that will need to be addressed. For C2 technology to evolve there needs to be a coherent vision about the technology that will be acquired and how it will be employed. This shapes how science, technology and innovation streams are resourced. The vision needs to lead such streams and ensure that insights are developed in such a manner that they solve the problems required to enable the technologies chosen, noting that there still needs to be a balance of this support and discovery. The more effort, the more people and the better the resourcing of these streams, the better the outcomes.

Defence needs to invest in the development and retention of the 'good thinkers' needed for these streams.[77]

'The Commonwealth needs to rethink the commercial logic that provides it with many and varied closed-looped C2 systems. With at least control over the IP of the system of systems that provides the sovereign common control system.'[78]

Industry argues that the challenge is not necessarily technical. Proprietary C2 systems will need to be integrated and electronic protocols will need to be established to enable this. The challenge will be to develop both strong Commonwealth and ADF leadership with the critical entrepreneurial commercial leadership required. It cannot be achieved only within government. There will remain '...huge commercial opportunity, but it's just different. How this will look in terms of a headquarters is kind of an interesting opportunity to think about.' 'Primes will remain invested in integration which creates more stove pipes...' rather than allowing for an open C2 system.[79]

There is a risk that without understanding how the future ADF intends to fight, and thereby contextualising the Agile C2 requirement, that the problem space becomes a 'fun fair' carried away by new technologies.

77 Lennon, Richard Air Commodore, Interview with Ash Colmer, 14 September 2020, 4.
78 Scholz, Professor Jason, Interview with Ash Colmer, 5 August 2020, 3.
79 Ibid, 3.

To play successfully in this space there must be a balance between creativity and constraint. Australia cannot afford 1000 different C2 architectures with hundreds of different providers. Like all advanced technology endeavours, there needs to be a healthy level of acceptance of failure.[80]

There needs to be a development plan that challenges C2 research and acknowledges what we may need to buy or borrow from the Five Eyes (FVEY) community. It should identify the niche sovereign technologies that we can develop at a world-class level and make an international impact.

It needs to be underpinned by an acquisition process that is non-standard. It must be agile and adaptive. Developing, integrating and deploying Agile C2 technologies will not be successfully addressed by the standard acquisition process where everything must succeed. We must have an accepted failure rate that allows for the creativity needed, and a continual process of ideation → prototype → test → refine.

This is easy to say but difficult to implement. A component of building a successful Agile C2 capability is the warfighter. The warfighter is needed to confirm the requirement, tell the technologists what will work in a warfighting environment and to 'walk the middle path' to ensure that the user interface is fit for purpose. Typically, the day-to-day activities of these warfighters restrict this availability. How then do researchers and technologists gain access to warfighters?

Can AI assist with strategic decision making? How might it be integrated into the Department? Would it be possible to use AI to assist with making Integrated Investment Plan (IIP) decisions?

80 Lindsay, Dr Tony, op. cit., 2.

While Australia does not have a concept for future multi-domain operations as our American and British counterparts do, we have a much stronger investment program in modern systems than both. While there are very good reasons for this investment, it is possible that Australia is building on an old model whereby we replace like-for-like when it reaches its agreed use-by date rather than building and adapting to a new model.

There may well be a danger that we might invest all our money on the wrong platform, which we might have had the opportunity or capability, to realise in advance.[81]

'Who is looking to the future? Are we just replacing old stuff?'[82]

This argument is not questioning the fact that Australia does not acquire the best capabilities but suggests that we acquire the best capabilities that replace the existing capabilities that we had – the next iteration. We might do well to invest in decision making capabilities. In this sense 'the scope of Agile C2 might be too narrow? It should be warfighting focused but the scope should include the whole enterprise, including "the back end" and how it fights in the 21st Century. It is not just the tactical side, but how we organise to fight. To get the best submarines, we need to get the best people to work out what those submarines need to do.'[83]

81 Noble, Roger, Major General, op. cit., 4.
82 Ibid, 4.
83 Ibid, 4.

Trust, Reliance and Overreliance

There is always a risk with these emerging technologies that they will provide the wrong answer. This risk might be amplified if humans rely too heavily on them. The systems may not have been 'trained' to answer the right questions, or the ways in which they may have been asked. The provision of wrong answers creates mistrust. Likewise, if the systems have provided a series of correct answers, the user needs to be prepared for failure. Risk is mitigated through training the machine and expanding its experience base.

The reason we do not have driverless cars yet is because the likelihood of a mistake, although highly unlikely, is not outweighed by the consequence of such a mistake.

How do we quickly transition our armed force into a digital armed force? The biggest challenge is to change our thinking about the future battlespace. Paul Dalby says that it has drastically changed from one where whoever has the most humans and the most hardware wins to one where the winner will be whoever has the best AI, and the most imaginative application of AI. He argues that the ADF is still struggling to catch up with this view and suggests that it may be 'de-powering' for some leaders who have built their capabilities in a particular area. 'We spend a lot of money on technology that is probably already obsolete. We need to understand what the battlefield of the future will look like and start investing in the technology that can win in those environments, rather than pouring money into technologies that will be pretty easy to defeat with a future AI-enabled system.'[84]

84 Dalby, Paul, Interview with Ash Colmer, 27 August 2020, 4.

Safe, Trustworthy and Reliable?

To gain an advantage in the future, Dr Gary Klein argues that we need to challenge the assumptions that these future capabilities must be 'safe, trustworthy and reliable.' He argues that this is a mistake and may be another challenge for DST research. 'Buying AI is not the same as buying a vacuum cleaner,' he says. 'If I buy a vacuum cleaner, I want it to be reliable, as well as safe and trustworthy.' In the world of advanced technology, 'reliable means rigid.'[85] An AI system that uses machine learning and reinforcement learning is always going to be upgrading. It will always be learning, and designers will be constantly improving it.

'And what about safe?' he asks. 'Safe' to him means 'sclerotic.' He sees the US Army creating powerful verification and validation (V&V) protocols for AI. These are very powerful protocols that will take years for new AI programs to receive approvals.

At that point the modern AI system will already be outdated. This is the challenge – to devise V&V protocols that are not 'sclerotic', and acquisition processes that do not deliver outdated systems.[86] This is important, especially if our adversaries are not as sclerotic as we are.

'And trustworthy for me, translates as 'timid'', he says. 'Trustworthy' means that you can never be wrong. This leads to the avoidance of addressing the tougher challenges. Dr Klein says that he does not think the emerging systems need to necessarily be trustworthy. For example, a US Navy electronic warfare specialist who called the system he used a 'liar', because it did not always provide him with the correct answer. He was happy to use the system because he grew to know when the information being provided was false and could make the necessary adjustments to re-align it to 'truthful' solutions.[87]

85 Klein, Dr Gary, op. cit., 6.
86 Ibid, 6.
87 Ibid, 6.

What Dr Klein says is missing from 'reliable, safe and trustworthy' is 'performance.' If you maximise 'reliable, safe and trustworthy', you will be compromising 'performance.' What he would like to see is a focus on making the AI work better. This will reduce the amount of wasted funding; reduce the number of expensive systems that are developed, but never used and reduce brittleness.

Ethics

There are cultural issues that need to be overcome. These will be bound by legal and ethical arguments that will need to be explored. Paul Dalby says that '...while nobody wants killer robots, the fact is whoever has the most effective killer robots will win future wars unless we all agree to not build them and police this agreement effectively.'[88]

The concept of automation brings with it potentially significant cultural questions that will need to be addressed. There are increasingly more examples of technology defeating and easily overcoming traditional war machinery.

88 Dalby, Paul, op. cit., 4.

Earlier this year we saw a small flight of Turkish drones locate over one hundred pro-Assad Syrian armoured vehicles, enabling their engagement and destruction by ground-based artillery and drone strikes. AI fighter pilots have been recording significant victories against human opponents. We are entering a new tactical environment where the infrastructure that delivered superiority in the past may not be the same as in the future.

'...the future is already here, and it's not as advertised.' It's already here in some places and it doesn't work the way people say it's going to work. We need to understand those things if we are going to understand adaptive systems and agility.' [89]

It will always be important that humans set the objectives and are able to intervene when they believe that the machines are delivering an outcome that is not part of the mission, or that the situation has changed and the machines require re-calibration.

There will always be a danger that there may be unintended consequences resulting from the instructions that we have given to the machine. It therefore requires endless testing; a 'kill switch', a capacity to talk and reason with the machines, not in the way that humans think about reasoning, but how machines think about reasoning; and adjust their behaviour to meet our needs. 'Machines don't have an evil bone in their body. The computer doesn't care if it lives or dies, it doesn't care who's in charge; it doesn't have an ego, it's not offended by anything. It's not going to get to a point where it's going to say "...look, I want to be in charge now." It is just going to follow our instructions.' The question is, will we be able to codify those instructions in a way that enables the machine to deliver the outcomes that we want? We will need to use a lot of simulation and will need to start slowly and integrate it slowly, giving it a little more license every time. On the other hand, we need to keep in mind that our adversaries are not waiting. They are not necessarily bound by the same cultural or political restraints as us.

89 Woods, Professor David, op. cit., 3.

What is terrifying is that machines will be more powerful than they have been before. It will be very challenging. We need to work internationally to set rules of engagement for how these future capabilities are employed. The world needs to agree upon what we will, and will not accept. Whilst this seems a bit far flung we have successfully navigated a path with nuclear weapons. There remains the threat of mutually assured destruction that underlies any dialogue on this issue and may provide the necessary 'enlightenment.'

Skills Degradation

One of the key challenges that the ADF will face with a rapid increase in technology is one of decreasing expertise. As technology advances, there is going to be continued pressure to replace people with smarter systems and to do it in a way that replaces expertise. Dr Gary Klein argues that we are witnessing a self-fulfilling prophecy. It points towards a scenario where there is increasingly less opportunity for people to gain expertise. Dr Klein and his colleagues call it 'the war on expertise.' He says that it is essential to resist this tendency. He does not envisage AI technology coming even close to substituting for human expertise. He does, however, see a world where we have diminished the need for human expertise, so that it becomes even more tempting to replace people with systems, because people will never have the opportunity to be as good as they used to be.[90]

A military example is the continued need for soldiers to be able to navigate using a map and compass. In a future conflict we may lose GPS, but we cannot let that expertise lapse in the meantime.

Dr Klein argues that we must try to capture some forms of essential expertise. A beneficial research program that could underpin Agile C2 could focus on defining the types of essential expertise that cannot be allowed to lapse in the future. How can they be sustained, and how can they be developed?

90 Klein, Dr Gary, op. cit., 6.

People-Technology Partnering

It is critical to understand that Agile C2 is not just a technological area. Indeed, how humans interact with machines, how information is displayed and the level of confidence in a machine's ability are all important questions that need to be considered. A proper appreciation of human-machine teaming requires consideration of four interrelated elements:

- the cognitive – encompassing individual planning, initiative, and decision-making
- the social – encompassing teamwork, communication, coordination, and collaboration
- the cultural – encompassing norms, values, and human and societal needs
- the technological – encompassing hardware and software networks.[91]

Taken together, these elements form a sociotechnical system and when all these elements work well, human-machine teaming can be highly effective.

Presently, Artificial Intelligence (AI) and Machine Learning (ML) technologies are attracting global attention but are largely still too immature for widespread use in a Defence context. Yet there is a broad range of specific technologies that will affect the cognitive, social and cultural aspects of Agile C2. Some of these include human-computer interfaces that mediate commanders' interactions with the battlespace, including visualisation tools for situational understanding; technologies for remote sensing, processing and dissemination of information; interconnectivity and collaboration technologies; and decision aids for asset coordination in a joint all-domain battlespace.[92]

91 Naikar, Dr Neelam, Interview with Oscar Dowling and David Vallance, 6 August 2020, 1.
92 Ibid. 1-2.

Technologies have the greatest impact only when effectively integrated with their human users, not just with individuals but with teams and large-scale networks of people. Visualisation, decision support systems and collaboration technologies may present significant opportunities for Agile C2. These technologies can enable faster and more nimble forces in the field, though only if they can be designed to account for the constantly shifting context of the 21st century battlespace.

As automation and intelligent machines become more prevalent both in Defence and broader civilian contexts, they may have the ability to free people from more mundane tasks and create time for cultural, intellectual and social pursuits. These advances may also affect an individual's ability to exploit their creative, social and economic potential and to derive a sense of satisfaction and dignity from their work. It is equally important to ensure that the increasing automation does not result in a degradation of key skills and that it generates opportunities for new skills to be cultivated so that the inherent value of people, with their unique capabilities, can be harnessed for the continuing betterment of society.

A critical issue relating to automation and intelligent technologies is that they are not necessarily suited to the fluidity that future working environments will demand. Current applications for scheduling and planning of supply airlifts can perform well in idealised or routine situations, but are less useful in contexts when human priorities and goals are constantly changing and evolving.[93] For example, if a flight needs to be diverted, expedited or re-routed and additional fuel and supplies are required.

It is already well established that in rapidly changing circumstances with high stress, high workload, and considerable time pressure, the very times when people could actually do with some assistance, technologies often go unused or are overridden by their human operators.[94] A key problem is that these machines have not been designed adequately for the changing context. These issues must be

93 Ibid, 2.
94 Ibid, 2.

overcome for AI/ML technologies to have wide-scale or meaningful impacts on human activity.

As research in the sociotechnical sphere involves not just the study of people or the study of technology, but rather the study of how people interact with technology, it has a critical part to play in the design of autonomous technologies that are sensitive and responsive to human requirements and therefore in the design of agile systems. Indeed, it is well-established that the greatest threats to system performance and safety are posed by unforeseen events, or events which have not been and cannot be anticipated by analysts, designers or engineers.[95]

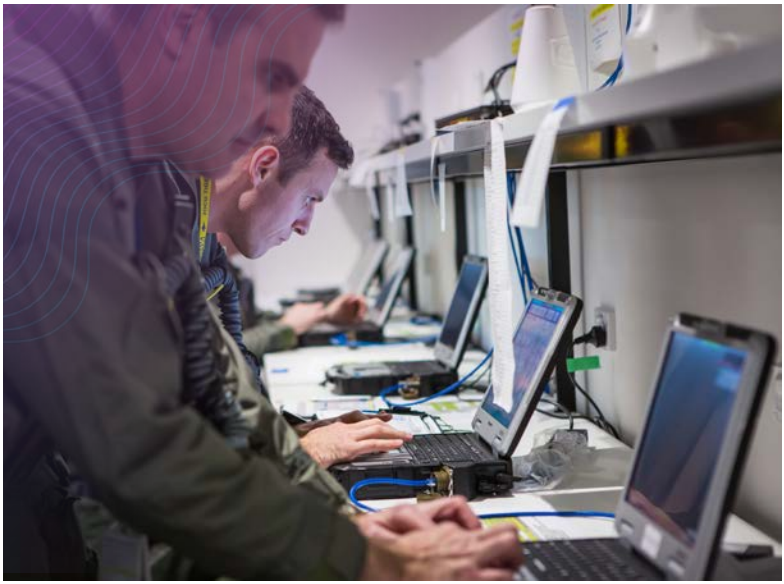
These studies have also shown that people can play a key role in dealing successfully with these novel situations, provided that they are equipped with the right tools and support. In other words, it is clear that people and their effective partnering with technology will be critical in developing Agile C2 systems. This means that research conducted on emerging technologies relevant for Agile C2 should focus as much on the people-technology interaction as on the technology itself.

Humans do not operate in a vacuum. They work constantly in interaction with each other and technology. As obvious as that may sound, this understanding is particularly important to grow the skills that the future ADF will require. Defence will need these skills, not only in their own workforce, but within academia and industry as well. More effort needs to be invested in developing academic and professional pathways that enable human and social scientists to work 'hand in glove' with technologists and engineers to improve and even revolutionise the design of systems and to transform the nature and quality of work.[96]

95 Ibid, 3.
96 Ibid, 3.

Enhancing understanding of this area will help to empower initiatives by individuals and teams across Defence organisations that is informed by a comprehensive understanding of a commander's intent.

The aim is to enable distributed networks of actors to pursue multiple courses of action, undertaken with initiative, that are all based on the common ground of a commander's intent. Such an approach, which can facilitate agility in action while working towards a shared goal or purpose, is aligned with the ADF's Future C2 Concept that describes the need to retain a hierarchical command structure but incorporate mechanisms for agile control in the future Joint force.[97]



Sourced from: Defence Images

97 Ibid. 3-4.

INSIGHTS

Collaboration

The ADF Concept for Command and Control of the Future Force states that the principle of agility is central to the implementation of Mission Command within the future C2 system. Agile control allows for the proactive '…transition between centralised or decentralised relationship models to optimise force integration for the operating environment and mission.'

What is key for this agility and underpins the concept is the need for collaboration. It implies that force elements 'collaborate horizontally across the organisation…' to achieve the mission, bound together by 'unity of effort.' How this might work in practice needs to be tested. Doctrine and training allow for different force elements to work together and for an understanding of role clarity, but simply bolting disparate force elements together and saying 'here is the mission, off you go' implies the need for something else for it to work. It is a fundamentally human problem, but one where technology might assist.

Dr Gary Klein, famous pioneer in the field of naturalistic decision making, suggests that to support such a concept Australia needs to identify cognitive performance requirements for completing various tasks, regardless of the organisational structure, and that these need to be captured in the specifications for new systems. If the specifications require the technology to enable force elements to collaborate to achieve mission command, DST should consider building tools and techniques for capturing the cognitive dimension that clarify what is involved and demonstrate its implications.[98]

He suggests that when new technologies are proposed, DST start to speculate what the cognitive requirements are that these technologies support. What are the demands of these new technologies and what kind of problems they present that have not been anticipated?

98 Klein, Dr Gary, op. cit., 4.

Dr Klein believes that Australia is in a unique position to allow the ADF to save enormous amounts of money by not pursuing technologies that would be fruitless. The burden will be on DST to find ways to demonstrate this to the military leadership.

The research needs to be about 'adaptive teams.' It must address future C2 problems that may be presented to the future warfighter and how decentralised control will solve them using collaboration. How adaptive can the future force be? What is the pathway? What are the steps to get there?

Research will be needed into how force elements — these adaptive teams — solve fundamental problems. As the Future Concept acknowledges, it is highly likely that force elements will have competing goals and priorities. It suggests that mission command should resolve these. An adversary will attempt to provide our force elements with multiple dilemmas, possibly delivered through multiple domains, which they must either choose to react to or ignore. Research is required to understand how the mission is achieved without continually re-configuring force elements to 'adapt' to each new dilemma.

There needs to be more coordination at the scientific level. Research continues to be conducted in silos. Whilst bureaucracy will always be there, effective leadership can enable and force more collaboration.

Additionally, more work and collaboration is required between FVEY and Allied operational communities. Although there have been significant examples of collaboration that have been effective, most is superficial. For instance, if we want to successfully conduct Coalition operations then we need to collectively build the necessary tactics, techniques and procedures. This requires the sharing of information to which there remains barriers, particularly when it comes to revealing information about the threat or own capabilities. So, without sharing this kind of information, such collaborative activities will be limited in what they can achieve. How do we align priorities or allocate and coordinate research tasks amongst allies and partners effectively?[99]

99 Irandoust, Dr Hengameh, Interview with Ash Colmer, 25 August 2020, 3.

A Notion of Disruption?

> Many are happy to fund and talk about disruptive technologies, but few are keen to disrupt anything else that is being done now to adapt to new challenges.[100]

How can we use emerging technology to support more agile approaches that support strategic decision making? At this level, decisions are generally made by committees supported by email, PowerPoint presentations and written briefs and dependent upon who happens to be sitting around the table on that day. Could AI support decision making at this level? Could it enable a briefer to seek a decision with a recommended course of action that had been rigorously analysed through the 'Agile C2 wargame system'?

Conversely, at the other end of the planning spectrum is Defence's IIP. Is there a way of using AI to assist decisions about long term military and strategic investment? Is AI so far outside the 'frame of reference' and the culture of the Department? Defence needs to revisit the initial question of what is the future warfighting requirement? What is the actual requirement? The task of describing a future Agile C2 system will be much easier. It would be reasonable to assume that our potential competitors are endeavouring to seek advantage in similar ways.

Research into how technology can inform strategic decision making will assist Defence leaders in seeking better decisions from Government that will give Australia an advantage in the future.

100 Noble, Roger Major General, op. cit., 3.

An Australian Sovereign Agile C2 System?

There is an argument that if we need a sovereign Agile C2 system, we must build our own AI. We cannot rely on the US. We cannot assume that the US is always going to make decisions that will be in Australia's best interest. Would they sell their best AI? Reduced performance in capability will have existential consequences. 'Unlike a tank, that once it's delivered, we own the tank. With AI, we don't know if there is a code within it, or a kill switch if we use it for something that we need it for that may not be in the best interest of America.'[101]

We should realise that AI will most certainly emerge from a commercial testbed. A foreign-grown AI could not be expected to enable an Australian competitive advantage in any domain. More importantly, will a foreign built AI meet the unique requirements of an Australian C2 system? The Chinese are investing billions and so should we so that we can control our own destiny.

DST has the opportunity to lead the investment and research into the core capability needed for technologies to support the unique requirements for a sovereign Agile C2 system. DST needs to sell this to the ADF leadership. Decisions have been made about the next generation of investment. If the future warfighting concept is less about ships, submarines, fighter aircraft, tanks and field guns, and more about the agility of C2 systems then this is the research that is needed. If there is a requirement for our own home-grown and solely owned C2 system, we need to start now. We have the capacity to build it, we just require the investment.'[102]

The architecture for such a system needs to be open enough to allow it to be modular, flexible, human-centric, all-informed and multi-domain, joint and interagency, as well as allow for the ADF to work as seamlessly as possible with our friends and allies.

101 Dalby, Paul, op. cit., 4.
102 Ibid., 5.

Agile C2 System – Development Plan

A sovereign Australian Agile C2 system requires a development pathway that recognises all aspects of the capability and how they are affected. It needs to articulate how iterations are entered into service and how we deal with the unexpected consequences that these capabilities will no doubt present. The ADF needs to stand ready to apply the Agile C2 system in ways that have not previously been imagined and the leadership needs to stand ready to manage the expectations of Government, industry, academia and our friends and allies through this journey.

The development plan will be required to set challenges for Agile C2 research and how Australia will work with the FVEY community and our partners. It should identify those niche sovereign technologies that can be developed in Australia at a world-class level. It must be underpinned by an acquisition process that is non-standard but aligns with the processes necessary for responsible government.

The ADF needs to be wary though. Network Centric Warfare (NCW) became the catch cry and buzzword of the early 2000s. So much so that a new layer of bureaucracy was created to ensure that all capability was compliant with the 'NCW Roadmap.' From an organisational view, Defence unintentionally created this 'new thing' that was NCW. 'It had legs' and an ability to interfere with the mainstream acquisition processes of the ADF. Eventually though, NCW grew obsolete. Its bureaucracy gradually whittled away until it was no more. Its Roadmap, once taking 'pride of place' on every staff officer's bookshelf, gradually found its way to the recycle bins of Russell and Edinburgh. While the central idea of NCW remains valid to this day, what happened to the concept?

Most importantly, all areas of the Australian Defence Organisation (ADO) will need to be invested in Agile C2. This includes the availability of warfighters. There is a necessary demand by DST, academia and industry for warfighters to provide input to and test evolving technologies and concepts.

Codifying performance metrics and success criteria required to meet challenges for the future warfighter is fundamental to technology and concept development.

If there is a lack of warfighter participation, DST will have difficulty setting the conditions for scientific research correctly. Dr Gary Klein argues that the research required in this field is not the kind that is conducted in a laboratory and needs to be conducted 'in the field.' He believes that too much of this research is conducted in laboratories because it is easy. Maybe it is because researchers cannot gain access to warfighters. 'Folk gravitate towards doing research in laboratory settings.' This leads to the performance of artificial tasks because the people playing the roles have differing skill and experience levels, which reduce the validity of the results. With more variability, it is more difficult to achieve significant results. [103]

He cites an example of where he was talking to a researcher who told him '...I give my subjects lots of practice. I give them ten hours of practice.' Gary had recently finished an assignment with firefighters who had twenty years' experience fighting fires. Given that, he asks, how could such a researcher claim to have produced meaningful results?

Sourced from: Defence Images

103 Klein, Dr Gary, op. cit., 3-4.

Leading and Encouraging Public Sector and Industry Innovation Through Agile Acquisition

The ADF needs to articulate how it intends for the future force to fight. While there are increases in budgets, there are those who question the validity of the massive size of the Defence budget in contrast to other areas of national security. An updated Future Joint Operating Concept (FJOC) is required to inform some key decisions about future capability investment and to shape how academia and industry fund their R&D activities.

If the ADF cannot contextualise the Agile C2 problem and select the technologies to be investigated, then there is a risk that the problem escalates out of control due to a fascination with each emerging technology.[104] There must be a balance between creativity and constraints. Additionally, and like all advanced technology endeavours, there needs to be a healthy level of acceptance of failure.

Developing, integrating and deploying Agile C2 technologies will not be successfully addressed by the standard acquisition process where everything must succeed. We must have an accepted failure rate that allows for the creativity needed, and an iterative approach. The process must be agile and adaptive, and must be part of an alliance between Defence, industry and academia.

It will also require an ever increasing 'race' to improve technologies to attain and maintain 'decision overmatch.' Current procurement processes do not support rapid acquisition and there will remain friction between this need and accountable government processes. In addition to acquisition, change management and training challenges for personnel will need to be continually overcome to successfully integrate agile technologies into C2 systems.

To build world class AI, we need to have world class talent here in Australia. Other countries are driving their AI talent through investment by government and particularly through the military. Australia should consider following this example.

104 Lindsay, Dr Tony, op. cit.., 3.

Technology First v User First

'User centred design' will not work as developers and computer programmers don't care about humans – they care about algorithms.[105]

While Agile C2 may provide the right answers for operators, these answers need to be delivered in a way that is understandable and allows the operator to build an accurate situational awareness of the battlespace. Therefore, it must present the right information, in the right way, at the right time, to the right people. How then do we build the interface between the human and the machine?

The desire is to work more closely with practitioners to build something that is most helpful to them. What is of little to no use is technology that is '...clunky, non-intuitive, and requires training.' Technology interfaces are designed by technology developers who are comfortable with complex interfaces. To the developers it looks terrific, but not so for military operators. The challenge is to build technology interfaces in a way that is natural, easy and comfortable to use by people who are under high stress. It should not be another job for operators to learn to use the technology. That extra step needs to disappear and the interface should become a 'stream of consciousness' for them. They can simply say what is in their head and then a response appears out of the aether. The response may be on a screen or it could be verbal.[106]

Dr Gary Klein argues that 'user centred design' will not work as developers and computer programmers do not care about humans – they care about algorithms. They do not want their creativity bound by users.

'That is why they talk about autonomous systems, because they don't want to be bothered with users at all.' He argues that if these developers were interested in people, they may have pursued careers in human factors, cognitive systems engineering or psychology. Instead they pursued careers in computer science because they do not care about users.

105 Klein, Dr Gary, op cit., 5
106 Dalby, Paul, op. cit., 3

He describes the pursuit of trying to persuade these developers about the perspective of users as a 'blind alley.' He suggests that a better approach is to educate the 'warfighting community' so that human factor standards are put in place for developers to adhere to.[107]

Integrating Science and Innovation in Organisational Structures

As previously discussed, the day-to-day pressure on the warfighter typically does not allow for the breadth of 'bandwidth' required to inform research and innovation. Dr Tony Lindsay acknowledges what has worked well in the past has been when an 'innovation cell' is embedded within a headquarters. A good example is the UK Defence Intelligence fusion Centre at RAF Wyton, where UK ONLY, UK-US ONLY and FVEY laboratories were built into the headquarters supporting an innovation system that sits right next to the operators. The 'litmus test' was that the operators got to use the innovation early, not necessarily in the operational environment, but within a 'test environment' that has access to and is fed by the real data. There is a 'bronze' (S&T), 'silver' (SecDevOPs), and 'gold' (Operation) maturation model, with gold being the operational system used by the analysts. Solutions to evolving warfighter problems can be tested in any of the environments dependent on the situation. They can be adjusted with the input of the warfighter. This, says Dr Lindsay, is real innovation. It may not come with the full 'whole of capability' inputs such as supply chain, but it works and has been tested and accepted by the warfighter. A much better proposition than 'buying innovation.' [108]

A major step forward in the ADO's capability, and what could be a challenging success metric for the Agile C2 STaRShot, would be the establishment of an 'innovation cell' at HQJOC.

107 Klein, Gary, loc. cit.
108 Lindsay, Dr Tony, op. cit., 3.

If the ADF has a concept for how it wants to fight, then it can make some better decisions regarding Agile C2. There needs to be an obvious link between technology, concepts and strategy. If we could clearly articulate this then we would know the standards required to build and test the system and justify expenditure.[109]

Paul Dalby argues that we do not need to be the biggest. We need to be clever, strategic and targeted about how we make our investment. 'We do not need to invest $20 billion every year. We could invest $1 billion and make an enormous impact. If the US want AI capability, they have to go to Amazon. Amazon is investing $20 billion per year in AI. The US aren't that far ahead of where we are and we can build systems that operate effectively, suit our particular requirements and strategic needs, rather than adapting something from somewhere else.'[110]

Sourced from: Defence Images

109 Molan, Senator Jim, Interview with Ash Colmer, 10 August 2020, 1.
110 Dalby, Paul, op cit., 5.

Decision Making

There is a general agreement that technological support to decision makers is largely absent. Warfighters need smart tools for assisting with planning and seek the promise of wargaming the tactical plan quickly to validate it. Decision support is the space that presents the biggest opportunity for AI.

Additionally, it may be argued that similar tools are required at the strategic level. Decisions are made supported by email, PowerPoint presentations and written briefs and are dependent upon who happens to be sitting around the table on that day. 'We need to push forward with new approaches to support strategic decision making. How could AI support decision making at this level? It may enable a briefer to seek a decision with a recommended course of action that had been rigorously analysed through the 'Agile C2 wargames system 1 million times and has X probability of success....'[111]

We must assume that our potential competitors are moving forward in similar ways and, without the drive to move forward, without an acknowledgement of 'we can do better,' the competitors will potentially increase their advantage. Support at this level will enable Defence leaders seek better decisions from Government.

Sourced from: Defence Images

111 Noble, Roger, Major General, op. cit.,

Degraded Network Environments, ICT Resilience and Disinformation

Electronic warfare and its enhanced electronic footprint is the traditional risk to C2. There are other experts trying to solve this problem in the coming years. Although you cannot lower your visibility within the electronic spectrum, there are other things that may be done to avoid looking like a single bright spot and disguise locations. As discussed earlier, the Future C2 Concept seeks to eliminate 'C2 nodes' and distribute decision making across the network.[112]

What is more important for an Agile C2 system is how it continues to function within a degraded communications setting. What happens 'when the lights go out'? What happens when the C2 system is degraded? How does the system deal with uncertainty? What happens when you know that the system has been degraded, but you do not know by how much? What about breaches of security? How do operators perform work arounds to deal with this uncertainty? DST should not only look into how teams need to adapt their structures to account for these effects, but also into their overall effect on the mission. How does an Agile C2 system operate in such circumstances?

In a 'near peer' contest, a force's electronic communication capacity might be shut down completely. How does an Agile C2 system operate with a less modern ensemble of maps, couriers, runners, signals and notebooks? Such a scenario reminds us of the need for mission command. When communications are degraded, subordinate staff must have a clear understanding of the mission, its purpose, objectives and constraints.

112 Eikelboom, Dr Aletta, op. cit., 4.

This enables them to operate and achieve the mission in the face of uncertainty. They need to be able to work in an environment where they do not know everything that is happening.

A modern, highly effective C2 system must also be able to counter disinformation. The problem is that the argument quickly moves into the classified space which implies that some people are immediately left out of the conversation. Professor David Woods argues that disinformation will be prolific during the prelude to and fundamental to any future conflict. The problem for Defence Science in this instance, says Professor Woods, will be that Defence will say that it already has a disinformation program. He argues that the problem, 'the big problem for the Twenties,' is different and intensely human. We will require a 'new coalition' of thinkers and disciplines to tackle this. This is a research project with immense practical implications '...that cut every which way – inside the country, outside the country, internal, external, business, competition, politics – and, as stated, is intensely human.' There needs to be an entirely different 'synthesis' and new approaches to tackle this immensely complex problem.[113]

Professor Woods suggests says that DST needs to think of ways to keep the conversation open. What about business entities that are already using successful counter-disinformation techniques against competitors?

113 Woods, Professor David, op. cit., 3.

A Last Word on Communications

In terms of an insight for emerging disruptive communications technologies, a final word on communications from Major General Roger Noble is that there is no substitute for human-to-human communication. Constant, open, face-to-face communications between people up and down the chain and laterally, from strategic to tactical, is essential. This is important, and it is fundamental to warfare because this is how leaders must lead.

This is how leaders enable their people to actually fight – putting themselves in harm's way, killing the enemy, so that the mission is achieved.[114]

General Noble cites the introduction of the Defence Secret Network (DSN) Unified Communications as the most important innovation in Defence for many years. It has allowed people to dial somebody and have a classified conversation, face-to-face over the DSN. This single change, to be able to instantly 'picture-face connect' in a secure environment is extremely important. Such interaction can override the inaccessibility of elements of situational awareness, key deductions or triggers that may be hidden within certain 'ponds' due to classification or need to know requirements. Something in a top-secret system is not necessarily available to somebody on a secret system. These information gaps are filled by humans who can make deductions, draw insights and conclusions that machines cannot, and can walk from one room to the next to pass information. The alternative is to invest huge amounts of money in investigating how technology might solve this problem, which may ultimately be stopped by policy anyway. 'Classification means that we just won't ever have an "ubiquitous" system – so don't even try.'[115]

114 Noble, Roger, Major General, op. cit., 3.
115 Noble, Roger, Major General, op. cit., 3.

General Noble asks, 'why can't anybody be able to talk to anybody across the network if they need to? You should be able to always have access to intent and get it direct from the key leaders at any level. This has always been the way. At the crossing of the Meuse in 1940, Rommel simply drove up and parked behind a Panzer troop leader, got out and talked to him. It doesn't mean we need to be doing this all the time. We should just have the capacity to do it, so that leaders can lead face to face and human to human.'[116]

General Noble was Second-in Command of the US 101st Airborne Division in Iraq in 2016. He said the Divisional Commander spent two and a half hours a day talking to the brigade commanders. Visiting them, talking to them on the radio or the phone 'because that's how it works when people are getting killed.'[117]

He is concerned that the argument is getting too academic and the leadership element is getting lost with the passage of messages and other data.

The fundamental elements of warfare – a life and death struggle between humans – does not change. There will always be the need for face-to-face human to human contact when people are getting killed. 'People are not going to fight and kill because of an email. They are going to fight because they believe in what they are doing, and they are well led. You are not "well led" by an email.'[118]

116 Loc. cit.
117 Loc. cit.
118 Loc. cit.

Appendix – SMEs interviewed

Name	Organisation
Coen van Antwerpen	Defence Science and Technology Group
Professor Uwe Aickelin	University of Melbourne
Leung Chim	Defence Science and Technology Group
Dr Paul Dalby	Australian Machine Learning Institute The University of Adelaide
Dr Aletta Eikelboom	Netherlands Organisation for Applied Scientific Research
Dr Deborah Fish	Defence Science and Technology Laboratory, UK
Duncan Fletcher	Defence Science and Technology Group
Dr Aditya Ghose	University of Wollongong
Commodore Ivan Ingham	Royal Australian Navy
Dr Hengameh Irandoust	Defence Research and Development, Canada
Dr Alexander Kalloniatis	Defence Science and Technology Group
Dr Gary Klein	Macrocognition LLC
Hing-Wah Kwok	Defence Science and Technology Group
Grace Kennedy	University of Wollongong
Air Commodore Richard Lennon	Royal Australian Air Force
Dr Tony Lindsay	Lockheed Martin
Senator Hon. Jim Molan	Australian Army (retd.)
Dr Glennn Moy	Defence Science and Technology Group
Dr Neelam Naikar	Defence Science and Technology Group
Major General Roger Noble	Australian Army

Name	Organisation
Professor Adrian Pearce	University of Melbourne
Dr Jason Scholz	Trusted Autonomous Systems Defence CRC
Professor David Woods	Ohio State University

Australian Government
Department of Defence
Science and Technology

EDTAS

EMERGING DISRUPTIVE TECHNOLOGY
ASSESSMENT SYMPOSIUM

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